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Deploying Climate-Related Technologies in the Transport Sector:

Exploring Trade Links

By Rene Vossenaar,
Independent Consultant

ICTSD
International Centre for Trade
and Sustainable Development

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ICTSD welcomes feedback on this document. These can be forwarded to Joachim Monkelbaan, jmonkelbaan@ictsd.ch

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LIST OF ABBREVIATIONS AND ACRONYMS

AEV	All-Electric Vehicle (AEV)
AFDC	Alternative Fuels and Advanced Vehicles Data Center (US Department of Energy).
AFV	Alternative fuel vehicle
AHSS	Advanced high-strength steels (AHSS)
ARRA	American Recovery and Reinvestment Act
ASI	Avoid-Shift-Improve
BAT	Best available technology
BEV	Battery electric vehicle
BTL	Biomass-to-liquids (fuels)
CBU	Completely built up
CKD	Completely knocked down
CN	Common nomenclature (European Union)
CNG	Compressed natural gas
CTF	Clean Technology Fund
CVT	Continuously variable transmission
DOE	Department of Energy
EE	Energy efficiency
EPA	Environmental Protection Agency
EPAct	Energy Policy Act (United States)
ETP	Energy Technology Perspectives (published by the IEA)
EV	Electric vehicle
FCV	Fuel-cell vehicle
FFV	Flex-fuel vehicle
GHG	Greenhouse gas
GVW	Gross vehicle weight
GW	Gigawatt (1000 MW)
HDV	Heavy-duty vehicle
HSS	High-strength steels
HTSUS	Harmonized Tariff Schedule of the United States
HVO	Heavy fuel oil
IANGV	International Association for Natural Gas Vehicles
ICE	Internal combustion engine
IEA	International Energy Agency
IPCC	Intergovernmental Panel on Climate Change
ITF	International Transport Forum (an organization within the OECD)
Ktoe	Kilo tonnes of oil equivalent
LPG	Liquefied petroleum gas
MEPS	Minimum energy performance standard
MW	Megawatt
NAMAs	Nationally appropriate mitigation actions
NGV	Natural gas vehicle
LDV	Light-duty vehicle
LRR	Low rolling-resistance (tyres)
OICA	International Organization of Motor Vehicle Manufacturers (“Organisation Internationale des Constructeurs d’Automobiles”)
PHEV	Plug-in hybrid electric vehicle
PV	Photovoltaic
RE	Renewable energy
RS	Reference scenario (IEA in WEO-2009)
WEO	World Energy Outlook
WITS	World Integrated Trade Solution (World Bank software)

FOREWORD

Environmental goods and services (EGS) as a subset of goods and services was singled out for attention in the negotiating mandate adopted at the Fourth Ministerial Conference of the World Trade Organization (WTO) in November 2001. Increasing access to and use of EGS can yield a number of benefits including reduced air and water-pollution, improved energy and resource-efficiency and facilitation of solid waste disposal. Gradual trade liberalization and carefully-managed market openings in these sectors can also be powerful tools for economic development as they generate economic growth and employment, enable the transfer of valuable skills, technology, and knowhow, all of which are embedded in EGS. In short, well-managed trade liberalization in EGS can facilitate the achievement of sustainable development goals laid out in global mandates such as the Johannesburg Plan of Implementation, the UN Millennium Development Goals and various multilateral environmental agreements.

This paper focuses on liberalizing environmental goods (EGs) in the transport sector. The reduction or removal of trade restrictions affecting transport-related EGs supports the deployment of climate-related technologies and allows for easier and less costly access to equipment needed to make transport more sustainable. A review of a range of technology options for reducing energy use and emissions in transport reveals that negotiations on EGs may, in theory, be relevant for the implementation of only some of these technology options: certain alternative fuel vehicles (AFVs), certain components used in AFVs (such as batteries used in electric cars) and alternative fuels (such as biofuels). With regard to non-technology options, some WTO members have proposed that specific types of equipment used in public transport and bicycles could be included in the negotiations (with a view to facilitating shifts to more sustainable modes of travel).

In order to properly understand the possible contribution that the environmental goods and services (EGS) negotiations in the WTO could make to sustainable transport strategies, this paper addresses a number of questions: What trade issues are involved in the deployment of climate-related transport technologies? What EGs can be identified in the transport sector? Do tariffs and NTBs affect international trade in these products? Will trade liberalisation alone support the deployment of climate-friendly technologies and products to developing countries? What are the key issues to be considered by governments in assessing the pros and cons of liberalising trade in specific EGs? Also discussed in this paper are issues related to tariff classifications. The analysis in this paper focuses on specific trade-related issues involved in the deployment of climate-related technologies in the transport sector rather than on the much broader theme of sustainable transport strategies.

This paper highlights three sets of issues.

First, issues related to trade in biofuels are of key significance, especially from the perspective of trade negotiations.

Second, it is important to determine when trade liberalisation can contribute to the deployment of alternative fuel vehicles. The effective deployment of certain AFVs (such as plug-in hybrid electric vehicles (PHEVs), electric vehicles (EVs), and hydrogen fuel-cell vehicles (FCVs)) requires a strong enabling environment such as extensive investments in new infrastructure and fuel delivery systems, as well as coordinated approaches at the national level.

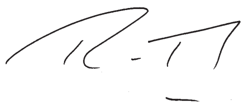
Third, this paper clarifies the role of subsidies and other incentives and their potential trade implications. Subsidies and other incentives currently play a large role in supporting the deployment of AFVs (and components such as advanced batteries). Subsidies may be justified when very efficient AFVs require support to overcome market barriers in order to become competitive with conventional, less efficient vehicles. However, subsidies may also pose risks if they affect conditions of competition and result in trade friction.

Mr. Rene Vossenaar is from the Netherlands and presently lives in Brasilia, Brazil. He worked for the Economic Commission for Latin America and the Caribbean (ECLAC) and also served as the Head of the Trade, Environment and Development Branch at the United Nations Conference on Trade and Development (UNCTAD). Since his retirement in March 2005, he has carried out work for UNCTAD and other institutions as an independent consultant.

The paper is part of a series of issue papers commissioned in the context of ICTSD's Environmental Goods and Services Project. This project aims to enhance developing countries' capacity to understand trade and sustainable development issue linkages with respect to EGS and reflect regional perspectives and priorities in regional and multilateral trade negotiations.

This assessment of the transport sector complements earlier papers on climate-friendly goods in the energy supply and buildings sectors. One key objective of these studies is to enhance public understanding of the possible contribution that WTO negotiations on EGS could make to climate mitigation.

We hope you will find this paper to be stimulating and informative reading and useful for your work.



Ricardo Meléndez-Ortiz
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EXECUTIVE SUMMARY

Based on a mapping of different technology options for increasing fuel efficiency and reducing GHG emissions in the transport sector, this paper analyses how the WTO negotiations on environmental goods (EGs), which form part of the EGS mandate, could contribute to the deployment of such technologies.

The analysis largely focuses on road transport. Product categories that may, in principle, be characterised as EGs include alternative-fuel vehicles (AFVs), certain components used in AFVs (such as batteries used in electric cars) and alternative fuels (such as biofuels). Some WTO members have proposed that certain types of equipment used in public transport as well as bicycles could also be considered EGs. This paper, however, focuses on technology options.

This report pays special attention to vehicles with an electric motor, including hybrid-electric vehicles (HEVs), plug-in hybrid electric vehicles (PHEVs) and all-electric vehicles (AEVs). Hydrogen fuel-cell vehicles (FCVs) may be produced commercially beginning around 2020. Other AFVs include flexible fuel vehicles (FFVs), clean-diesel vehicles, liquefied petroleum gas (LPG) vehicles, and vehicles that run on natural gas (NGVs) or biomethane (biogas).

In theory, the elimination or reduction of tariffs and NTBs could contribute to the diffusion of AFVs worldwide by reducing their costs in the domestic market. However, trade liberalisation alone is unlikely to have a significant impact on the penetration of AFVs into automobile markets.

There is a strong case for eliminating distortions in trade in those biofuels that contribute to net GHG savings on a life cycle basis (such as sugar cane ethanol). However, there is uncertainty regarding the net GHGs savings in the case of other first-generation biofuels (the biofuel versus food issue is also a matter of concern). Gaining policy support for trade liberalisation in biofuels may require certainty that biofuels do, in fact, contribute to GHG reductions on a life-cycle basis. Biofuel certification may help provide such assurance, but may also act as an NTB.

This paper provides examples of policies and measures aimed at improving the efficiency of transport modes by supporting the deployment of climate-friendly technologies. Regulatory measures and incentives play a key role. Subsidies play a fundamental role, particularly in the development of battery technologies and the deployment of PHEVs and EVs. Subsidies consist of both market-creation measures (e.g. subsidies for the purchase of an AFV) and measures to support investments in manufacturing capacities. The latter may include tax credits, grants and low-interest loans. Subsidies may be justified when very efficient AFVs need support in order to overcome market barriers, allowing them to become competitive with conventional, less efficient vehicles, though there may be certain risks associated with this type of subsidisation. Both the United States and Chinese governments are actively promoting their domestic PHEV and AEV industry.

By December 2009, there were more than 35 million alternative-fuel and advanced-technology vehicles operating worldwide (Wikipedia). The largest category is FFVs; there are also large numbers of HEVs, NGVs and LPG vehicles. In some cases the number of AFVs actually using the alternative fuel may, in fact, be much smaller. For example, many owners of bi-fuelled and flex-fuelled AFVs (which can run on either conventional or alternative fuels or a combination of both) do not run their cars on alternative fuels, especially where alternative fuelling facilities are not available.

The world biofuels market has been estimated at USD 45 billion in 2009 (based on ethanol and biodiesel production and wholesale prices), an increase of 29 per cent compared with 2008 (Clean

Edge, 2010). World production of fuel ethanol reached an estimated 74 billion litres, an increase of more than 10 percent over 2008. Several countries apply high MFN rates of duty to ethanol imports (MFN applied rates on biodiesel are much lower). Standards and certification requirements may also affect markets for biofuels.

Although many of the different options identified in the technology mapping study for the transport sector may have significant implications for international trade, it is very difficult to link these options with international trade statistics. Only in a few cases is it possible to use existing tariff classification for analysing links between climate-related technologies in the transport sector and international trade flows. These include certain categories of AFVs (such as PHEVs and AEVs), batteries used in electric cars and biofuels. However, even in these cases it is not possible to identify the relevant products in dedicated 6-digit HS codes. To help address this problem, the reference is made to national and regional schedules that define more detailed items. However, several AFV categories (such as PHEVs and AEVs) and batteries used in electric vehicles are only starting to be commercialised and current international trade is still insignificant.

In some cases, national or regional (EU) authorities have already taken or are considering steps to add specific subheadings to the common 6-digit HS codes in their national or regional tariff schedules. As of 1 January 2012, the HS will have a new heading for biodiesel in Chapter 38 (heading HS 38.26). With the growing importance of government policies to support EVs and PHEV and the expected increase in market shares in alternative policy scenarios, it may be desirable in the future to consider possibilities for creating more detailed tariff lines at national and regional levels, or perhaps even at the 6-digit HS level.

