INTERNATIONAL ENERGY AGENCY
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FUEL EFFICIENT ROAD VEHICLE NON-ENGINE COMPONENTS

Potential Savings and Policy Recommendations

IEA INFORMATION PAPER

In support of the G8 Plan of Action

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- To operate a permanent information system on the international oil market.
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- To promote international collaboration on energy technology.
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FUEL EFFICIENT ROAD VEHICLE NON-ENGINE COMPONENTS: POTENTIAL SAVINGS AND POLICY RECOMMENDATIONS

ABSTRACT

The need to address global energy issues, i.e. energy security and climate change, is more urgent than ever. Road vehicles dominate global oil consumption and are one of the fastest growing energy end-uses. This paper studies policies and measures to improve on-road fuel efficiency of vehicles by focusing on energy efficiency of automobile components not generally considered in official fuel efficiency test, namely tyres, cooling technologies and lightings. In this paper, current policies and industry activities on these components are reviewed, fuel saving potential by the components analysed and possible policies to realise the potential recommended.

1. INTRODUCTION

The need to address global energy issues is more urgent than ever. Economies face threats to their energy security, and the spectre of climate change requires urgent government action. As a result, G8 leaders at Gleneagles in July 2005 and in St. Petersburg in July 2006 called on the International Energy Agency (IEA) for "advice on alternative energy scenarios and strategies aimed at a clean, clever and competitive energy future".

Road vehicles are a major part of the energy-use puzzle. Road vehicles dominate global oil consumption, consuming as much as 80% of transport energy and are one of the fastest growing energy end-uses. As a result, transport sector's share of oil consumption has been increasing steadily at around 0.5% per year. In 2004, 58% of oil was consumed in this sector world wide, emitting 20% of CO_2 emissions. Transport energy demand will continue on this path unless more action is taken urgently.

Current policies are not sufficient to stem road vehicle energy use. Even if governments actually implement all the measures that are currently being considered, road vehicle energy use and CO_2 emissions would still rise between now and 2030 at 1.4% and 1.3% per annum respectively.

New measures to provide a more secure, environmentally acceptable energy system must be implemented urgently. Further, raising vehicle fuel efficiency should be a first step in this campaign. These policies make economic sense, produce energy savings and provide time to develop and reduce cost of technologies such as hybrids, bio-fuels, fuel-cells, etc., which may run our economies in the future.

Many policies have been introduced to improve vehicle fuel efficiency, including establishing standards and targets. However, despite on-going efforts to better understand actual driving styles including the use of energy consuming components and to adopt these in their test procedure in major regions, standards of fuel efficiency assessment do not accurately measure average on-road vehicle fuel efficiency. The IEA, therefore, has been focusing on the factors which are not covered in official vehicle fuel efficiency tests.

Motor vehicles fuel is used into:
- overcoming engine and driveline losses;
- standby and idling;
- accessories (e.g. air conditioning, lighting);
- overcoming aerodynamic drag;
- inertia ;
- overcoming tyre rolling resistance.

Engine and driveline losses, standby and idling, aerodynamic drag, and inertia are generally covered in official fuel efficiency tests. Rolling resistance of tyres on new vehicles is also covered, but not that of replacement tyres on which vehicles run much longer. Accessories are not covered either with the exception of the US Environment Protection Agency (EPA)'s recently issued new test methods for fuel economy window stickers in which load by air-conditioner is considered.

Those elements not considered in official tests, or only partially, have an important and generally ignored impact on vehicles' fuel efficiency. If the mechanical energy required is considered, overcoming tyres' rolling resistance and running accessories only account for 4% and 2% respectively of fuel energy. However, it should also be noted that, due to the engine yield and power train losses, only about 15% to 25% of the fuel energy is converted to the mechanical work for moving the car and running accessories, and that the rest of the energy is lost. Reducing fuel energy demand by tyre and accessories by a certain percent therefore means a higher percentage of reduction in fuel consumption. An estimation presented at the 2005 IEA Tyre Workshop shows, and experts agree, that a typical mid-size passenger car uses roughly 20% of fuel to overcome tyre rolling resistance and nearly 10% for the accessories such as air conditioning and lighting. Technologies to reduce these energy demands have substantial fuel savings potential. However, these technologies are unlikely to be exploited as manufacturers have little incentive and consumers have difficulties in making informed purchasing decisions.

The purpose of this paper is to review policies, measures and activities on these components, to analyse fuel saving potential by the components and to recommend possible policies to realise the potential savings. This paper focuses on the three components, namely tyres, cooling cars technologies and lightings[1].

In this paper, tyres are first discussed in chapter 2, followed by cooling technologies (chapter 3) and lightings (chapter 4).

[1] As for cooling the cars, the paper will not only address the efficiency of the air conditioning technologies, but also all possible improvements through reduction of the solar gain and better control options. That is what is referred as "cooling technologies" later.

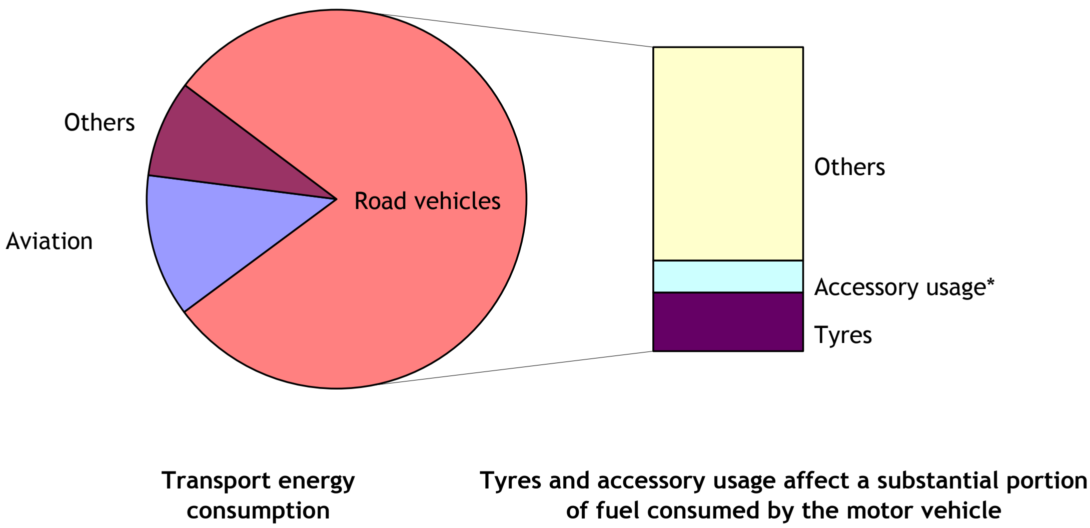
For each of the three components, three issues are discussed:

- Background information;
- Current policies and measures;
- Options for the future.

As for background information, detailed information on the energy used and CO_2 emissions, the available technologies and some other characteristics (e.g. market or climate consideration) are provided. The section on current policies and measures reviews government programmes, industry activities and possible regulatory balances (when energy saving can compete with other policy objectives like e.g. road safety). In terms of options for the future, an assessment of the possible reductions for each component given available technologies and the possible recommended policy options to deliver such improvements are provided. On the way through the paper, there is a box with additional information about another key issue of the “on-road” consumption of cars: improving drivers’ behaviour (eco-driving) including those through provision of drivers feedback systems.