Apart from the elimination of distortions affecting trade in those biofuels that contribute to net GHG savings on a life cycle basis, trade liberalisation alone may not have a significant impact on sustainable transport development. Certain (autonomous) trade liberalisation measures may effectively support the implementation of specific projects and programmes resulting from wider sustainable transport strategies at the national or sub-national (e.g. city) levels (which may go beyond the consideration of technology options and take into account the ASI framework for exploring options for reducing transport GHG emissions). It may be worthwhile to explore whether trade liberalization might play a role in supporting the implementation of certain transport-related CDM projects or nationally appropriate mitigation actions (NAMAs).

1. INTRODUCTION

The ICTSD Global Platform on Climate Change, Trade, and Sustainable Energy (the Global Platform) has commissioned a series of studies on the linkages between the deployment of climate-related technologies and international trade issues. The studies focus on the renewable energy (RE) supply sector and technology options for reducing CO_2 emissions in two end-use sectors: (i) residential and commercial buildings and (ii) transport. For each sector the Global Platform has commissioned a technology mapping study and a paper exploring links between the deployment of climate-friendly technologies and international trade. The objective is to support public understanding of the possible environmental, trade and developmental implications of the WTO negotiations on Environmental Goods and Services (EGS) – as far as they relate to climate change.

This paper explores possible links between the deployment of climate-related technologies in the transport sector and international trade. Based on a mapping of different technology options for increasing fuel efficiency and reducing GHG emissions in the transport sector, this paper analyses whether and how the WTO negotiations on environmental goods (EGs), which form part of the EGS mandate, could contribute to the deployment of such technologies, particularly in road transport.[1] This paper argues that certain alternative (i.e. other than petroleum-based) fuels and alternative-fuel vehicles could, in principle, be characterised as environmental goods in the context of EGS negotiations.

Apart from technology options for improving the efficiency of transport modes, other strategies for reducing transport GHG emissions may also lead to the identification of transport-related environmental goods.[2] For example, some WTO members have proposed using the EGS negotiations to support trade in components used in public transport, railway equipment (to promote a shift from road and air transport to a generally more efficient mode) and bicycles (to promote a shift to non-motorised travel mode). This report, however, focuses on technology options..

Technology options

The transport sector encompasses different subsectors (or modes of transport): road transport, rail transport, aviation and shipping. This paper focuses largely on technology options for reducing CO_2 emissions, notably in road transport. There are several reasons for this. First, road transport is responsible for almost three quarters of the transport sector's total CO_2 emissions and offers the largest potential for future CO_2 savings. Second, international trade in motor vehicles for road transport (and their parts) is much larger than trade in equipment used in the railway, aviation and shipping subsectors. Third, the WTO negotiations on environmental goods (EGs), which form part of the EGS mandate, are unlikely to have implications for technology deployment in the latter modes of transport.[3] Tariffs applied in the railway, aviation[4] and shipping subsectors are, in general, very low. The introduction of new transport equipment in these subsectors generally requires large investments (including in infrastructure) and often implies government involvement. Also, due to the very long total life span of locomotives, airplanes and ships (and their engines), there are less opportunities to improve emissions performance through the introduction of newly-manufactured (and generally more efficient) units than there are in vehicles.

There are many technology options for reducing energy use and emissions in road transport, but negotiations on EGs may only be relevant for some of them. Further improvements of internal-combustion engines (ICEs) and non-engine technologies may result in significant CO_2 savings and may also have implications for trade and competitiveness (the latter could be assessed on the basis of expert opinions and industry surveys). Many countries have already implemented a range of policies and measures at national and regional levels with the goal of increasing fuel efficiency and lowering GHG emissions of petroleum-based vehicles. Some developing countries have implemented autonomous tariff reductions with the aim of facilitating the importation of critical components for producing cleaner and more fuel-efficient vehicles.[5] In general, however, trade measures have not been used and WTO negotiations on EGs are unlikely to play a significant role in the future. Mandatory standards[6] and fiscal measures are far more effective in promoting the overall objectives of reducing CO_2 emissions and increasing the fuel efficiency of conventional vehicles.

On the contrary, trade policies and tariff reductions may, in theory, play some role in promoting the larger market penetration of low-carbon vehicles (such as clean-diesel vehicles, natural gas vehicles (NGVs), hybrid-electric vehicles (HEVs)[7] plug-in hybrid electric vehicles (PHEVs), electric vehicles (EVs), and, in the future, hydrogen fuel-cell vehicles (FCVs)). Similarly, the elimination or reduction of tariff and non-tariff barriers (NTBs) to trade may contribute to increased trade in alternative fuels, such as biofuels.

It follows that the product categories that may, in principle, be characterised as environmental goods in the context of the EGS negotiations include alternative fuel vehicles (AFVs), certain components used in AFVs (such as batteries used in electric cars) and alternative fuels (such as biofuels).[8] All these EGs form part of the 6-digit HS items that also include other (unrelated) products and therefore, must be defined as ex-out items. AFVs can be identified (as "ex-out" items) on the basis of product-related characteristics. However, from the perspective of trade analysis the question remains whether existing tariff classifications (in particular at the common 6-digit HS level) can provide a reasonable indication of trade in the EGs in question. In some cases, this is simply not possible. For example, tariff classifications do not distinguish most AFVs (such as hybrid,[9] natural-gas or clean-diesel vehicles) from other vehicles with the same ignition type and cylinder capacity. In a few cases, particularly electric vehicles and biofuels (even though none of these products find a perfect match in 6-digit HS codes), some indication of corresponding trade flows can be derived from more detailed national and regional (EU) tariff classifications and trade statistics. The analysis presented in this paper therefore focuses largely on these technologies and products.

Even if AFVs may be defined as environmental goods, there may not be a strong case for including AFVs in the EGS negotiations. In theory, the elimination or reduction of tariffs and NTBs can contribute to the diffusion of AFVs worldwide by reducing their costs in the domestic market. This paper argues that trade liberalisation alone is unlikely to have a significant impact on the penetration of AFVs into automobile markets:

- Several alternative fuels and AFVs (e.g. PHEVs, EVs and FCVs) require extensive investments in new infrastructure and fuel delivery systems as well as coordinated approaches (e.g. between automakers, fuel suppliers and the public sector).[10]

- Certain AFVs (in particular electric cars and FCVs) contribute significantly to CO_2 reductions only if the alternative fuels are obtained from low-CO_2 technologies. Many countries do not currently generate enough low-CO_2 electricity to enable electric cars to contribute significantly to emission reductions. Similarly, hydrogen (H2) must be produced with low CO_2 technologies in order for FCVs to provide significant CO_2 reductions (IEA, 2009).

- Even if import duties were to be reduced, most AFVs would still require extensive subsidies and other incentives to increase their market penetration.

- Initiatives to promote the use of certain alternative fuels and AFVs are often taken at the sub-national (i.e. city) level. Such initiatives may benefit from (autonomous) import duty concessions, but these may be granted in the context of specific projects and programmes rather than through nation-wide tariff reductions.

- Proposals in the EGS negotiations appear to focus on the reduction of import tariffs for completely built AFVs. The experience of autonomous tariff reductions in some developing countries would indicate that developing countries with domestic automobile production tend to grant import-duty concessions (and other incentives) with the aim of facilitating the importation of critical parts and components for the production of more efficient and cleaner cars (including AFVs), rather than fully assembled vehicles.[11]

In regards to trade negotiations, trade in biofuels appears to be the most important issue (though some WTO members have been opposed to this, including agricultural products in the EGS negotiations; the Doha mandate does not confine EGs to manufactured products). Biofuel markets are affected by government support measures and trade restrictions. The Global Subsidies Initiative (GSI) found that by 2006 government support for biofuels in OECD countries (in particular for biofuel facilities, production related payments and exemption of biofuels from fuel excise taxes) had reached USD 11 billion a year (GSI, 2006). Eliminating distortions in biofuels trade may provide sustainable development opportunities for low-cost, developing-country producers. However, according to a recent UNEP report, life-cycle assessments of first-generation biofuels show a wide range of net GHG savings compared to fossil fuels based on feedstock, conversion technology, and other factors, including methodological assumptions. Sugar cane ethanol recorded the highest GHG savings.[12] High net GHG savings were also recorded for biogas (methane) derived from manure. However, large variations were observed for biodiesel, in particular from palm oil and soya. Negative GHG savings, i.e. increased emissions, may result in particular when production of biofuel feedstock takes place on converted natural land (UNEP, 2009).[13] Gaining policy support for trade liberalisation in biofuels will require that assurance is given that biofuels contribute to GHG reductions on a life-cycle (from well-to-wheel) basis. Biofuel certification may help provide such assurance, but may also act as a technical barrier to trade.

Non-technology options

Substantive gains can also be derived from non-technological options (such as operational measures, the provision of public transport, policies aimed at reducing traffic congestion, intelligent transportation systems[14] and eco-driving), modal shifts (in particular, shifting some passenger travel and freight transport from road and air transport to more efficient modes, such as by rail or ship), and promoting non-motorised modes of transportation, such as cycling.

A range of policy measures can be implemented to promote such options, but trade measures are scarcely used, if at all. Yet it can be argued that trade liberalisation may contribute to reducing fossil fuel consumption and GHG emissions, by potentially decreasing the domestic cost of certain transport equipment used in non-technology options for reducing GHG emissions, such as trains and bicycles.

Policies and measures

This paper also discusses key policies and measures implemented in different countries aimed at reducing GHG emissions in the transport sector. This discussion focuses on those policies and measures aimed at improving the efficiency of transport modes by encouraging the use of climate friendly technologies (e.g. vehicle efficiency measures, AFVs and alternative fuels), rather than supporting avoid and shift approaches (in the ASI framework).

Appropriate fuel pricing and, where applicable, the reform of fossil-fuel subsidies is of crucial importance. An IEA review of fuel-economy policies in selected countries indicates that the implementation of progressively tighter mandatory fuel-efficiency standards, particularly for light-duty vehicles (LDVs), has proven instrumental in achieving steady, rapid technology uptake (IEA, 2009). Taxation policies may also stimulate demand for fuel-efficient vehicles. For example, vehicle taxes and registration fees may be differentiated on the basis of vehicle efficiency and CO_2 emissions. Regulatory measures (for example, the mandatory conversion of urban buses to natural gas with to the goal of reducing urban air pollution) and public procurement guidelines have stimulated demand for NGVs in some countries. Several nations use targets, bending mandates, subsidies and tax incentives to support the use of biofuels.

Subsidies and other incentives are currently used to support the market penetration of AFVs. Subsidies consist of both market-creation measures (e.g. subsidies for the purchase of an AFV) and measures on the supply side (e.g. incentives for investment in refueling stations and conversion kits). The latter may also include tax credits, grants and low-interest loans to support investment in new or larger domestic manufacturing capacities. Subsidies play a key role, particularly in the development of battery technologies and the deployment of PHEVs and EVs.

Many incentives have been implemented in the context of stimulus packages. The IEA estimates that G20 stimulus packages committed in 2009 included a total of USD 21 billion to be invested in vehicle efficiency and USD 108 billion in rail transport (IEA, 2009).[15] Stimulus packages sometimes generate formal and informal pressure to favour domestic production and employment. In the United States, for example, recipients of ARRA grants for the development of a national high-speed and intercity passenger rail system must comply with Buy America provisions.

Incentives, including subsidies, may be justified where very efficient AFVs need support to overcome market barriers in order to become competitive with conventional, less efficient vehicles. For example, incentives for the development and manufacturing of advanced batteries may enable economies of scale to be achieved, which is needed to substantially reduce the cost of batteries. Incentives may also be required in the case that specific AFVs need substantial investments in infrastructure, e.g. for recharging, in order to overcome the "chicken-and-egg problem".[16] In general, however, technology-specific incentives may be less effective than technology neutral policies at encouraging the use of highly fuel-efficient and low-carbon vehicles.[17] First, there is a risk that certain AFVs may always need regulatory preference and subsidies to be competitive. Second, certain manufacturing subsidies may affect conditions of competition. For example, under the American Recovery and Reinvestment Act of 2009 (ARRA), tax credits can be awarded for qualified investments in advanced energy projects to support new, expanded, or re-equipped manufacturing facilities located in the United States, including for fuel cells, advanced batteries, and electric vehicles.

Climate instruments

Although the bulk of investments for climate action in the transport sector may need to come from domestic sources, external funding can play a key role in catalysing and leveraging domestic funding. The Clean Development Mechanism (CDM), Global Environment Facility (GEF) and the Clean Technology Fund (CTF) may support the implementation of climate policies in the transport sector, in accordance with the Avoid-Shift-Improve (ASI) framework (Huizinga and Bakker, 2010). New climate instruments such as nationally appropriate mitigation actions (NAMAs) also offer potential to strengthen climate change mitigation in the transport sector in developing countries.[18] It may be worthwhile to explore the role trade liberalisation might play in supporting the implementation of certain transport related NAMAs.

Tariff classification issues

This paper pays considerable attention to tariff classification issues. Since AFVs (including battery technologies) and biofuels are important for the implementation of climate mitigation policies in the transport sector, national and regional (EU) authorities have, in some cases, already taken, or are in the process of considering steps to add specific subheadings to the common 6-digit HS codes in their national or regional tariff schedules. As of 1 January 2012, the HS will have a new heading for biodiesel in Chapter 38 (heading HS 38.26). EVs and PHEVs are only starting to be commercialised and current international trade is still insignificant. Yet because of the growing importance of government policies to support EVs and PHEVs and the expected increase in market shares in alternative policy scenarios, it may be desirable to consider possibilities for creating more detailed tariff lines at national and regional levels, or perhaps even at the 6-digit HS level.

Structure of the paper

Section II analyses some trends in CO_2 and GHG emissions in the transport sector. It also analyses key policies and measures to support the deployment of relevant climate-related technologies in road transport. Section III describes a mapping of technology options in road transport. Section IV briefly analyses technology options in other modes. Section V discusses practical issues involved in the identification of products and components linked with climate-related technologies in existing tariff classifications and analyses, to the extent possible, corresponding trade flows, tariffs, non-tariff barriers (NTBs), subsidies and other incentives. The principal conclusions are presented in Section VI.

2. TRENDS, POLICIES AND MEASURES

2.1 CO_2 Emissions in the Transport Sector

According to the International Energy Agency (IEA) the transport sector accounted for approximately 19 per cent of global energy use and 23 per cent of global energy related CO_2 emissions in 2007.[19] Road transport was responsible for 73 per cent of the sector's CO_2 emissions, followed by aviation (11 per cent), international shipping (9 per cent), and other transport, including rail transportation (7 per cent) (IEA, 2009a). Between 1990 and 2007, transport related CO_2 emissions increased by 45 per cent, a much faster increase than other end-use sectors.[20] In the IEA Reference Scenario,[21] total CO_2 emissions in the transport sector are expected to increase by 41 per cent from 2007 to 2030 and those related to road transport by 43 per cent (Table 1).[22]

Table 1: Global CO_2 emissions in the transport sector in the IEA Reference Scenario

Transport mode	Mt				Share in total in 2007 (%)	Increase per period (%)		
	1990	2007	2020	2030		1990-2007	2007-2020	2007-2030
Road transport	3291	4835	5646	6920	73	47	17	43
Aviation	538	742	884	1067	11	38	19	44
International shipping	358	613	685	780	9	71	12	27
Other transport	387	433	518	564	7	12	20	30
Total transport	4574	6623	7733	9332	100	45	17	41

Source: IEA (2009a), World Energy Outlook 2009, Table 4.4.

Transport relies on oil for more than 95 per cent of its fuel needs worldwide (IEA, 2009b).[23] In its Reference Scenario, the IEA expects that the transport sector will account for 97 per cent of the projected increase in global oil demand until 2030 (from 85 million barrels per day in 2008 to 105 mb/d in 2030), with non-OECD countries accounting for the entirety of the increase. On the contrary, oil demand in OECD countries may drop significantly, due to major efficiency gains in the transport sector, which offset a modest expansion of the car fleet (IEA, 2009a).

With regard to future developments in the transport sector, the IEA (2009b, p57) notes that:

> "The overall picture that emerges from the projections and scenarios is that OECD countries are nearing or have reached saturation levels in many aspects of travel, whereas non-OECD countries – and especially rapidly developing countries such as China and India – are likely to continue to experience strong growth rates into the future through to at least 2050. In OECD countries, the biggest increases in travel appear likely to come from long-distance travel, mainly by air. In non-OECD countries, passenger LDV ownership and motorised two-wheeler travel are likely to grow rapidly in the decades to come, although two-wheeler travel may eventually give way to passenger LDV travel as countries become richer. Freight movement, especially trucking, is also likely to grow rapidly in non-OECD regions. In all regions of the world, international shipping and aviation are likely to increase quickly".

Road transport includes several modes: light-duty vehicles (LDVs); trucks (for the movement of goods) and buses. Improving the fuel economy of LDVs is one of the most important and cost-effective mitigation strategies. The IEA estimates that the implementation of incremental fuel-economy technologies could cost effectively cut the fuel use and CO_2 emissions per kilometre of new LDVs worldwide by 30 per cent by 2020 and 50 per cent by 2030 (IEA, 2009b).[24] Similarly, new trucks can probably be made 30 to 40 per cent more efficient by 2030 through better technologies (such as advanced engines, light-weighting, improved aerodynamics and better tyres). In addition, CO_2 emissions can be reduced through greater market penetration of alternative fuel vehicles (such as hybrid cars; electric vehicles (EV); natural gas vehicles (NGVs) and, in the future, hydrogen fuel-cell vehicles) and the increased consumption of certain biofuels.

A wide range of cost-effective fuel-efficiency technologies, including aerodynamic improvements, weight reduction and engine efficiency, are also under-exploited in the railway, aviation and shipping sectors. All transport modes also offer – in differing degrees – opportunities for increased use of biofuels. To harness potential fuel and emissions reductions, a range of policies and measures need to be implemented. This section first lists key policies and measures that have already been implemented in several countries. Technology options are discussed in more detail in section II (mapping technologies). Apart from technology, substantive gains can also be derived from non-technological options (such as operational measures, public transport, policies aimed at reducing traffic congestion and eco-driving) and modal shifts (in particular shifting some passenger travel and freight transport from road and air transport to more efficient modes, such as rail and ships). However, this paper focuses on technological options for increasing fuel efficiency and shifting the fuel mix in the transport sector.

2.2 GHG Reduction Strategies in the Transport Sector

2.2.1 Policies and measures

This section lists examples of key policies and measures – including technological, regulatory, economic and information instru-ments – applied in different countries to help address obstacles to the development and deployment of climate-friendly technologies in the transport sector (in particular in the areas of AFVs and biofuels).[25] It is not the intention here to present an exhaustive list of such policies and measures. Technology options, while particularly relevant in the specific context of the analysis presented here, are only part of a broader policy framework.[26] For a broader analysis of policy instruments in accordance with the different approaches of the ASI framework see Dalkmann and Brannigan (2007) and the European Environment Agency (2010).

Generic policies and measures for reducing GHG emissions in the transport sector include:

- Fuel pricing. Since the transport sector depends heavily on oil for its fuel needs, lower oil prices tend to significantly reduce the effects of policies aimed at increasing fuel efficiency and the reducing GHG emissions. This calls for appropriate fuel pricing, including, where appropriate, the reform of fossil-fuel subsidies.[27]

- Policy targets. For example, the Republic of Korea has a specific target for reducing GHG emissions by 2020.[28] Policy targets to meet a given share of transport-related energy demand by renewable sources of energy by a given date may support markets for AFVs and biofuels. In the EU for example, the general objectives of the Renewable Energy Directive are to achieve a 20 per cent share of energy from renewable sources in the Community's gross final consumption of energy and a 10 per cent share of energy from renewable sources in each Member State's transport energy consumption by 2020.[29]

- Public procurement. Several countries have public-procurement guidelines for the purchase of vehicles for government institutions.[30]

Policies and measures to improve the fuel efficiency and GHG performance of LDVs and trucks include:

- Fuel-economy and CO_2 emissions standards. These may be combined with long-term targets setting tighter standards to help manufacturers plan for the future and provide incentives for continuous improvements.

- Taxation and tax incentives. These may be differentiated on the basis of vehicle efficiency and/or CO_2 emissions. Some countries apply “feebates” i.e. a combination of fees and rebates, whereby fees on inefficient cars are used to fund rebates for more efficient cars, thereby promoting the purchase of low-emission cars. CO_2-based vehicle registration fees are applied in some countries.

- Penalties imposed on car manufacturers (e.g. if the average CO_2 emissions of their vehicles are above a certain limit value).

- Promotion of the use of fuel-efficient tyres.

- Labelling (information on fuel economy and CO_2 emission performances of vehicles)

- Car-scrapping. Several EU countries provided tax incentives as part of their national stimulus packages (in addition to existing incentives for green cars in some of these countries) for scrapping old cars and replacing them with new cars that meet specified CO_2 emission standards.[31] In the United States, the Car Allowance Rebate System (CARS), also known as the “cash for clunkers” programme, provided similar incentives.[32]

- Restrictions on imports of second-hand vehicles (which may slow the penetration of new vehicle technologies).[33] For example, Australia applies a tariff of USD 12,000 on imports of second-hand vehicles (other than for specialist use).

Policies and measures to help increase the market penetration of AFVs include:

- Grants and tax credits for the purchase of AFVs.

- Incentives that reduce operating costs for AFVs.[34]

- Targets and mandates for AFVs. For example, in 2008 China’s Ministry of Science and Technology (MOST), which oversees China’s auto industry, mandated that 10 per cent of new cars must run on alternative fuels by 2012.[35]

- Subsidies and other incentives (including loans) for investment in AFV manufacturing capacities, in particular for electric vehicles and batteries (for example, under the American Recovery and Reinvestment Act (ARRA)).

- Incentives for investment in infrastructure and fuel-delivery systems (for example the US Alternative Fuel Infrastructure Tax Credit).[36]

- Regulatory measures (for example, the mandatory conversion of urban buses to NGVs with a view to reducing urban air pollution, as has been implemented in some developing countries).

- Obligations on government institutions to acquire AFVs as part of their purchase of vehicles. For example, in the United States the Energy Policy Act of 1992 (EPAct) requires that 75 per cent of all covered light-duty vehicles (LDV) acquired for Federal fleets must be AFVs.[37]

- Government support for deployment and demonstration projects.