Finally, possible policy recommendations presented for each component in the previous chapters are summarized in the concluding chapter (chapter 5) where a comprehensive and consistent approach is proposed.

Figure 1: Non-engine components are an important end-use of energy in transport sector



* Accessory usage includes air conditioning and lighting

2. TYRE

a. Background information

i. The energy used and CO_2 emitted by components

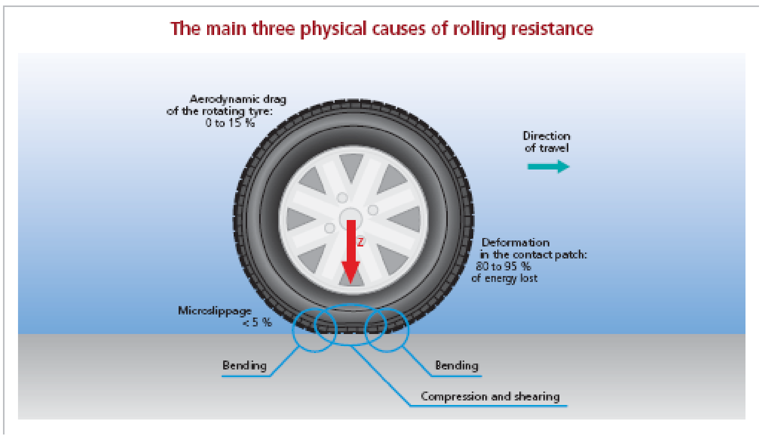
According to the World Energy Outlook 2006, road transport is responsible for over 1,500 Mtoe of energy use and over 4 Gt of CO_2 emissions globally. As mentioned above, roughly 20% of a motor vehicle's fuel is estimated to be used to overcome rolling resistance of tyres. Therefore, tyre is responsible for very roughly 300 Mtoe energy consumption and 800 Mt CO_2 emissions.

Furthermore, additional fuel is required when tyres are under-inflated. Data presented at the 2005 IEA Tyre Workshop and generally supported by not only the participants of the workshop but also industry experts show that in the EU, the tyres in service are under- inflated by 0.2 to 0.4 bar on average for passenger cars and 0.5 bar for trucks. It is generally understood that these numbers correspond to an increase in energy consumption and CO_2 emissions of roughly 1 to 2.5% for passenger cars, and 1% for trucks. Assuming that the tyres in service worldwide are similarly under-inflated, this corresponds very roughly to over 15 Mtoe energy consumption and over 40 Mt CO_2 emissions. If tyres in regions other than the EU were less well maintained, additional energy would be consumed and CO_2 emitted. Although governments have been working on the issue of under-inflated tyres for many years, this issue has been regarded as a safety issue and not an energy efficiency issue.

ii. Technology

Pneumatic tyres offer a number of advantages related to the highly compliant nature of rubber, such as generating the forces responsible for traction and providing increased cushioning for comfort. A disadvantage, however, is that energy is expended as the pneumatic tire repeatedly deforms and recovers during its rotation under the weight of the vehicle. Energy is dissipated when a tyre is deformed due to rubber hysteretic losses behaviour. This phenomenon is called rolling resistance (RR) and it is the force that induces a resistive force to be overcome to move a tyre-fitted vehicle.

Figure 2: A tyre in action



Two main factors have an influence on tyre RR: tyre design (including size, structure, and materials) and operating conditions (including inflation pressure, load, alignment, and temperature).

As for tyre design, a study conducted in the EU and presented at the 2005 IEA Tyre workshop shows that there is a wide range of RR values for the tyres currently on the market. Tyres with the lowest RR have half the RR of the ones with the highest RR. The workshop participants as well as tyre industry experts generally share these results. It implies that tyre design technologies for low RR are already on the market. Since tyres with low RR typically are more technically advanced and generally have lower tread life expectations than conventional tires, they may cost more for consumers; nevertheless, the consumers would likely recover the price differential through reduced fuel costs over the life of the tyre.

Figure 3: Tyre rolling resistance measurements

	Rolling Resistance Coefficient	
	Maximum	**Minimum**
Passenger Cars (For new cars & Replacements)	0.014	0.007
Trucks & Busses	0.0085	0.0055

Source: the IEA tyre workshop presentation (presented by Michelin)
Note: Measurements made in EU countries

Concerning operating condition, tyre inflation pressure is important. 10% decrease in tyre inflation pressure generally increases the tyre RR by about 4 percent. Tyre inflation pressure maintenance on existing vehicles would, therefore, achieve significant fuel savings immediately at virtually no cost to consumers. Tyre Pressure Monitoring Systems (TPMS) which alert drivers when their tyres are under-inflated are also widely available on the market.

iii. Other characteristics

Data presented in the 2005 IEA Tyre Workshop showed two separate tyre markets, those tyres supplied with new vehicles (Original Equipment -- OE) and replacement tyres. In the US, where auto manufacturers rely on low RR tyres to meet the US Corporate Average Fuel Economy (CAFE) standards, the difference in RR between the two markets is significant. This finding was echoed in a study by the National Research Council of the US (NRC) issued last year (TRB report), pointing out that the vast majority of replacement passenger tyres have rolling resistance coefficients (RRCs) within the range of 0.007 to 0.014 when measured new, while the range for new OE tyres tends to be lower—on the order of 0.006 to 0.01. Experts see that such difference also exist in Japan where manufacturers have to meet the fuel efficiency standards. The difference between RRC of OE tyres and that of replacement tyres are said to be smaller in the EU where currently there are no mandatory fuel efficiency standards.

b. Current policies and measures

i. Government programmes

Several policies and measures are currently under consideration as ways to improve vehicle fuel efficiency or to reduce CO2 emission from vehicles.

1. EU

The European Commission published a communiqué on Energy Efficiency Action Plan in October 2006 in which it states that it will take the following measures:

- issue a mandate for a recognized European Norm and international standard to measure tyre RR (2008);
- propose a labelling scheme for tyres (2008);
- facilitate voluntary agreements and propose other measures on accurate tyre pressure monitoring schemes (2008-2009);
- consider compulsory fitting of Tyre Pressure Monitoring Systems (TPMS) on new vehicles (2008-2009).

The European Commission published another communiqué in February 2007 on "Results of the review of the Community Strategy to reduce CO_2 emissions from passenger cars and light-commercial vehicles" in which it states that it will "set maximum tyre rolling resistance limits in the EU for tyres fitted on passenger cars and light-commercial vehicles (2007-mid 2008)."

2. USA

The NRC made a recommendation in the 2006 TRB report that Congress should authorize and make sufficient resources available to National Highway Traffic Safety Administration (an administration under the Department of Transportation responsible for, among others, Federal Motor Vehicle Safety Standards, the Uniform Tire Quality Grading system, and the corporate average fuel economy program) "to allow it to gather and report information on the influence of individual passenger tyres on vehicle fuel consumption…. and ensure that the information is made widely available in a timely manner and is easily understood by both buyers and sellers".