Policies and measures to promote the use of biofuels include:

- Biofuels blending mandates. Blending gasoline and diesel with biofuels can increase the shares of renewable sources of energy in the transport sector without creating a need for new investments in infrastructure and fuel delivery systems. Practically all spark-ignition vehicles can run on a blend of up to 10 per cent ethanol with gasoline and most diesel vehicles can use biodiesel fuel at up to 5 per cent concentrations without modifying the vehicle's fuel system and powertrain, provided that quality standards are met. Higher blending rates may affect warranties issued by automakers and engine manufacturers. In early 2010 some 27 countries, including 16 developing countries, had binding biofuels blending mandates[38] (REN21, 2010).

- Specific biofuels targets and plans that define future levels of biofuel use (in addition to targets for renewable fuels, see above). For example, the US Renewable Fuels Standard (RFS) requires fuel distributors to increase the annual volume of biofuels blended to 36 billion gallons (136 billion litres) by 2022. Japan's target is to produce 6 billion litres of biofuels per year by 2030, representing 5 per cent of its transport energy. China targets the equivalent of 13 billion litres of ethanol and 2.3 billion litres of biodiesel per year by 2020 (REN21, 2010).
- Production subsidies are applied in several countries.[39]
- Tax measures, such as excise tax exemptions.[40]
- The introduction of flex-fuel vehicles (FFV) which are able to use any mixture of gasoline and ethanol.
- Research and development, including on second-generation biofuels
- Biofuel standards and certification may help assure that increased biofuel production contributes to net reductions in GHG emissions on a life cycle, but may also act as NTBs.

2.2.2 Transport-related climate instruments

The Clean Development Mechanism (CDM), Global Environment Facility (GEF) and the Clean Technology Fund (CTF) may support the implementation of climate policies in the transport sector, in accordance with the ASI framework (Huizenga and Bakker, 2010). New climate instruments such as nationally appropriate mitigation actions (NAMAs) also offer potential to strengthen climate change mitigation in the transport sector in developing countries.[41] Some of these projects may be of certain relevance in the context of the discussions on transport-related EGs.

The transport sector has so far played only a very limited role in the CDM. As of July 2010, only 30 out of 5312 projects in the pipeline are related to transport (UNEP/Risø, 2010, quoted in Huizinga and Bakker, 2010). Only some of these projects support technology options as analysed in this paper (e.g. biodiesel[42] and regenerative braking in the railway sector). Most transport-sector CDM support Bus Rapid Transit (BRT) and mode shifts.

As of mid 2010, the GEF had funded 37 transportation projects in more than 73 cities worldwide (Huizenga and Bakker, 2010). GEF support to the transport sector initially focused on technological solutions. However recent GEF support (GEF-4, 2006–10) emphasized "non-technology" options, such as planning, modal shift and promotion of better managed public transit systems, including Bus Rapid Transit (BRT).

The CTF is designed to help fill an immediate financing gap while an agreement on the future (post 2012) climate regime is worked out. It aims to provide financing for transformational actions that contribute to demonstration, deployment and transfer of low carbon technologies with a significant potential for long-term GHG emissions reductions. For the transport sector, measures which the CTF supports may include: (i) a modal shift to low carbon public transportation in major metropolitan areas; (ii) a modal shift to low-carbon freight transport (iii) improvement of fuel economy standards and fuel switching; and (iv) the deployment of electric and hybrid (including plug-in) vehicles (Huizenga and Bakker, 2010). As of March 2010, transport is included in seven of the twelve country investment plans approved by the CTF, all in the realm of public transport, particularly BRT (Huizenga and Bakker, 2010).

As of May 2010, 25 out of 36 NAMA proposals submitted by developing countries explicitly include the transport sector, including actions in the areas of infrastructure development, energy efficiency, biofuels, electric vehicles, fiscal incentives and regulatory measures. However, there is no indication that proposed transport NAMAs have been developed in the context of wider transport and development strategies (Binsted and Sethi, 2010).

3. MAPPING TECHNOLOGIES: ROAD TRANSPORT

According to the IPCC, GHG emissions associated with vehicles can be reduced by four types of measures: (i) reducing the loads (weight, rolling and air resistance and accessory loads)[43] on the vehicle, thus reducing the work needed to operate it; (ii) improving drive-train efficiency and recapturing energy losses; (iii) changing to a less carbon-intensive fuel; and (iv) reducing emissions of non-CO_2 GHGs, such as methane (CH4) and nitrous oxide (N2O)[44] (IPCC (2007). The technology mapping study prepared for the ICTSD by the Energy Research Institute, China (Kejun, 2009) closely follows the IPCC analysis.

For analytical purposes, this section follows a slightly different presentation of technological options, based on recent work by the IEA (IEA, 2009a and 2009b). From a technology point of view, most of the future CO_2 savings in road transport are likely to occur due to a combination of: (i) more efficient petroleum-powered vehicles; (ii) larger market penetration of alternative fuel vehicles (AFVs), in particular more advanced plug-in hybrid and pure electric vehicles; and (iii) increased consumption of biofuels (IEA, 2009a and 2009b).

3.1 Making Petroleum–Powered Vehicles More Efficient

A large share of fuel savings in the past, and for potential future savings, comes from deploying fuel-efficient vehicle technologies (IEA, 2009b). There are several ways to make petroleum-powered vehicles more efficient, in particular:

- Further improvements to gasoline and diesel internal combustion engines (ICEs), e.g. through advanced direct-injection (DI) gasoline and diesel engines; and more efficient power-train options, such as moving away from four-speed transmission toward a six-speed, seven-speed or continuously variable transmission (CVT);
- improvements to auxiliary systems, such as lighting and air conditioning, and the use of rolling-resistant tyres; and
- the use of lightweight materials (such as high-strength steel (HSS) or aluminium).[45]

Governments play a key role in inducing automobile makers to introduce incremental improvements in vehicle technologies by setting increasingly stringent fuel-efficiency and emissions standards, in combination with other policies and measures such as affecting the price of fuel. Such instruments generally leave it to the automobile industry to choose which technology, or which combination of technologies, they can use to achieve the desired result. Trade measures are normally not used to encourage the deployment of specific technological options, although governments may keep tariffs on critical components low.[46]

An interesting question is how incremental improvements in LDVs are deployed on a global scale. The IEA argues that most of these improvements began to be deployed in the OECD countries and that these countries may still lead future improvements, partly on account of higher average incomes of consumers compared with those in most non-OECD countries. In general, there appears to be a lag time for technologies to enter non-OECD markets where new vehicles are often equipped with technologies introduced in OECD markets five to ten years earlier. However, the IEA recognizes that the fast growth of vehicle markets in some developing countries may be changing this picture: some vehicle models equipped with advanced technologies are appearing at nearly the same time in fast-growing markets, such as China, as they appear in the OECD, and some models are sold worldwide with similar specifications, varying only as needed to meet regulatory requirements (IEA, 2009b). Some nationally owned carmakers in developing countries, e.g. China and India, are playing an important role in technology development.

3.2 Alternative–Fuel Vehicles (AFVs)

Improving efficiency of conventional vehicles alone will not be enough to reduce future road transport GHG emissions to below the current level; it will also be necessary to promote the larger market penetration of alternative-fuel vehicles (AFVs), i.e. vehicles that can run on alternative fuels (other than petroleum) such as electricity, compressed natural gas or hydrogen.[47]

There are a number of barriers to greater market penetration by AFVs: (i) high first cost for certain categories of AFVs; (ii) on-board fuel storage issues (i.e. limited range of electric vehicles); (iii) high fuelling cost (compared with gasoline); (iv) limited fuel stations (the "chicken-and-egg" problem); and (v) competition from improved and cleaner petroleum-powered vehicles. The larger market penetration of AFVs therefore requires, in most cases, government incentives or mandates (see previous section). Questions may also arise as to whether certain specific AFVs and alternative fuels necessarily provide the most cost-effective and sustainable solution to major energy and environmental problems, which may affect the policy case for government intervention in the marketplace (see also IEA, 2009b).

This report pays special attention to electric vehicles. Vehicles with an electric motor include hybrid-electric vehicles (HEVs), plug-in hybrid electric vehicles (PHEVs) and all-electric vehicles (AEVs).[48] Hybrid-electric vehicles use a gasoline (or diesel) ICE, a battery-powered electric motor, and a concept known as regenerative braking to power the vehicle.[49] HEVs do not contribute to the use of alternative fuels, but incorporate advanced technologies which allow for a more efficient use of liquid fuels. A PHEV is a hybrid vehicle with rechargeable batteries that can be restored to full charge by connecting a plug to an external electric power source. Pure EVs, also known as all-electric vehicles (AEVs) or Battery Electric Vehicles (BEVs) – use one or more electric motors for propulsion. The term "electric vehicles" (EVs) normally refers to AEVs. For short-range driving, a PHEV operate as a pure EV.

The move to advanced electric cars is expected to be gradual. Hybrids[50] are the first step, with the ultimate goal being vehicles that run only on batteries. The IEA estimates that without larger policy support (the Reference Scenario) the share of non-plug-in hybrids in the global fleet may reach about 8 per cent by 2030, but plug-in hybrids and electric cars will remain marginal, accounting for only 0.2 per cent of the global fleet. In an alternative policy scenario ("the 450 scenario") hybrids may take 30 per cent by 2030, while plug-in hybrids and electric vehicles take another 30 per cent (IEA, 2009a).

The larger market penetration of hybrid vehicles and EVs depends, to a large extent, on the availability of incentives and cost-effective components, e.g. for energy storage. Therefore, the further development of battery technologies is of critical importance and several battery technologies, such as nickel-metal-hybride (NiMH) and lithium-ion (Li-ion) batteries, are analysed in the technology mapping study (Kejun, 2009). Li-ion batteries are the current dominant choice for EVs. Further R&D efforts are needed for the future use of hydrogen and fuel-cell vehicles (FCVs).

3.2.1 Market penetration of AFVs

Some market research organisations and industry associations publish data on the market penetration of AFVs. Wikipedia estimates that by December 2009 there were more than 35 million alternative-fuel and advanced-technology vehicles on the world's roads, representing approximately 5 per cent of the world's automobile fleet. This includes more than 2.7 million hybrid electric vehicles, led by the United States with 1.6 million units, followed by Japan with 870 thousand and Europe (more than 237 thousand).[51] The largest category is FFVs; since their introduction in 2003, 10 million FFVs have been sold in Brazil and there are more than 7 million FFVs in operation in the United States. The International Association for Natural Gas

Vehicles (IANGV) estimates that more than 11 million natural gas vehicle (NGVs) are on the road in selected countries (Table 3). The US Department of Energy (DOE) estimates that more than 270,000 propane (or liquefied petroleum gas (LPG)) vehicles are on the road in the United States and that there are more than 10 million worldwide.[52]

The US Department of Energy publishes online comprehensive data on AFVs (DOE, Alternative Fuels and Advanced Vehicles Data Center (AFDC)), including historic data on AFVs "made available" and AFVs in use in the United States. Some lessons can be learned from these data. First, certain AFVs have been promoted with only limited success. For example, methanol (M85 and M100) and E95 FFVs have practically disappeared from the roads in the United States. (Similarly, in Brazil pure ethanol vehicles accounted for two-thirds of domestic sales of cars and light commercial vehicle in the 1980s, but these vehicles are no longer produced). Second, in some cases the number of AFVs actually using the alternative fuel may be much smaller than could be expected on the basis of data on AFVs "made available". For example, many owners of bi-fuelled and flex-fuelled AFVs (which can run on either conventional or alternative fuels or a combination of both) do not run their cars on alternative fuels, especially where alternative fuelling facilities are not available (in this case, the vehicle will simply operate on conventional fuel, negating any benefit of using alternative fuel). Hybrid vehicles use ICEs at least part of the time (for example when the vehicle needs more power, as when going uphill or during quick accelerations).