In the State of California, legislation was signed into law in 2003 that requires tyre manufacturers of light duty tyres sold in the state to report fuel economy information. The California law mandates tire energy efficiency consumer information, rating system and minimum efficiency standards. The minimum efficiency standards must be technologically feasible and cost effective, must not adversely affect the safety, must not adversely affect average tire longevity and must not affect the waste tire recycling programme in the state. California is currently working on promulgating regulations establishing requirements under this law.

3. G8

The IEA concluded in 2006 that international best practice with respect to fuel-efficient tyres would consist of the following two elements and recommended them to the St. Petersburg G8 summit:

- Maximum allowable levels of rolling resistance for major categories of tires.
- Measures to promote proper inflation levels of tires.

Action on fuel-efficient tyre programme has comprised a component of the St. Petersburg G8 Communiqué on Energy. The communiqué specifically stated that the fuel-efficient tyre programme, among other things, should be examined in more details.

4. UNECE/WP29

The World Forum for harmonization of vehicle regulations (UNECE/WP29) is a forum established in the UN framework to address global issues regarding vehicle energy as well as safety, environmental pollution and anti-theft. In the 141 session of WP29 held in March 2007, it was agreed that a group be set up to discuss on mandatory fitting of TPMS.

ii. Industry activities

A reference tire RR measurement method was proposed and submitted to International Standards Organization (ISO) in early 2006 for an international standard. The proposal was accepted by the ISO and ad-hoc meetings started in August 2006. In December 2006, alternative test methods using conversion formula were discussed. In May 2007, a test procedure for RR measurement was adopted as a Committee Draft.

iii. Regulatory balances

People tend to think that a tyre with low RR will not stick to the road and, therefore, will be less safe.

Concerning the relationship between RR and safety, the NRC concluded in the TRB report issued in 2006 that "although traction may be affected by modifying a tire's tread to reduce RR, the safety consequences are probably undetectable".

Further investigation on correlation between RR and safety in relevant categories under the appropriately defined condition should be necessary but technological breakthrough to achieve the compatibility could be expected. The most important thing is that the lowering RR should be pursued while the safety is always maintained.

c. Options for the future

i. Possible reduction

It is widely perceived that a 10 percent reduction in RR yields a 1 to 2 percent change in vehicle fuel economy, depending on several factors, including vehicle, load, tire inflation pressure and drive cycle.

In the US, tyre RR has decreased significantly. The lowest RR of today's new tyre is 20 to 30 percent lower than the lowest value of tyres sampled during the early 1980's.

Furthermore, the TRB report concluded that reducing the average RR of replacement tires by 10 percent in the next 10 years is technically and economically feasible and attainable.

In the EU, although different size and speed rating resulted in different RR, the passenger car tyre with the highest RR has higher RR than that with the lowest RR by as much as 100 percent.

Such kinds of numbers for other regions of the world are not available. And given different vehicle fleets, traffic environmental and service conditions, different fuel economy improvement projections may be applicable to other regions.

It is clear, therefore, that further study on the latest tyre RR situation is warranted. The IEA is ready to engage in this. However, in the meantime, assuming that world wide average RR of all tyres were lowered by 20 percent, although this would require technological breakthrough, over the mid-term period of now and 2030 might not be preposterous. Under such assumption, fuel demand in road transport sector would be reduced by 2 to 4 percent.

Additional reduction of fuel consumption could be possible by proper and vigilant maintenance of tyres. As is mentioned above, over 1% fuel could be wasted due to under-inflation of tyres. Maintaining proper inflation pressure of tyres by regular checking by drivers or by state-of-the-art technologies or both could approximate the above mentioned numbers to zero. It should also be noted that the decrease could be achievable instantly and with a small amount of extra money.

Combining these numbers, roughly 3 to 5 percent or 70 to 120 Mtoe fuel consumption and 190 to 320 $MtCO_2$ emissions could possibly be reduced in mid-term.

These estimated numbers could become bigger if the situation in developing countries was taken into consideration. Some manufacturers facing tough programmes to reduce RR in developed countries might seek to find receptive markets for high RR tyres in the expanding markets of developing countries. In addition, more and more tyres in these countries could be under-inflated due to lack of proper maintenance. Given the fact that these countries will account for the majority of growth in fuel consumption, potential reduction of the efficient tyre programme could be even higher.

ii. Possible policy recommendation

Official tests for fuel efficiency standards are conducted using the same tyres as are fitted to vehicles sold in the market. Therefore, manufacturers have incentive to fit the fuel efficient tyres to their new vehicles in order to meet the standards.

Replacement tyres are not tested for fuel efficiency. And since they are not tested, consumers of replacement tyres face difficulty in choosing their tyres from a fuel efficiency point of view.

Some governments begin considering testing replacement tyres. The absence of a globally harmonized test procedure to measure RR has been one of impediments to coordinated international efforts to improve tyre fuel efficiency. Given that tyres are globally traded products, such international coordination would benefit both consumers and industry.

In addition, without combined user's education and on-board devises such as TPMS for new vehicles, etc., it is also difficult for drivers to attain possible savings from proper tyre inflation pressure.

Given those mentioned above, countries could consider:

1. accelerating establishment of an international test procedure and adopting it if it is established and appropriate;
2. establishing a system to disseminate information about RR, including labelling scheme;
3. setting maximum levels of RR for major categories of tyres;

4. establishing programmes to ensure proper inflation and maintenance of tyres (including through compulsory fitting of TPMS on new vehicles and consumer education programme on proper tyre maintenance).

3. COOLING TECHNOLOGY

a. Background information

i. The energy used and CO_2 emitted by components

When in use, mobile air conditioning (MAC) systems are responsible for as much as 15% of the fuel used by modern cars, and may be up to some 30%, depending on the vehicle in specific driving conditions (e.g. during heavy congestion). Identifying technologies that can reduce the amount of fuel used to cool motor vehicles was the purpose of the IEA's workshop Cooling Cars with Less Fuel, held at the IEA headquarter in Paris in October 2006. Several presentations indicated that air conditioning is estimated to contribute 5-10% of passenger cars oil use in countries with high rate of equipment. Passenger cars and other Light Duty Vehicles (LDV) in the world consume about 1000 Mtoe every year. Taking into account that the rate of equipment is already high or quickly rising in all countries in the world, if applied worldwide, this kind of ratio, LDV MAC, accounts a very rough estimate of 50-100 Mtoe energy consumption and 140-280 $MtCO_2$ emissions. For the purpose of safe calculations, the assumptions in the below analysis will use the rather conservative figure of 50 Mtoe and 140 $MtCO_2$.

ii. Technology

Providing thermal comfort in cars is a rising concern of both manufacturers and consumers. While heating can generally be provided by the heat losses of the engine (although this usually first needs the engine to warm up before providing this service) and has been provided almost from the first times of automotive, cooling is a more difficult issue. Providing cool air requires active systems, basically heat pumps including a refrigerant fluid[2] alternatively evaporated (producing cold) and condensed (producing heat to be evacuated by external exchangers). The pump itself is usually activated through a belt driven by the engine (however there are also electrically driven MAC systems). More efficient MAC systems, including better pumps, better heat exchangers, and better system design can consume as much as 30% less energy to provide the same amount of cold production (I-MAC average estimate). However, ensuring thermal comfort in cars is not only a matter of efficiency of the MAC systems in themselves, but also the efficiency of "cooling" as a whole, including control options (adjust temperatures, "cool the driver instead of cooling the car") as well as the car envelope design protecting from solar gain (colour, albedo, glazing, insulation) and raising the awareness of users.