A total of 7.1 million AFVs (not including 1.6 million HEVs) were "made available" in the United States in the period of 2001-2008 (Table 2). However, the DOE estimates that the number of AFVs in use was only around 775,000. The main difference is in E85 FFVs, as only 450,000 of the 7 million E85 FFVs were believed to actually be using E85.[53] The availability of FFV credit has been an incentive for automakers to produce FFVs. After model year 2015, FFV credits will be granted only if the manufacturer can demonstrate that the FFVs actually use E85.

Table 2: United States, AFVs made available and AFVs in use in 2006-2008 (Thousands)

	AFVs made available 1/		AFVs in use 2/			
	Total in period 2001-08	Annual average in the period 2006-2008	2000	2006	2007	2008
LPG vehicles	11.4	0.5	182.0	164.8	158.2	151.0
CNG vehicles	47.3	3.4	100.8	116.1	114.4	114.0
LNG vehicles	1.4	0.2	2.1	2.2	2.8	3.1
E85 FFVs 3/	6996.5	1100.6	87.6	297.1	364.4	450.3
Electric vehicles 4/	47.7	2.9	11.8	53.5	55.7	56.9
Hydrogen vehicles	0.3	0.1	0.0	0.2	0.2	0.3
Total	7104.5	1107.6	394.7	634.6	695.8	775.7

Source: US Department of Energy, AFDC (various tables).
1/ "Made available" means the sale or lease of a new AFV or conversion of an existing vehicle to enable it to use an alternative fuel".
2/ "Vehicles in use" represent accumulated acquisitions less retirements, as of the end of each calendar year.
3/ E85 FFVs in use include only FFVs believed to be using E85.
4/ Does not include hybrid-electric vehicles.

The principal markets for hybrid vehicles are in the United States and Japan, in part driven by air-quality concerns in large metropolitan areas (in addition, diesel is not very well accepted as a car fuel in these countries). Toyota developed and successfully introduced the first serial hybrid electric car, the Prius. In Europe, there was a push for hybrid models in the early 1990s, but due to the market entry of clean-diesel technologies and lack of progress in battery technologies, European manufacturers did not strongly pursue further development at the time (Doll, 2008). Recently, there has been a renewed interest in hybrid-electric vehicles in Europe.[54]

Strong government support in several developed and developing countries, including in the context of stimulus packages, creates favourable conditions for further increases in AFV shares in automobile markets. European firms have been leading in diesel technologies, whereas Japanese carmakers (in particular Toyota and Honda) have dominated hybrid technologies. Although several carmakers are developing plug-in hybrid electric vehicles and battery electric vehicles, no nation has yet emerged as the clear leader, but a report by McKinsey & Company suggests that China may become a leader in this sector and a pioneer in the conversion of PHEVs and AEVs from an expensive niche technology to an affordable, widely-used technology (Gau, Wang and Wu, 2008). It has also been mentioned that China (which already produces mild hybrid vehicles) plans to leapfrog full hybrid vehicles to move directly to the development of plug-in and battery-electric vehicles (Liu, Yang and Klampfl, 2010). In 2010, China's BYD became the first automaker to offer a mass-produced plug-in hybrid to individual buyers.[55]

3.2.2 Plug-in hybrid and all-electric vehicles

PHEVs and AEVs can contribute to reducing transport-related oil consumption and GHG emissions if key barriers to their larger market penetration can be overcome. These barriers include the high cost of the vehicles, on-board storage issues and the need for investment in infrastructure and fuel delivery systems. There is also a need to mitigate the impact of the larger market penetration of electric vehicles on electricity demand and to ensure that this demand is met as far as possible by low-CO_2 electricity. This section briefly reviews some Government interventions (including in the context of stimulus packages) and partnerships involving Governments and the private sector, particularly in the United States and China.

Government support

Both the United States and Chinese governments are actively promoting their domestic EV industry. Subsidies and other incentives consist of both market-creation measures (e.g. subsidies for the purchase of PHEVs and AEVs) and measures to support investments in manufacturing capacities and the development of advanced battery technologies.

With regard to market-creation measures, the American Recovery and Reinvestment Act (ARRA), also known as the US stimulus package, provides tax credits of up to USD 7,500 for those who purchase plug-in hybrid vehicles. In addition, USD 300 million is included for the government's automobile fleet - "for capital expenditures and necessary expenses of acquiring motor vehicles with higher fuel economy, including: hybrid vehicles; electric vehicles; and commercially available plug-in hybrid vehicles".

In the area of support for investment in domestic manufacturing capacity, the Department of Energy (DOE), as part of its USD 12 billion investments in advanced vehicle technologies, has been investing more than USD 5 billion to electrify the US transportation sector (US Department of Energy, 2010). This includes:

- USD 2.4 billion under the ARRA for the establishment of electric vehicle battery and component manufacturing plants and support for electric vehicle demonstration projects.[56] In addition, award-winning companies have matched funds received out of ARRA with another USD 2.4 billion.

- USD 2.6 billion in loans (to Nissan, Tesla and Fisker) under the Advanced Technology Vehicle Manufacturing (ATVM) Loan Program for the establishment of electric-vehicle manufacturing facilities.[57]

The Chinese government is also actively promoting a national electric vehicle strategy. A number of factors may contribute to making this strategy successful. First, China has a large and growing domestic car market. China's car production increased by 48 per cent in 2009 to 13.8 million vehicles (Table A.6); yet its market remains largely untapped, as only 1.7 per cent of the Chinese population owns a car. Mc Kinsey Consulting estimates that electric vehicle penetration may rise to 30 per cent by 2030, creating a $220 billion market. China's emphasis on the production of small cars is also an advantage.[58] Second, China has a compelling reason to embrace electric vehicles because of mounting and unsustainable air pollution and oil dependence. Third, the electric alternative is particularly well suited to the Chinese driving profile of mostly intra-city commutes and low speeds. Fourth, China is a low-cost producer and already is the world leader in lithium-ion battery manufacturing.

However, China also faces some disadvantages which need to be addressed. China still heavily depends on coal-fired power plants for its electricity generation. This very much affects the CO_2 abatement potential of electric vehicles. However the CO_2 abatement potential of PHEVs and AEVs may increase as China enhances the use of renewable energy sources for electricity generation (the National Development and Reform Commission (NDRC) has set mandatory targets to increase the share of alternative sources of energy used by the national power grid to 30 per cent by 2030). Another disadvantage is the relatively low price of gasoline, which makes it difficult for Chinese consumers to recoup the premium cost of acquiring an electric vehicle from fuel savings. This disadvantage may become less pronounced as the Chinese government may gradually adjust the price of gasoline.

The following are some components of China's national electric vehicle strategy:

- The Ministry of Science and Technology (MOST), which oversees China's auto industry, has established a mandatory target that 10 per cent of new cars must run on alternative fuels by 2012. To help achieve this target the ministry launched the "National high-tech R&D program", commonly known as the "863 program" an instrument that may be used to channel financial resources to R&D in EV technology.

- The "Ten Cities, One Thousand Vehicles" plan is set to demonstrate the operation of 1,000 "new energy vehicles" (NEVs) in ten cities each year to encourage people to buy them. The plan targets the deployment of 60,000 NEVs in China by 2012. Under the plan, taxi fleets and local government agencies in 13 Chinese cities are offered subsidies of up to USD 8,800 for each hybrid or all-electric vehicle they purchase. Local governments tend to direct the subsidies to support Chinese automobile manufacturers.

- In June 2010, the Chinese government extended these benefits to private consumers in five cities (including Shanghai) until 50,000 eligible cars are sold. The subsidy is around USD $8,800 for all-electric cars and approximately USD 7,400 for PHEVs.

- Under another scheme, also announced in June 2010, manufacturers of fuel-efficient cars may receive subsidies worth around USD 440 per vehicle (only vehicles no bigger than 1.6 litres may be approved for the incentives).

- The country's largest electric power company, the State Grid Corporation of China, is setting up charging stations in larger cities such as Beijing and Shanghai.

Electricity as a fuel for road transport: some issues.

Using electricity as a transport fuel involves a number of issues. First, the larger market penetration of AEVs and PHEVs will create additional demand for electricity. This increased demand can be met more easily if electric vehicles are charged as much as possible during “off-peak” periods; if electric vehicles are charged up at night, electric power can be used that would otherwise go to waste.[59]

Second, for EVs to contribute significantly to CO_2 savings, electricity demand must be met as much as possible by low-CO_2 electricity. Charging-stations can take electricity from the grid or generate electricity using renewable sources of energy. There are a number of interesting projects for promoting charging stations powered by solar or wind energy. For example, in 2009, SolarCity, a solar company, and Rabobank, a community bank, worked together to create a solar-powered, fast-charge electric-car charging corridor in California (a series of charging stations were located at Rabobank branches along highway 101, which connects San Francisco and Los Angeles).

Third, problems related to the limited range of electric vehicles and long charging time need to be addressed to encourage more widespread use of EVs and PHEVs. To reduce charging time, systems are being developed to swap (rather than refill) batteries at switch stations; replacing a depleted battery by a fully-charged battery may take less time than a stop at a gas station. Such a system, however, requires complex logistics to ensure that each EV gets a fully-charged and compatible battery each time the vehicle arrives at a station. Better Place, a California-based company that delivers services to support the use of EVs (including EV charging infrastructures and setting up networks of battery switch stations).

Interesting partnerships are being developed to help address these issues. For example, Better Place and the Renault Nissan Alliance have worked with the Governments of a number of countries to launch relatively large numbers of electric cars. For example, a project has been developed with the Government of Israel, in which the Israeli government will help customers through tax incentives, Renault will sell all-electric vehicles and Better Place will build an electric battery recharging network across the country. A similar partnership is being developed with the Government of Denmark. Renewable energy sources (such as solar energy in Israel and wind power in Denmark) will be used whenever possible.

3.2.3 Other Alternative Fuel Vehicles (AFVs)

The rest of this section briefly describes other AFVs.

Liquefied petroleum gas (LPG) vehicles.[60]

Liquefied petroleum gas (LPG) is a mixture of several hydrocarbons. The main constituent is propane, which is mixed with lesser amounts of ethane and butane. LPG can be used within a modified ICE. Most cars that operate on LPG are conversions designed to run in bi-fuel mode, i.e. gas or petrol (the advantage of bi-fuel operation is that vehicles are less reliant on a fully developed LPG refuelling infrastructure). The majority of LPG cars are essentially conversions of conventional petrol cars; these are either converted at the factory by the manufacturer or are retrofitted after being sold as a new car. Altogether, there are currently over 4 million vehicles using LPG in Italy, the Netherlands, Russia, Japan, Australia, the Republic of Korea, the United States and Canada.[61]

Tests indicate that bi-fuel LPG cars may result in around 15 per cent savings in life-cycle GHG emissions (per km) compared with cars running on petrol (LPG has a lower carbon context; however, LPG cars consume more fuel (litres per mile) than petrol-driven cars). Larger emission reductions are provided by mono-fuelled (dedicated gas) engines. The best quality LPG bi-fuel engines produce fewer NOx emissions and virtually eliminate emissions of particulates. LPG cars therefore provide significantly lower regulated pollutants than diesel. However, the relative environmental benefits of LPG cars may be diminishing due to the improvement in fuel economy of conventional petrol cars. In the United Kingdom, this has resulted in a reassessment (by the government) of the fuel tax advantages that have applied to LPG; as conventional cars improve, some LPG tax benefits are being reduced.

Clean diesel vehicles

Clean diesel vehicles are more fuel-efficient than both gasoline-powered and traditional diesel vehicles.[62] Advanced clean diesel vehicles combine cleaner fuel (in particular diesel fuel with very low sulphur content), a state-of-the-art engine (incorporating new high-pressure fuel injection technologies) and an effective exhaust-control technology. Some 40 per cent of Europe's new light duty motor vehicles run on clean diesel (Alliance of Automobile Manufacturers (Auto Alliance)).

Natural gas vehicles (NGVs)

Natural gas vehicles (NGVs) run on compressed natural gas (CNG) or, less commonly, liquefied natural gas (LNG). Natural gas is a fossil fuel. However, per unit of energy, natural gas contains less carbon than any other fossil fuel, therefore producing lower CO_2 emissions per mile travelled than, for example, gasoline (NGVs can also run on biomethane, a renewable fuel; see below). Natural gas has been applied to a wide range of vehicles, including passenger cars, heavy-duty trucks, three-wheelers (primarily in Asian countries) and buses. Most of the NGVs in use today are converted gasoline or diesel-fueled vehicles. Prior to the late 1980s, the number of NGV models produced by original equipment manufacturers (OEMs) was very small (IANGV, 1997). However, in recent years the variety of OEM-built vehicles has increased significantly.

The availability of large domestic natural gas reserves in several countries, for example Argentina, has encouraged Governments to promote the use of NGVs. Governments in several Asian and Latin American countries have promoted the use of natural gas in urban transport to reduce air pollution and energy dependence.[63] This has been done by a combination of market-creation measures (e.g. mandatory conversion of urban buses or government fleets and targets for the achievement of a particular market penetration rate of NGVs within a specific time frame) and measures on the supply side (e.g. incentives for investment in refueling stations, pipeline infrastructure, and conversion kits).

Since the 1990s, many countries that initially relied on imported technologies have gradually developed OEM vehicles, domestic CNG conversion kits, CNG dispensers, CNG compressors, and CNG cylinders. Although Italy is world's NGV technology leader of OEM vehicles, vehicle-conversion kits, and compressor equipment, some other countries, such as China and India, have also become technology exporters.

Table 3: Number of NGVs on the road in selected countries (2009, unless otherwise indicated)

Country	Number of NGVs (thousands)
Pakistan	2300
Argentina	1807
Iran	1666
Brazil	1632
India	935
Italy	629
China	450
Colombia	300
Ukraine (2006)	200
Bangladesh	178
Thailand	162
Bolivia	122

Table 3: *Continued*

Country	Number of NGVs (thousands)
Egypt	120
World total (most recent data available for each country)	11356

Source: International Association for Natural Gas Vehicles

Biogas vehicles

Vehicles that operate on natural gas can also operate on biomethane. Whereas natural gas is a fossil fuel, biomethane is a renewable fuel (obtained by upgrading biogas to at least 95 per cent methane by volume). Biogas is created by anaerobic digestion of organic wastes such as sewage, manure, food wastes and landfill.[64] Apart from climate change considerations, the need to find new ways of managing organic wastes, as opposed to landfill, and the legislation behind this may also be a driver for using biogas in transport in several countries. Biomethane is one of the most environmentally friendly fuels. Sweden is a world leader in upgrading and implementing bio-methane for transport.

As a transport fuel, biogas is normally cheaper per kilometre travelled than gasoline or diesel (the extent to which fuel-cost savings compensate for higher upfront costs depend on specific circumstances). The opportunity costs of using biogas as a transportation fuel also need to be considered. Biogas obtained from sewage treatment and landfill can also be used to produce electricity and heat. A study prepared in 2006 suggested that, in the United Kingdom, using biogas for electricity production offered slightly greater CO_2 savings and required less subsidies than using biogas as a transport fuel, although only small changes in economic variables could modify this result (NSCA, 2006). However, in Sweden, the development of biogas as a vehicle fuel resulted from a combination of a surplus of gas from existing biogas plants and a low electricity price (making it less attractive to use biogas for electricity production). In Europe, biogas as a transport fuel has reached a breakthrough in certain municipalities in Sweden and France.

Flexible fuel vehicles (FFVs)

Flexible fuel vehicles (FFVs) are built to allow the use of either any mixture of gasoline and ethanol (as in Brazil) or any mixture of gasoline and E85, a fuel made from 85 per cent ethanol and 15 per cent gasoline (as in the United States). In Brazil, 88 per cent of new vehicles sold in 2009 (3 million cars and light commercial vehicles) were FFVs (the share of FFVs was 95 per cent in the case of cars and 54 per cent in the case of light commercial vehicles). Since their introduction in 2003 and until the end of 2009, 9.6 million FFVs were sold (ANFAVEA, 2010).[65] This represents approximately 32 per cent of all new vehicles sold in the country in the last 18 years.[66] In the United States, there are more than 7 million FFVs in operation.[67] Of course, there is no guarantee that FFVs with E85-fueling capability will actually use E85. In fact, according to data published by the US Department of Energy, only 450,000 E85 FFVs were believed to be using E85 in 2008 (Table 2). This has been attributed to several factors such as the small number of filling stations and lack of awareness among FFV owners that they can use E85. Surveys in Brazil indicate that 65 per cent of FFV owners used ethanol fuel regularly in 2009 (ethanol use in any given period depends largely on the price of fuel ethanol vis-à-vis the price of gasoline; as a rule of thumb, most car users will use ethanol if a litre of it is 70 per cent or less than the price of a litre of gasoline, taking into consideration that ethanol consumption per kilometre is higher than that of gasoline).

Hydrogen fuel-cell vehicles (FCVs)

Hydrogen is being explored for use in combustion engines and fuel-cell electric vehicles. FCVs may be produced commercially beginning around 2020. According to the IEA, recent cost reductions in fuel cell systems for vehicles increase make this more likely, although costs and on-board energy storage are still important concerns (IEA, 2009b).

In order to achieve a larger market penetration of FCVs in the future, there is a need to develop hydrogen production and distribution infrastructure. This will require substantial new investments. In addition, hydrogen (H2) must be produced with low-CO_2 technologies in order for FCVs to provide significant CO_2 reductions. This will result in higher hydrogen costs than if it were produced from, for example, reforming natural gas (IEA, 2009b).

3.3 Increased Use of Alternative Fuels

In the IEA baseline scenario, petroleum-based fuels continue to account for about 90 per cent of all transport fuel in 2050. In one ambitious alternative scenario this share falls to below 50 per cent, as petroleum-based fuels are replaced by a combination of advanced low-CO_2 biofuels, electricity and hydrogen (produced from low-CO_2 feedstocks). The IEA argues that a combination of approaches, at least in the initial stage, may have the best chance to achieve increased market shares for alternative fuels, even if it would result in higher investment costs to develop adequate production and distribution infrastructures (IEA, 2009b).

Biofuels could make an important contribution to future CO_2 savings in the transport sector. So-called first-generation biofuels include bio-ethanol and biodiesel. Second-generation biofuels, based on lingo-cellulosic biomass, are still in the R&D and demonstration stages. First-generation biofuels include bioethanol from sugar and starch crops and biodiesel[68] from animal fats and oilseed crops; they utilize simple and known conversion technologies. Second-generation biofuels can be produced from various feedstocks, including agriculture and forestry residues, algae and many forms of waste that contain high levels of organic matter; they use highly promising but less proven technologies (ICTSD, 2008).[69] Biofuels constitute the most important renewable transport fuel in most countries. In the EU, biodiesel accounted for 75 per cent (6.1 Mtoe) of renewable fuels in transport in 2007, of which 26 per cent was imported; bioethanol accounted for 15 per cent (1.24 Mtoe), of which 31 per cent was imported.[70] The use of hydrogen from any source remains insignificant; little electricity from renewable energy sources is used in road transport (Commission of the European Communities, 2009).

Yet biofuels met only around 2 per cent of total world road-transport energy demand in 2008 (IEA, 2009a). Most of the increase in the use of biofuels in 2007 and 2008 occurred in the OECD, mainly in North America and Europe (IEA, 2009a). The share of biofuels in EU transport fuels increased from 0.6 per cent in 2003 to an estimated 3.4 per cent in 2008. The highest shares were found in Germany (6 per cent), France (5.7 per cent), Austria (5.5 per cent) and Sweden (5 per cent).

The IEA notes that the recent strong increase in biofuel demand is not expected to continue in the near term because of concerns about the effects on food prices from diverting crops to biofuels, as well as questions about the magnitude of the GHG emissions savings associated with switching to biofuels and doubts about their environmental sustainability. These concerns may have affected policy support for biofuels, at least in the short run. For example, Germany has reduced its blending target for 2009 from 6.25 to 5.25 per cent. In January 2009, the UK Government decided to reduce its target for biofuels in transport from April 2009 to March 2010 from 3.75 per cent to 3.25 per cent.[71] Biofuel standards and certification may help assure that increased biofuel production contributes to reductions in GHG emissions on a life-cycle basis and that it meets sustainable development criteria. Biofuel standards and certification may therefore constitute important instruments to facilitate the further increase in the use of biofuels that help reduce GHG emissions on a “well-to-wheel” basis. On the other hand, standards and certification may sometimes act as NTBs (see below).

The IEA reference scenario expects that biofuels will recover and meet 5 per cent of total world road-transport energy demand by 2030. Close to one-quarter of this increase would come from second-generation technologies (which may be deployed around 2020). In the "450 Scenario", the IEA expects that the share of total world road-transport energy demand met by biofuels would almost double and that second-generation technologies may be deployed earlier, i.e. in 2015 (IEA, 2009a).

A significant increase in the use of biofuels in transport can be achieved with conventional vehicles - without any modification to motor car engines - using blended fuels. Practically all spark-ignition vehicles can run on a blend of up to 10 per cent ethanol (E10) with gasoline.[72] Most diesel vehicles can use biodiesel fuel at up to 5 per cent concentrations (B5)[73] without modifying the vehicle's fuel system and powertrain.[74] The introduction of FFVs (see previous section) can also contribute to increased use of biofuels.

3.3.1 World production of fuel bioethanol and biodiesel

The world biofuels market has been estimated at USD 44.9 billion in 2009 (based on ethanol and biodiesel production and wholesale prices), an increase of 29 per cent compared with 2008 (Clean Edge, 2010). According to a market research report published by MarketsandMarkets (2010), the world biodiesel market was worth USD 8.6 billion in 2009.[75]

World production of fuel ethanol reached 74 million litres in 2009 (Table A.15), a 13 percent increase compared with 2008. The United States and Brazil are leading producers with a combined share of almost 88 per cent of total world production. China was the third-largest single-country producer, but accounted for only 3 per cent of world production; the 27 Member States of the EU collectively accounted for 4 per cent. After a strong growth in 2008 (almost 60 per cent), in 2009 European fuel ethanol production increased by 31 per cent. France is the EU's largest producer. Unlike other countries with substantial biofuels production, Brazil currently does not offer production subsidies for bioethanol.[76]

Biodiesel production increased strongly in recent years to approximately 18 billion liters in 2009 (Table A.15), representing a growth of 11 per cent from 2008 levels. The EU is responsible for almost half of world's biodiesel production. Germany is the world's leading producer (mostly from rapeseed), primarily used domestically and within the EU. The United States was the third largest producer in 2009. Important developing-country producers (in the period 2008-2009) include Argentina, Brazil, China, Colombia, Indonesia, Malaysia, and Thailand.