The reflectivity of the vehicle is a key issue in solar gain management. The visible colour contributes to the reflectivity (white painting reducing solar gain compared to black, e.g.) but it should be noted that about 55% of the solar radiation energy comes through invisible infrared wavelengths. According to an estimate, solar infrared rays(IR) reflective undercoating paintings can improve the overall reflectivity of the

[2] The refrigerant gases constitute a major environmental issue of Mobile Air Conditioning, because some were ozone depleting substances (and some are still used in developing countries) and most of them are very powerful greenhouse gases.

car's envelop blind parts by 17%, without changing the final colour of the car, and reducing the need for air conditioning inside the car in the range of 5%.

Even more importantly, part of the vehicle's solar gain passes through the windows. Implementing IR absorbing or even better IR reflective glazing can contribute a lot to the reduction of interior air temperatures, thus reducing the AC system load. A study shows solar energy entering the cabin through glazing can be reduced by 30-40%. Solar control glass can reduce the temperature in the car after parking in the sun by 7°C and reduce AC load in the range of 10% or more.

Another study claims that advanced comfort control in the cars (including IR radiation sensors and algorithms to calculate the real need of cooling) can reduce the MAC system fuel consumption in the range of 15-30%.

iii. Other characteristics

Depending the outside temperatures and humidity levels over the year, there is a wide regional divergence of consumption for achieving thermal comfort in cars.
Technologies have evolved quickly in the past years because of environmental policies. First the MAC industry moved away from the former gases they used (CFCs and HCFCs) because they were harmful to the ozone layer (a move compliant to the Montreal Protocol on phasing out of ozone depleting substances). However in developing countries, the phasing out of ozone depleting refrigerant gases is still underway. Second, refrigerant gases are usually strong greenhouse gases (GHG) accounted in UNFCCC and Kyoto protocol's inventories and now targeted by environmental regulations too (e.g. new EU regulation adopted in 2006 - Directive 2006/40/EC).

There are of course energy implications of changing refrigerants in MAC systems, and there is now a fierce competition between new gases that would fulfil the new EU regulation in the coming years. The challenge is now to have a very low direct contribution to the climate change (in terms of Global Warming Potential – GWP) while ensuring a good level of energy efficiency (and then a low level of fuel use and associated – indirect – GHG emissions).

Chemical companies producing refrigerant products are working on new products with GWP lower than 50. Other companies develop systems using high pressure CO_2 as a refrigerant (also named R744). By definition CO_2 has a GWP of 1. The energy efficiency of these systems will be a key in the competition as in both cases the indirect emissions will probably play the major role in the future because of the lower GWP of the new gases and of the improved sealings of the systems against gas leakages.

This first section on background information provided us with a clear view that providing thermal comfort in cars - especially in case of cooling - is a very complex issue involving comfort science, car parts thermal characteristics, coefficient of performance of MAC systems, efficiency of generating electricity necessary for the MAC systems, etc. Furthermore it is interrelated with other regulatory issues including international ozone depletion policy. Yet there are technologies available to dramatically reduce energy requirements. The next section will analyse how past and forthcoming public policies and private activities have evolved towards efficiency.

b. Current policies and measures

i. Government programmes

1. EU
   After several years of work and negotiations, the EU has introduced in 2006 a new regulation on MAC systems. This regulation focuses mainly on the issue of refrigerant gases and is not directly related to energy efficiency. But it may have implications for energy efficiency and the EU has now announced it would focus on a new directive on energy efficiency of cooling systems for cars. The October 2006 Action plan on energy efficiency includes in its proposed measures: "work towards minimum efficiency requirements for automobile air-conditioning systems (2007-2008)".

2. USA
   The Federal Test procedure FTP-75 used for emissions certifications of light duty vehicles doesn't include the effects of MAC systems operation, as they are switched off during operation. A supplemental federal test procedure called US SC03 has been introduced to represent the engine load and to assess local pollutant emissions associated with the use of air conditioning units in vehicles.

   In December 2006, the US Environmental Protection Agency (EPA) issued a regulatory announcement on new test methods for fuel economy estimates to be introduced in two steps: 2007 and 2010 (that is for model year 2008 and 2011 vehicles). By using the US SC03 fuel use data, the impact of air conditioning on fuel use will be better assessed: it is one of the three main improvements of the tests – together with higher speed/rate of acceleration driving and cold temperature operation – towards a more precise assessment of the real fuel use of the vehicle. The first phase – from model year 2008 cars on – will introduce improved ratios for accounting MAC fuel use, whereas the second phase will introduce a mandatory laboratory measurement of MAC fuel use for new car sold from the model year 2011 on.

   The new test methods for fuel economy window stickers issued by EPA will include simulation of solar gain (through harmonised temperature/humidity conditions and solar radiation simulating lighting facilities). This test methods will capture a realistic estimation of MAC fuel use including most the design options of the car's cooling (e.g. paintings albedo, windshield IR reflectivity, control options...).

3. I-MAC
   I-MAC is an international partnership initiated and administered by EPA. It gathers industries, organisations, governments and other public authorities and aims at investigating and commercialising new MAC technologies saving energy and reducing GHG emissions.
   This technical network allows exchange of information, work sharing for investigating new technologies and testing their efficiency, display of information and advocating of improved products and technologies.

4. UNEP
   The United Nations Environmental Programme (UNEP) has been involved for years in MAC issues, first because of the ozone protection concerns. It has developed knowledge and international partnership with governments, industries and others. Within the framework of common efforts agreed between the Montreal Protocol (on ozone depleting substances - ODS) and the UNFCCC (United Nations Framework

Convention on Climate Change), UNEP now pursues energy efficiency of the MAC systems together with its sustained efforts on ODS phasing out.
In the future, because of surging car ownership rates, developing countries will have huge fuel consumption and GHG emissions related to cooling their cars. Cooperation in the future should include major developing countries as much as possible.

In terms of government policies for "cooling cars" efficiency, the above screening demonstrates that neither effective regulation nor voluntary agreement is in force so far. As have been mentioned, however, various plans do exist.

Before making possible recommendations on such future policies, it is necessary to assess the existing work in terms of standardisation and other industrial activities to improve the efficiency in this field.

ii. Industry activities

1. ISO14505
The ISO 14505 standard provides method for "Ergonomics of the thermal environment -- Evaluation of thermal environments in vehicles". This standard is composed of three documents dealing with the assessment of the thermal stress inside vehicles, the calculation of equivalent temperature and the evaluation of thermal comfort using human subjects.
The standard provides guidelines for the assessment of the thermal conditions inside a vehicle compartment and can be used for inclusion in specific performance standards for testing of ventilation, heating and air-conditioning systems for vehicles.