In the EU, biodiesel production increased by 17 percent in 2009, following a 36 percent increase in 2008 (Table 4). According to the European Biodiesel Board, the lower growth rate in EU biodiesel production and the reduced capacity utilisation rate are to be explained primarily by the persistence of alleged unfair trade practices (Biofuels Platform, 2010). In 2009, German production fell by around 10 percent compared with 2008; France, however, more than doubled its biodiesel production compared with 2007.

Table 4: Biodiesel production in the EU, 2006-2009

EU and member States	Million litres				Change in 2009 compared with 2008 (%)
	2006	2007	2008	2009	
EU 27	5507	6435	8733	10187	17
- Germany	2998	3255	3175	2859	-10
- France	837	982	2044	2206	8
- Spain	111	189	233	967	315
- Italy	503	409	670	830	24
- Other	1058	1600	2611	3325	27

Source: Biofuel platform (http://www.plateforme-biocarburants.ch/en/infos/eu-biodiesel.php)

4. OTHER MODES OF TRANSPORT

Rail transport

Technology options for reducing GHG emissions in the railway subsector include mass reduction, regenerative braking, electrification, improved aerodynamics, and more efficient air conditioning. Mass reduction can be achieved *inter alia* through lightweighting. Component-based lightweight design focuses on lightweighting of specific components without fundamental changes to train configuration (for example using aluminium in place of conventional types of steel). System-based lightweighting seeks to redesign the whole train system to achieve an optimal weight without sacrificing the function or quality of the system (for example by reducing the number of bogies). Fuel-injection improvement is another area that has high potential for emission reductions from locomotive diesel engines.

Both pure electric and diesel-electric trains can use regenerative braking.[77] This technology captures the braking energy and converts it into electricity. The captured electricity is either stored on the train and used to supplement the main traction power supply during acceleration, or transferred to other trains or, in some cases, returned to the electricity distribution network.

High speed train links can play a major role in achieving reduced emissions through modal shift from air to train travel.[78] Similarly, improved local train services may reduce emissions from road travel.

Biofuels are still scarcely used in rail transport, but the use of biodiesel may become more important. In Brazil, the locomotives on Carajás Railway of the Mining group Vale do Rio Doce have run on biodiesel (B20) since 2007. Locomotives on Vale's Vitória a Minas Railway are run on a mixture of diesel and 50 to 70 per cent natural gas. Apart from biodiesel, ethanol-electric hybrid locomotives are also under development.[79]

Rail transport is a major beneficiary of G20 stimulus packages committed (IEA, 2009). For example, the US government is providing grants for High-Speed Intercity Passenger Rail (HSIPR) projects. USD 8 billion is being made available under ARRA as an initial down payment to develop a national high-speed and intercity passenger rail system. Grant recipients must comply with the Buy America provisions[80] which specifically provide that the Secretary of Transportation may obligate ARRA funds for a high-speed intercity passenger rail or congestion project only if the steel, iron, and manufactured goods used in the project are produced in the United States. The Buy America requirements described in this section shall only apply to projects for which the costs exceed USD 100,000.

Aviation

Air transport has grown faster than any other transport mode in recent years and is likely to continue growing rapidly in the future. The efficiency of air transport has been improving steadily over time as airlines respond to high fuel costs, but at a much slower rate than travel growth. As a result, aircraft CO_2 emissions have been rapidly rising (IEA, 2009b).

Aircraft fuel intensity can be reduced by a combination of measures, including improved engine technologies, airframe lightweighting, airframe aerodynamics and non-technology options, such as air traffic management and operations that can reduce fuel intensity (IEA, 2009b). In addition, the larger use of alternative fuels has the potential to reduce CO_2 emissions.

Shipping

IEA statistics indicate that maritime transport accounted for about 9 per cent of total transport fuel use in 2006. Approximately 83 per cent was accounted for by international shipping and the remainder by national shipping (IEA, 2009b).

The technological opportunities to reduce fuel consumption in ships can be broadly divided into five categories: engine and transmission technologies; auxiliary power systems; propulsion systems; superstructure aerodynamics; and hull shapes (IEA, 2009b). Some of these are briefly listed in table A.5.[81] In addition, a wide range of operational measures may be applied to reduce fuel consumption in ships. The Second IMO GHG Study 2009 identifies a wide range of options for increasing energy efficiency and reducing emissions by changing ship design and ship operation (IMO, 2009).[82]

International shipping largely relieson heavy fuel oil (HFO), a high-sulphur, low-cost fuel. Shifting to alternative fuels for ships may be relatively expensive. Fuels with lower life-cycle CO_2 emissions include biofuels and LNG (IMO, 2009). The use of biofuels on board ships is technically possible; however, use of first-generation biofuels poses some technical challenges. In addition, limited availability and an unattractive appearance make this option seem unlikely to be implemented on a large scale in the near future.[83] However, it is believed that LNG will become economically attractive, principally for ships in regional trades within Emission Control Areas (ECAs)[84] where LNG is available (IMO, 2009).

5. SOME INTERNATIONAL TRADE ASPECTS

This section analyses certain trade aspects linked with the deployment of climate-related technologies in the transport sector. It covers trade flows, tariffs, NTBs and subsidies. In addition, the Annex presents some general trade statistics that can be used for reference purposes only and should not be interpreted as trade in products and components associated with specific climate-related technologies in the transport sector.

5.1 Trade Flows

Many of the different technology options to reduce CO_2 emissions in the transport sector (Tables A.1 through A.5) may have significant implications for international trade. For example, developments in engine technologies may have implications for trade in engines (as well as in vehicles incorporating specific engines).[85] Lightweighting and the larger use of batteries may have significant implications for international trade in certain materials.[86] The drive towards better fuel-efficiency and emissions performance in vehicles generates demand for critical components. As a result, governments in some developing countries are encouraging imports of such components through autonomous tariff reductions. In most cases an analysis of such linkages would have to be based on expert opinions or industry surveys.

Nevertheless, it is very difficult to link the different technology options identified in the technology mapping study with international trade statistics. When particular climate-related technologies are incorporated into specific transport equipment, it generally becomes relatively easy to identify the HS codes for the equipment concerned. For example, a turbocharged direct injection (TDI) engine – which operates on diesel fuel – is incorporated into a diesel vehicle of a given cylinder capacity, though the corresponding HS code will capture all trade in diesel vehicles of the same cylinder capacity, whether or not it uses TDI technology.

Therefore, unless one is interested in analysing trade in specific components, HS codes generally have a limited use for analysing most of the climate-related technologies in the transport sector.[87] They may, at best, provide an indication of trade flows that may be exposed to the penetration of climate-related technologies.

Only in a few cases is it possible to use existing tariff classification for analysing links between climate-related technologies in the transport sector and international trade flows. These include certain categories of AFVs (such as EVs and certain hybrid vehicles, certain components used in AFVs (such as batteries used in electric cars) and alternative fuels (such as biofuels). However, even in these cases is it not possible to identify the relevant products in specific 6-digit HS codes. The trade analysis, therefore, makes extensive reference to national and regional schedules which define more detailed items.

For the reasons given above, this section presents (i) some general trade statistics, which should be used for reference purposes only and should not be interpreted as trade in products and components associated with specific climate-related technologies; and (ii) an analysis of trade flows which may, in principle, provide some indication of trade in products and components associated with certain technology options for reducing the use of fossil fuels and the release of CO_2 emissions in the transport sector.

5.1.1 Trade in equipment used for different modes of transport

Motor vehicles included in HS chapter 87 account for most of the international trade in transport equipment included in HS chapters 86 through 89 (Table 5). This does not include trade in parts included in other HS chapters. Developing countries account for approximately one-third of total world trade (excluding intra-EU trade). Developing countries are net exporters of ships and net importers of airplanes.

Table 5: Exports of equipment used for different modes of travel (HS 86 through 89), 2008 (Excluding intra-EU trade and trade in components included in other HS chapters)

HS	Subsector	World Value (USD b)		Developing countries				
				Value (USD b)			Share in world (%)	
		Exports	Imports	Exports	Imports	Balance	Exports	Imports
86	Railway	28	18	13	7	7	48	38
87	Motor vehicles	745	707	219	218	1	29	31
88	Aircraft	154	130	20	61	-41	13	47
89	Ships	127	52	75	20	55	59	39
	Total	1054	907	327	306	21	31	34

Source: COMTRADE

5.1.2 International trade in motor vehicles and selected components

According to data compiled by the International Organization of Motor Vehicle Manufacturers (OICA for its acronym in French) the world production of cars and commercial vehicles reached approximately 61 million in 2009, 13.5 per cent less than the year before. Production in Japan and the Unites States fell by approximately one-third. Production also fell in all other developed countries and in most developing countries. However, production in China increased by 48 per cent to 13.8 million units. In India, production increased by 13 per cent (Table A.6).

Japan, the EU and the United States together accounted for 65 per cent of world exports of LDVs (excluding intra-EU trade) in 2008. The principal developing country exporters are, in descending order: the Republic of Korea, Mexico, Turkey, Thailand, South Africa, Brazil, Argentina, China and India (Table A.7). World trade in heavy duty vehicles (HDV) is much smaller. Developing countries accounted for more than 40 per cent of world imports in 2008 (Table A.8).

With regard to engines, the EU, the United States and Japan together accounted for more than 70 per cent of world exports of engines (in the case of both engines for cars and engines for all modes of transport). Developing countries accounted for only around 20 per cent (Tables A.9 and A.10).

5.1.3 Alternative fuel vehicles

Tariff classifications often do not distinguish AFVs from other vehicles with the same ignition type and cylinder capacity. In such cases, it is not possible to use HS codes to analyse trade in AFVs or other low-carbon vehicles. One possible exception is fully-electric passenger cars. Table 6 shows what AFVs may be included, among conventional vehicles, in different 6-digit HS codes.