2. Development of standards for LCCP
Life Cycle Climate Performance (LCCP) is the name of the assessment of both direct and indirect emissions of MAC systems in a common study. Standards and methods to do so vary. Many companies have already performed this kind of analysis, but the results may not be compared because of different assumptions and methods. The SAE (Society of American Engineers) and JAMA (Japan Automotive Manufacturer Association) have agreed to work together to harmonise procedures and propose a new SAE J-standard for estimating LCCP of alternative refrigerants.

iii. Regulatory balances

1. Safety regulations on glazing
For safety reasons, the car glazing must have a high transparency rate (for example, those of new passenger cars in the US and Japan must have a transparency rate higher than 70% and those in the EU 75% or higher). So reducing the solar gain should not reduce too much the transparency to visible light in order to preserve the driver's ability to drive safely. However, due to the fact that IR radiation is responsible for large part of sunshine incoming energy, it is possible to reduce the glazing energy transmission up to 30-40% without reducing the transparency below these thresholds.

2. Direct and indirect emissions of MAC systems
As stated, the refrigerant gases used in MAC systems constitute in themselves a major environmental issue of Mobile Air Conditioning, because some of then - almost phased-out but still used in developing countries - are ozone depleting substances and also because most of them are very powerful greenhouse gases. Gas leakages during operation or maintenance or at the end of the vehicle's lifetime, as well as those relating to manufacturing processes contribute to GHG emissions that are already

addressed by some regulations. As discussed in the previous section, there is a need for a balance between the energy efficiency of the system and its refrigerant gas and related emissions.

3. Air quality inside cars
   In order to reduce the cooling load requirement, it is possible to partly recycle the air inside the car so that less new air has to be introduced - and cooled - into the car. However, the proportion of new air has to remain high enough to ensure air quality inside the vehicle; including preventing CO_2 concentration to rise too much. CO_2 is produced inside the cars by human breath. At higher concentration, it can induce drowsiness.

The review of policies and activities in terms of cooling energy efficiency has shown that a number of initiatives are underway that should be useful to ultimately deliver energy efficiency improvements of the MAC systems and of the overall cooling of the cars. However, these initiatives have not delivered very much so far in terms of effective large scale improvements of the energy efficiency. This would have to be done in the future, especially as the links to other safety or environmental issues discussed above seems to allow a high level of flexibility.

c. Option for the future

i. Possible reduction

As reported, improvement of the MAC systems efficiency can achieve an average 30% in terms of the coefficient of performance. Beside that, advanced control and solar gain reduction (through IR-reflective painting and glazing) can also reduce the need for running the active MAC system. Combined with advanced control options, they can reduce the load to be covered by the MAC system by about 30% in average. This means that technical solution could allow in a near future a reduction of about 50% of the fuel requirements of cooling the new cars.

If the vehicle stock was to be entirely replaced with new cars including these improvements - which could be the case by 2030 -, given the expected increase in global traffic and in LDV fuel use, the yearly energy requirement for cooling cars would increase to about 75 Mtoe if current technologies were to be used at this time. Improvements such as mentioned above may deliver a reduction of fuel use of about half of it, namely 38 Mtoe per year and a 100 $MtCO_2$ emission reduction.

Sound reductions are also possible through raising the awareness of the users and with provision of very simple improvements making it easier for them to save energy:

- Default setting of AC on “off” when starting the car;
- Use simple ventilation whenever possible (e.g. if low external temperature);
- Limit the difference of inside/outside temperature (also for health reasons);
- Built-in solar screens.

ii. Possible policy recommendation

Compared to tyres that have a significant replacement market and that one could find in retail stores, air conditioning systems are not very visible to the end user, nor do they directly intervene in the process of maintenance or replacement. Hence the displaying of information to consumers can hardly be undertaken by an energy label on the equipment or in the stores as could be the case for tyres. On the other hand, clear information on the Cooling efficiency could be introduced in the information displayed to consumers - in commercial material, in the retail places or directly on the cars windows - at the time people need to buy new cars.

1. Countries could adopt test procedures which include effects of cooling on the fuel efficiency measurement of the car. This could include:
   1.a. Introducing procedures to have the MAC system running during the dynamometer tests (that is what US-EPA is planning for fuel economy estimates, which are posted on window stickers).

   1.b. Developing harmonised procedure to test MAC components and MAC systems efficiency in laboratory conditions.

2. With provision of the later, countries could introduce Minimum Efficiency Performance Standards on components (the EU is considering this in its 2006 Energy Efficiency Action Plan).

3. With provision of the 1., countries could introduce a mandatory display of information on cooling efficiency in the current consumer information regulations (e.g. windows sticker regulation in the US, EU directive 99/94/EC).

4. Countries could promote simple solutions to reduce the cooling needs inside the vehicles (raising the awareness and technical provisions as listed in the paragraph i above). Communication campaigns, voluntary agreements or even regulation could be used to do so.

4. LIGHTING

a. Basic information

i. The energy used and CO_2 emitted by components

According to the recently published IEA book "Light's labour's lost" (IEA 2006, p.242, 245), lighting applications of road vehicles[3] account for 3.2% of all road vehicle energy use. Because of the very poor yield of the engines and alternators, the energy use by vehicle lighting accounts for a surprisingly high share of global oil demand: 1.4%. This is equivalent to 48 Mtoe per year and leads to the emissions of over 130 $MtCO_2$ per year. Furthermore, energy use for vehicle lighting is rising, due to three sorts of upward pressure. First, the global vehicle fleet is set to grow by 70% to 2030 from 1044 million vehicles in 2005. Second, the number and power of lights per vehicle is increasing. Third, many countries are introducing legislation requiring headlamps to be on during the daytime in response to safety data which has shown that a significant proportion of head-on collisions can be avoided by making vehicles more visible in the daytime.

ii. Technology

External lighting applications for road vehicles fulfil mostly driving and safety needs. From the signalling functions such as warning signs and stop lights, to night driving

[3] All road vehicles are taken into account here (including minibuses, buses, trucks, 2 and 3 wheelers). However, the lighting sources inside the vehicles are not considered (except dashboard lighting).

lighting functions and fog lamps, there is a wide variety of different applications and uses for lighting in road vehicles. Several factors determine the amount of lighting used by road vehicles. First the number of vehicles and the distances they travel, second the number and output of their lighting equipment, and finally actual use of these equipments.

Classical and halogen incandescence represents the first used technology in vehicle lighting applications: it is poorly efficient, even when implemented in a way to maximise its efficiency (ranging from 12 lm/W for inefficient classical incandescence to about 24 lm/W for good halogen lamps). Furthermore, for a lot of automotive applications, trade-offs have to be made in order to better fulfil other requirements such as longer lifetime, robustness, sustain short switching on and off cycles, loss of efficiency because of colour filters…
Some other technologies are either present or being currently introduced on the market. Amongst these are High intensity discharge (HID) lamps that already achieve a level of efficiency of 100 lm/W but are only relevant for high output applications (headlamps). There are also Light Emitting Diodes (LED), a quick evolving technology thought to achieve a 100lm/W efficiency within the 5 coming years (from 40 to 60 lm/W today depending the application).

iii. Other characteristics

The market is composed of a variety of different products, in terms of output (ranging from the couple of watts of dashboard lighting to 65W of each of the incandescent high beam projector), in terms of colour (amber, white, red) and pattern of use. Different technologies may be applied depending on these factors. For example, the LEDs are now competitive for low output applications (turn signals, stop lights, dashboard, etc.) but still need developments and cost reduction to widely spread in the front lighting market. In contrast, High Intensity Discharge (HID also called “Xenon”) lamps already equip a fast growing number of models for front lighting partly because they have a very high efficiency (100lm/W) but cannot be used for much lower outputs.

It is worth noting that, in contrast with the general belief, headlamps do not account for the majority of the energy use of road vehicle lighting. Other applications have much lower outputs, but they are numerous and have lower efficiency. For light-duty vehicles, headlights account for 43% of the total lighting related energy consumption, for truck 35% for two- and three-wheelers more than half. It is therefore necessary to study a much broader set of applications and technologies to cover the full range of possible improvements in the fuel use of road vehicle lighting. Another issue that is worth stressing is the cost of electricity used in cars. Due to the high price of the fuel and to the low yield of the engines (15-25%) and of the alternators (about 50%), the price of electricity as produced inside road vehicles is very high. Depending the countries, it ranges from about 0.4 to 1.25US$ per kWh. That is about four to ten times more expensive than the electricity delivered by the grid in homes.

The situation for lighting is quite similar to tyres and cooling technologies. It represents a significant part of the road vehicle fuel use (roughly 3% compared to 5% for cooling and 20% for tyres) and technologies are available to dramatically reduce the associated fuel requirements. It is therefore useful to review existing initiatives from both governments and the industry in order to understand if some recommendations could be considered there too.

b. Current policies and measures

i. Government programmes

Current regulatory consideration in the EU, namely the mandatory use of low beams (or dipped headlamps) during daytime for safety reasons may have the effect of increasing the energy use of road vehicle lighting. Such regulation is already in force in e.g. Scandinavia countries, Ireland, Canada.

Provision to ensure safety while reducing impact on energy use was introduced as early as 1989 in Canada –at the same time as the mandatory use of headlamps during daytime was introduced. New cars sold there have since then been equipped with automatic systems ensuring visibility through front lighting while reducing energy requirements (namely Daytime Running Lamps – DRL see below).

Some governments are for the time being considering actions to phase out inefficient incandescence light sources (Australia, California, Ontario, Cuba...). Automotive lightings has not been specifically targeted so far, but high cost of generating electricity necessary for them, as well as the surge of alternative solutions may push authorities to do so in the future.

Except for the Canadian mandatory provision ensuring energy efficiency of the automatic daytime switch-on of head lighting, no active government policies are reported in terms of energy efficient road vehicle lighting.

ii. Industry activities

1. New developments in LEDs
A number of car manufacturers have introduced LED lighting fixtures in their models lately, first on high end vehicles. First moves concerned rear/tail lamps and stop lights, as the red LEDs were among the cheapest and most efficient ones. Other applications are being developed, e.g. DRL, direction indicators. Research for wide deployment is still underway for headlamps.

2. New developments in HIDs
The use of HID technology for high output lighting applications (namely front lighting) is spreading. It used to be a feature of high-end vehicles about 10 years ago. It is now common on a much wider range of models, depending on the manufacturers.

3. Daytime Running Lights (DRL)
Canada's 1989 decision to make the use of front lamps mandatory during daytime for safety reasons was accompanied by a regulation to equip the cars with automatic systems to provide front lighting while the engine is running. These lights are meant to produce a gentle luminescence that ensures visibility without excessive glare for on-coming traffic. Side and tail lighting devices are supposed to be off during this automatic daytime operation. Further to this improvement, SAE developed in 1991 the definition of DRLs in the technical document J2087, introducing the possibility for manufacturers to equip the road vehicles with Daytime Running Lights in northern America. UNECE did the same later for a lot of countries in Europe and other parts of the world.

DRLs can consist of any of the following:

- The use of low beams which would simply be automatically switched on with the engine, sometimes with a lowering of voltage to save energy,
- The use of the regular high beams (also called headlamps on full beam) automatically switched on with the engine, and in all cases provided with lower voltage to prevent glare.
- Adding specific headlights dedicated to daytime use, also switched on automatically. These lamps can be mounted in the same headlight fixture as the other head lamps or in a separate fixture for example lower on the front shield.
  Note that the two former approaches can be easily implemented on existing cars as they use the existing lighting facilities. For all three of the above cases the manual switch to regular night time head light use overtakes the DRLs; the tail lights and other night use related lights are switched off during DRL operation

The industry activities have allowed the development of new efficient lighting. However, solutions in terms of fuel efficiency are far from being widespread on the market and further developments are needed taking into account possible trade-offs with other policies analysed in the following section.

iii. Regulatory balances

1. Road safety and energy use of vehicle lighting
   For safety reasons, the light application of cars should not be stemmed or reduced without much circumspection. The general trend is to add new lighting safety applications, especially in developing countries where the safety applications are not yet widely spread in the vehicle stock. Beside this, the use of front lights during daytime is a spreading recommendation and is even mandatory in a number of countries. In general, the safety issue makes it difficult to reduce lighting outputs. However, energy efficiency of the lighting sources and of luminaries allows high rate of improvements in the vehicle lighting energy use.

2. Using front lamps during daytime
   On the one hand road safety specialists conclude that using front lighting of vehicles during daytime would provide a significant improvement in crashes and fatalities, but on the other hand the fuel use impact could be high if cars and other road vehicles continue using the existing lighting design and technologies. DRLs are a sound response to this possible increase in fuel requirement of lighting, as they allow a reduction of 50% of the power needed to provide front lighting during daytime compared to manual switch of low beams.

3. Debate on DRL mandatory equipment
   There is a debate in several countries and also for EU as a whole about the introduction of mandatory use of headlamps during daytime for safety reasons. The additional energy consumption it would induce is one of the strongest arguments again such regulations. On the other hand, mandatory equipment of cars with DRL could reduce this additional consumption. Furthermore, in some EU countries headlamp use during the day is already mandatory. There, the provision of DRLs would reduce the additional fuel use. The work done by the IEA in Light's Labour's Lost clearly demonstrates that the overall road vehicle lighting fuel use can be dramatically reduced globally (by 70% in 2020 - comparison of the REF and EET scenarios), even with introduction of mandatory DRLs (-64% in this case).

However, there is another reason why some people oppose the regulatory use of DRLs for cars. In most countries motorbikes are already equipped with DRLs that add to the visibility and safety of the bikers. Some bikers associations believe that having cars equipped with DRLs as well would reduce their (relative) visibility on the road, hence reduce their safety.

Some specialists answer that from a purely physiologic point of view, this is not true: the visibility of a vehicle would not be reduced in itself by increasing the visibility of others to the same level. From their view, things would be different if there was a need to recognize a vehicle type from another. The question to be raised would then be: why would the bikers want to be recognized as such in the traffic? One possible answer is that they have a different behaviour, e.g. higher speeds, overcoming in road sections where cars wouldn't overcome, slaloming in heavy traffic conditions. As these behaviours are contradictory with safety rules, they would say it would be difficult to take the relative visibility argument into account.

Since there are different views on this issue, further discussion among the stakeholders would be necessary.

While road safety clearly has to be the first priority in terms of public policy, the screening of regulatory balances above clearly states that a lot can be done for energy efficiency without really hampering the safety.

c. Option for the future

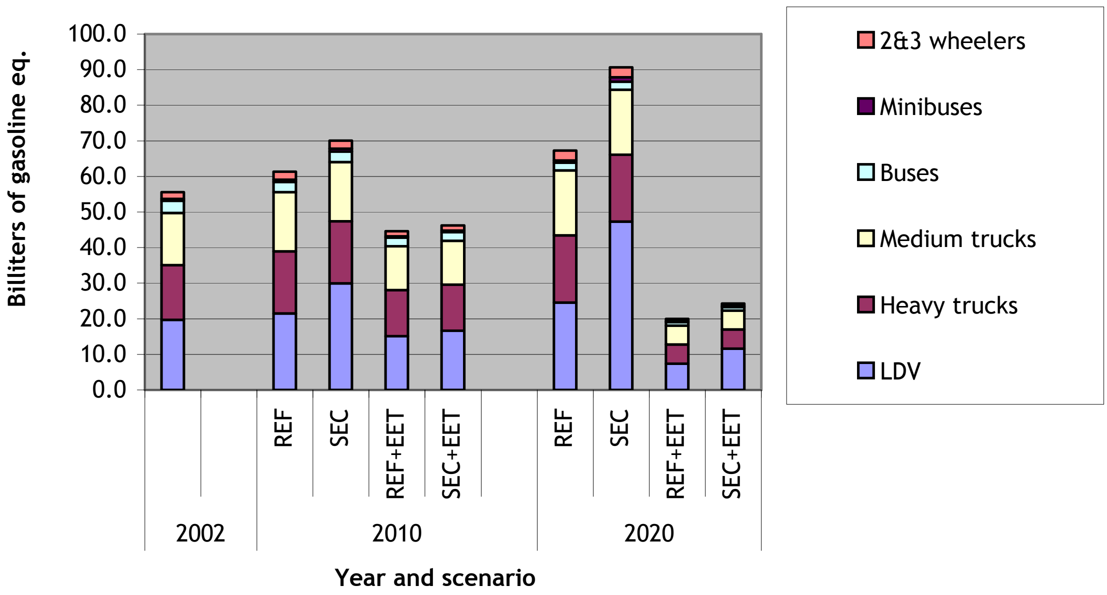
i. Possible reduction

The calculations performed at the IEA in preparation of Light's Labour's Lost book provide a good overview of the possible reductions in the fuel requirements linked to the road vehicle lighting operation. Four different scenarios were used and compared, of which some include quicker penetration and development of new Energy Efficient Technologies (EET and SEC+EET) and some include a more general requirement to use front lamps during daytime for security reasons (SEC and SEC+EET). Would there be new regulations on daytime use of lighting or not, implementing and developing the technology allows in 2020 more than 70% reduction in lighting fuel requirement in both cases compared to their respective baseline.

In the case of stronger regulations on daytime use of lighting, the amount of energy saved would reach 66 billion litres of gasoline equivalent per year that is 55 Mtoe and CO_2 emissions of 155 $MtCO_2$. In case of constant regulations of daytime lighting use, these would represent respectively 47 billion litres, 39 Mtoe and 105 $MtCO_2$ by the year 2020. Building up on these figures, we can evaluate the effect by 2030 with an extrapolation of the trend based on the road vehicle traffic increase between 2020 and 2030 (roughly +15% for cars and +25% for trucks). The result for 2030 is 45 Mtoe and 120 $MtCO_2$ for all road vehicles.

The EET scenarios assume that all incandescence lighting sources are replaced by HID and very efficient LED technologies so that all lighting applications can reach 100lm/watt. The efficiency improvement is supposed even higher for coloured applications (stop lamps, side markers, indicators...) as the direct emission of the correct colour by LEDs cancels the losses in colour filters.

Figure 4: World lighting fuel use - road transportation



It is also assumed in EET and SEC+EET that it is possible to produce 18 W xenon HID lamps that have the same light output as a standard halogen headlamp of today but require one-quarter of the power; this compares to the typical 35 W xenon HID lamp available today, which provides twice the light but requires nearly half the power of a standard halogen headlamp.

For DRLs, the assumption is that very low power devices will soon be available on the market in EET scenarios. Given the lighting output required for DRLs, which is much lower that the output of regular headlamps, it is assumed here that very efficient future LEDs will be able to equip DRLs with less than 10W consumption.

ii. Possible policy recommendation

The incandescence technology can already be replaced in most cars lighting applications, either by LEDs (at least for low output applications) or by HID technology (for highest output applications - namely headlamps). With the current development of more efficient, more powerful and cheaper LEDs, provided progress continues sufficiently, almost all incandescent light could be replaced at a competitive life-cycle cost (including purchase, energy use and replacement). On the other hand, lighting manufacturers announced groundbreaking improvements in the incandescence technologies, including the possibility to reach up to 40lm/W with new light bulbs. In this context more than ever, energy efficiency should be pushed through performance requirements rather than through technology description.

To foster this change in the market, governments could:

1. Develop harmonised test procedures which include lighting fuel use.
2. Introduce Minimum Efficiency Performance Standard for lighting applications (with minimum requirements in lumens per Watt that would be progressively strengthened in time).
3. For countries adopting mandatory daytime use of headlamps, adopt at the same time a regulatory requirement of DRLs on new cars.
4. With provision of the 1., introduce a mandatory display of information on lighting efficiency in the current consumer information regulations (e.g. windows sticker regulation in the US, EU directive 99/94/EC).

Similarly to MAC systems, lighting fixtures and lamps are very rarely purchased, installed or directly maintained by consumers. Therefore it doesn't seem relevant to push for labelling schemes on vehicle lighting per se. Nevertheless, it would be useful to include a standardised mention of lighting efficiency in the mandatory information provided to the consumer, e.g. within the framework of existing obligations in this field.

Box: Improving vehicle fuel efficiency through behavioural changes

Not only technologies but also driving styles bring in large variations in on-road "real" fuel efficiency. The International Transport Forum (former European Conference of Ministers of Transport) categorizes measures that can stimulate vehicle fuel efficiency into the following three types.

Type 1 - technical adaptations in vehicle design, such as downsizing, engine port injection, direct injection, hybrid drives, etc.
Type 2 - behavioural changes in driving, i.e. more fuel efficient driving.
Type 3 - behavioural changes in purchasing automobiles (consumers switch to smaller or lighter or more fuel efficient vehicles such as diesel engines).

And now, it is widely perceived that although policies to accelerate technical adaptations (type 1 measures) can potentially deliver more improvement in fuel efficiency and, therefore, has been focused on so far in this paper, promoting more fuel efficient driving generally tend to be more cost effective than type 1 measures.

European governments have been focusing on the issue of energy-efficient driving. They have implemented several programmes to support techniques of more efficient driving, or "Eco-Driving" as defined in European countries such as Netherlands, Sweden, Germany and Hungary. The Dutch programme seeks to influence the drivers, the trainers of drivers, and other decision makers. Activities that have contributed most to CO_2 emission reductions included (i) the implementation in driving school curricula, (ii) public campaigns to reach existing drivers, (iii) subsidized activities to reach professional drivers, and (iv) financial incentives for in-car devices. Between 200 and 2004 the cost efficiency of the "Eco-Driving" programme for end users ranged from -€234 to -€414 per avoided ton CO_2 emission. The negative costs of conserved carbon can be explained by the high value of the fuel savings as a result of the implementation of "Eco-Driving" and relatively low investments by car owners for in-car devices. Cost efficiency for *society* is estimated from -€105/ton to €73/ton avoided CO_2 emissions.

A Japanese programme called the Eco-driving Management System or EMS also aims to promote more efficient driving by the combination of driver education and utilization of kinds of sophisticated digital tachograph-like devices. 13 transportation companies participating in the programme in 2006 showed an average improvement of 8% of CO_2 reduction with 20% as the top score.

In the US, EPA has established in 2004 a voluntary collaboration programme with the freight industry called the SmartWay Transport Partnership. The goal of the programme is to reduce fuel consumption as well as pollutant air emissions from commercial transportation. By 2012, the programme aims to save between 3.3 and 6.6 billion gallons of diesel fuel per year. In accordance with the "Energy Policy Act of 2005," EPA developed a national loan programme for trucking fleets to enable them to adopt fuel-saving technologies including idle reduction technologies and low RR tyres. EPA also conducted testing on several of the most promising emerging technologies such as single-wide low RR tyres. To date, commitments from nearly 500 partners will result in annual fuel savings of over 218 million gallons per year.

One of the challenges to these programmes could be to have steady and continuing realisation of the effect. Drivers who have participated in these programmes are generally surprised when they find how effective the acquired efficient driving is to improve their fuel economy. The same drivers, however, could find several months later that such driving style rarely takes root firmly.

Technologies to increase the chances for those drivers to make their acquired new driving style established are already on the market. Those technologies include:

- Fuel consumption meter
- Gear Shift Indicator
- Telematics

5. CONCLUSION

There are significant energy savings potentials in the transport sector. Achieving such savings requires urgent policy attention. Implementation of appropriate mandatory fuel efficiency standards for cars and small trucks (light-duty vehicles) in all countries is a necessary condition for achieving the significant energy savings in this sector. However, additional measures are also needed to realize the savings.

Roughly 20 percent of a motor vehicle's fuel is used to overcome RR of tyres. Additionally nearly 10 percent fuel is consumed for the other accessories including those for cooling and lighting addressed in this paper. The automobile components, therefore, have high potential for reduction of fuel consumption and CO_2 emissions. There is now consensus that aggressive policies for promoting the deployment of fuel-efficient tyres and proper tyre maintenance, while maintaining safety and so forth, can achieve as much as a 5% reduction in overall vehicle fuel consumption. Fuel efficiency policies for cooling cars and vehicle lighting combined could be as effective as the policies for tyres. The following chart sums up the potentials calculated in the earlier chapter of this study for each type of components.

Figure 5: Potential energy savings and CO_2 emission reductions of non-engine components

	Tyres	Cooling	Lighting
Vehicles addressed	All road vehicles	Passenger cars only	All road vehicles
Consumption in 2004 (Mtoe)	300	50	48
Potential energy savings by 2030 (Mtoe)	70-120	38	45
Potential CO_2 emissions reductions by 2030 ($MtCO_2$)	190-320	100	120

Total possible energy savings for the three addressed components reach 153 to 203 Mtoe, which corresponds to a reduction of CO_2 emissions of 410 to 540 $MtCO_2$. That is about 6 to 8% of the road vehicle energy use and greenhouse gases emissions in 2030.

The issue of raising energy efficiency of these components, however, often tends to receive low priority in consumer information programmes. This is partly because government responsibility for the components is often widely dispersed among ministries of transportation, industry, and environment.

The IEA thought specific, high-level actions were justified and recommended an action on fuel efficient tyres to G8 leaders in 2006. This recommendation was based on international best practice and consisted of two elements: maximum allowable levels of rolling resistance for major categories of tyres; and measures to promote proper inflation levels of tyres. The St Petersburg G8 communiqué reiterated that the issue should be investigated further.

Automobile industry and automobile component industry are global industries. Therefore, experts have reached a consensus that international perspectives including international test procedures are necessary, at least for effective deployment of fuel efficient tyres and cooling systems. Following this, many activities on international test procedures such as those for maximum level of tyre RR, and international regulations such as those for compulsory fitting of tyre pressure monitoring devices can be expected at international fora including the International Standard Organization and UNECE/WP29.

Given the above mentioned facts, The IEA recommends that governments should consider adopting new international test procedures for measuring the rolling resistance of tyres to set maximum rolling resistance limits and for road-vehicle tyre labeling. In addition, all governments, in cooperation with international organisations including UNECE/WP29, should consider making the fitting of tyre-pressure monitoring systems on new road vehicles mandatory.

“Similar conclusions could be drawn for the other components addressed in this paper. However, each of these components do not have as much fuel savings and CO_2 emission reduction potentials as tyres and, unlike tyres, these components are generally only chosen by vehicle manufacturers, not by customers, limiting the effectiveness of component labeling to raise customer awareness.

Therefore, the IEA does not propose that policy effort in cooling and lighting be pursued as a matter of priority at present. Future analysis of vehicle cooling and lighting may be useful as other high-priority options are exploited.

However, the fuel saving and CO_2 emission reduction potential of these components are not trivial. Policy options exist, including minimum efficiency performance standards, adding specific information in the consumer information schemes (e.g. windows sticker in the US) that seem to be applicable to all the components addressed here. There are also specific options for each of the components (e.g. improved control for cooling). Some governments might find it useful to intervene in these areas.

CLOSING REMARKS

Implementing measures for the deployment of fuel-efficient tyres and other components has a huge fuel saving and CO_2 emission reduction potentials. Appropriate government intervention is the key to realise them and should be made at the earliest opportunity. Therefore, the IEA will cooperate with governments to tackle this issue.

The IEA will also play several roles on this issue. Since components are internationally traded products, the IEA will collaborate with related international organizations including UN/ECE/WP29 and ISO, especially for tyres at first.

In addition, since developing countries will account for the majority of growth in fuel consumption, attention should also be paid to these countries. The IEA will seek a possibility to collaborate with relevant stakeholders on this issue as well.

If further work was to be decided on cooling cars, it should include cooperation with UNEP.

Finally it should be reiterated that improving driving behaviours including proper and diligent tyre maintenance can have a significant impact on “real” on-road fuel efficiency and instantly. As is mentioned above, it is now widely accepted that promoting more fuel efficient driving tends to be even more cost effective than policies in vehicle design. In this regards, the IEA will hold a workshop on eco-driving later this year.

ANNEX A: G8 ENERGY EFFICIENCY ACTIVITIES AT THE IEA

Founded in 1974 by several member states of the OECD, the IEA established three strategies of energy use in response to OPEC oil embargos. Along with energy diversification and strategic, coordinated oil stock management, energy efficiency was one of three original missions. In the three decades since, the IEA has broadened the scope of its work. G8 leaders at Gleneagles in July 2005 and in St. Petersburg in July 2006 called on the IEA for "advice on alternative energy scenarios and strategies aimed at a clean, clever and competitive energy future". In order to properly response to the requests from G8 leaders, the IEA has launched, among other activities, study on policies for "transforming the way we use energy" focusing on end-use efficiency including the one in transport sector.

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