Table 6: AFVs that may be included in 6-digit HS codes (among other vehicles)

Vehicle types	6-digit HS codes		AFVs that may be included
	HS code	Description	
Buses	870210	Compression-ignition ICE (diesel or semi-diesel):	CNG Clean diesel Hybrid diesel-electric
	870290	Other	CNG Fully electric

Table 6: *Continued*

Vehicle types	6-digit HS codes		AFVs that may be included
	HS code	Description	
LDVs	870321-24; 8704.31	Spark-ignition ICE	Gasoline/ethanol (FFV) Hybrid gasoline-electric Gasoline/CNG
	870331-33; 8704.21	Compression-ignition ICE (diesel or semi-diesel):	Hybrid diesel-electric Diesel/CNG Clean-diesel
	8703.90	Other	Fully electric Plug-in hybrid electric (PHEVs) Hydrogen fuel-cell vehicles (FCVs)
HDVs	870431-32	Spark-ignition ICE	Hybrid gasoline-electric Gasoline/CNG
	870422-23;	Compression-ignition ICE (diesel or semi-diesel):	Hybrid diesel-electric Diesel/CNG Clean-diesel
	870490	Other	Fully electric

One interesting question is how to classify hybrid vehicles in the HS. A hybrid motor vehicle, which has two or more distinct power or fuel sources, may be classified under different HS positions. Where an ICE provides the vehicle's power system its essential characteristic , it will normally be assigned to the same HS position as a motor vehicle whose sole power or fuel source is an ICE (with the same ignition type and cylinder capacity). Therefore, gasoline-electric hybrids will be classified under HS 870321- HS 870324 and diesel-electric hybrids under HS 870331- HS 870333). If the essential characteristic of the vehicle's power system is not an ICE it may be classified under HS 870390. In the case of PHEVs one could consider that it is the electric motor that provides the essential character of the power systems and that these vehicles should therefore be classified as HS 870390

Although it is impossible to know from 6-digit HS trade statistics the amount of exports and imports that correspond to electric cars, a list of the main exporters and importers of the vehicles included in HS 870390 in 2008 and 2009 are shown in Table 6. Total world trade (excluding intra-EU trade) under the provisions of this HS item was around USD 1 billion in 2008. Export and, in particular, import statistics do not appear to be closely correlated with possible incipient developments in EV markets, suggesting that the 6-digit HS code may include other types of vehicles. In any case, it is clear that world trade in vehicles classified as HS 870390 are still very small, accounting for only 0.3 per cent of the value of world trade (excluding intra-EU trade) in passenger cars (see also Table A.7).

Table 7: "Other" vehicles for the transport of persons, including electric cars (HS 870390)

	2008		2009		2008		2009
Exporters	**USD m**	**%**	**USD m**	**Importers**	**USD m**	**%**	**USD m**
All reporters	1138	100.0	–	All reporters	1033	100.0	–
United States	770	67.7	495	Philippines	238	23.1	177
Japan	163	14.4	–	United States	179	17.4	117
EU27	112	9.9	–	Yemen	100	9.7	82
South Africa	17	1.5	6	EU27	99	9.6	–
China	16	1.4	43	Israel	80	7.7	53
India	11	1.0	–	India	73	7.1	–
Canada	10	0.9	6	Qatar	44	4.3	–
Singapore	8	0.7	–	Australia	23	2.2	6
Pakistan	6	0.5	13	Singapore	21	2.1	–
Australia	4	0.4	7	Tunisia	21	2.1	4
Top 10	1118	98.3	–	Top 10	879	85.1	–
Developing countries	71	6.2	–	Developing countries	626	60.6	–

Source: COMTRADE

The Philippines is the largest import market for products included in 870390 (Table 7). The Philippines Tariff Schedule, under various subheadings of 870390 (and 870290), includes duty-free imports of components, parts and/or accessories (including both CBU and CKD) for assembly of specific motor vehicles by participants in the Motor Vehicle Development Program (with a certificate from the Board of Investment (BOI)). The tariff schedule explicitly lists: hybrid (electric and gasoline/diesel), electric, flex-fuel (bioethanol and bio-diesel) and CNG vehicles.

The EU uses a more detailed tariff line, i.e. CN 8703.90.10 for "cars with electric motors". EU trade statistics show that cars with electric motors represent only a relatively small portion of all trade under HS 870390, particularly in the case of trade with third countries . In the period from 2008 to 2009, average annual EU imports (excluding intra-EU trade) were only 23 million euros, whereas exports were only 14 million euros (Table 8). Imports came mainly from Taiwan, China and the United States. Trade flows were irregular, in particular in the case of EU exports.

Table 8: EU27, trade in vehicles with an electric motor (CN 8703.90.10), 2007-2009 (Million euros)

Imports				
	2007	**2008**	**2009**	**Average**
Total extra-EU27	25302	25392	18695	23129
- Taiwan	8715	11502	5346	8521
- China	7839	5512	3548	5633
- United States	4588	5348	1209	3715
- Other	4160	3030	8592	5260
Imports of electric cars as a portion of total imports in HS 870390 (%)	10	12	13	11

Table 8: *Continued*

Exports				
	2007	2008	2009	Average
Total extra-EU27	10425	23282	8504	14070
- United States	852	17518	757	6376
- Switzerland	1906	1311	3888	2369
- Brazil	5269	0	0	1756
- Other	2398	4453	3858	3569
Exports of electric cars as a portion of total exports in HS 870390 (%)	4	35	14	10

Source: EC Export helpdesk

Electric vehicles may also be included in HS 870290 ("Other" motor vehicles for the transport of ten or more persons) and HS 870490 ("Other" motor vehicles for the transport of goods). As in the case of passenger cars, it is not possible from 6-digit HS trade statistics to know the number of exports and imports that correspond to electric vehicles.

5.1.4 Batteries

Battery technologies are of critical importance for facilitating larger market shares for hybrid and electric vehicles. Batteries used for EVs may be included, as "ex-out" items, in all subheadings of HS 8507 (Electric storage batteries) except HS 8507.10 (Lead-acid storage batteries, of a kind used for starting piston engines). Currently, only a small portion of batteries traded under the provisions of these subheadings are likely to be used for electric cars. However, this portion may increase in the future as electric cars gain greater market shares.

World exports of batteries (HS 850720 through HS 850780) are dominated by Asian countries, in particular China and Japan (Table A.12). The EU, Taiwan, Malaysia and Singapore are also significant exporters.

Interestingly, the HTSUS, at the 8-digit level, has dedicated tariff lines for batteries "of a kind used as the primary source of electrical power for electrically-powered vehicles of subheading 8703.90",[88] as follows:

8507.20.40 Other lead-acid storage batteries
8507.30.40 Nickel-cadmium storage batteries
8507.40.40 Nickel-iron storage batteries
8507.80.40 Other storage batteries

Annual US imports of batteries corresponding to these four 8-digit sub-positions reached USD 29.6 million, on average, in the period 2006-2009 (Table 9). This was only 1.6 per cent of total imports of batteries defined at the 6-digit HS level.

Table 9: US imports of batteries of a kind used in electric vehicles, 2006-2009

		2006	2007	2008	2009	Average
Batteries, other than lead-acid storage batteries, of a kind used for starting piston engines						
8507.20	Other lead-acid storage batteries	425.4	550.3	642.2	481.8	524.9
8507.30	Nickel-cadmium storage batteries	261.4	289.4	284.7	218.2	263.4
8507.40	Nickel-iron storage batteries	14.3	9.1	10.5	4.9	9.7
8507.80	Other storage batteries	1092.3	1054.2	1237.7	1020.0	1101.1
Total		1793.4	1903.2	2175.1	1725.0	1899.2
Of a kind used as the primary source of electrical power for electrically-powered vehicles						
8507.20.40	Other lead-acid storage batteries	7.4	15.8	10.5	4.0	9.4
8507.30.40	Nickel-cadmium storage batteries	2.1	6.8	15.3	11.6	9.0
8507.40.40	Nickel-iron storage batteries	0.5	0.3	1.1	0.5	0.6
8507.80.40	Other storage batteries	11.5	9.1	14.8	7.0	10.6
Total		21.5	32.1	41.6	23.1	29.6

Table 9: *Continued*

		2006	2007	2008	2009	Average
Batteries used for electrically-powered vehicles as a portion of all batteries (%)						
8507.20.40	Other lead-acid storage batteries	1.7	2.9	1.6	0.8	1.8
8507.30.40	Nickel-cadmium storage batteries	0.8	2.4	5.4	5.3	3.4
8507.40.40	Nickel-iron storage batteries	3.7	3.8	10.6	10.3	6.4
8507.80.40	Other storage batteries	1.1	0.9	1.2	0.7	1.0
Total		1.2	1.7	1.9	1.3	1.6

USITC Interactive Tariff and Trade DataWeb

In 2009, US imports of batteries used in electric vehicles fell sharply from the levels reached in 2007-2008. The decline was more pronounced than the overall decline in US battery imports. One should not read too much in to this, as trade flows are very small and irregular. As interest in EVs increases, domestic manufacturing capacities of batteries for use in EVs may also increase. Incentives for investments in new and expanded domestic manufacturing capacities may also encourage foreign-owned companies to install or expand manufacturing capacities in the United States rather than exporting to the US market.

The common nomenclature of the EU has more detailed tariff codes for several subheadings of 8507.80 that may be used in electric cars, particularly nickel-hydride (CN 8507.80.20) and lithium-ion (CN 8507.80.30) batteries (Tables A.13 and A.14). Average annual EU imports of lithium-ion batteries from outside the EU were worth 772 million euros in the period of 2007-2009.

The US Department of Energy expects that battery costs will drop by half between 2009 and 2013, as battery factories, having benefitted from ARRA support, begin to achieve economies of scale (by the end of 2015, ARRA investments should help lower the cost of some electric car batteries by nearly 70 percent and a similar same cost improvement applies to plug-in hybrids). The DOE expects that US-based factories will be able to produce batteries and components to support up to 500,000 electric-drive vehicles annually by 2015.

5.1.5 Fuels

In all transport subsectors, the use of alternative fuels has the potential to reduce CO_2 and other GHG emissions on a life-cycle basis (see Tables A1 through A5). This section discusses some trade-related issues, in particular trade flows, classification issues and the possible trade implications of biofuel standards and certification.

Based on the technology mapping study for the transport sector (Kejun, 2010), Wind has identified a range of HS codes for biofuels (Wind, 2010):

- First-generation biofuels, specifically fuel ethanol (included in HS 2207) and biodiesel (which are mostly included in HS 382490, but represent only a very small portion of international trade under the provisions of this HS code).[89]
- Ethanol-blended gasoline and biodiesel-blended petroleum oils. These are included in HS 271011 (light oils and preparations) and 271019 (distillate and residual fuel oils, including blended fuel oils).
- Liquefied natural gas (HS 271111).
- Propane (HS 271121).
- Methanol (methyl alcohol) (HS 290511).

Trade in the above-mentioned HS codes is shown in Annex Table A.17. In general, these HS codes also include unrelated products with alternative fuels often accounting for only a very small portion of total trade captured by the 6-digit HS code. For example, ethanol-blended gasoline and biodiesel-blended oils represent only a very small portion of trade in light oils and preparations. Methanol may be used as a fuel or in the production of synthetic natural gas (SNG). Consequently, the trade data presented in Table A.17 captures much more than actual trade in biofuels. Therefore, the more detailed trade analysis presented below covers only first-generation biofuels, particularly fuel bio-ethanol and biodiesel.

Fuel ethanol

Ethyl alcohol (HS 2207) can be used in beverages, industrial applications, and as a fuel. It is impossible to know the amount of internationally-traded ethyl alcohol that is used for fuel from trade statistics by looking at the 6-digit HS level, although it could be assumed that denatured ethyl alcohol (HS 2207.20) is largely used for industrial applications. World exports (excluding intra-EU trade) of ethyl alcohol were worth USD 4.3 billion in 2008 (Table 10). Those of undenatured ethyl alcohol (HS 2207.10) were worth USD 3.6 billion, with Brazil accounting for two-thirds. The United States is the largest importer of ethyl alcohol (if intra-EU trade is excluded), followed by the European Union.

Table 10: World trade in ethyl alcohol (HS 2207), 2008 (USD millions)

	Ethyl alcohol HS 2207*	Undenatured ethyl alcohol HS2207.10	Ethyl alcohol and other spirits, denatured HS2207.20
Exports			
All countries (excl. intra-EU trade)	4318	3603	671
Brazil	2390	2366	24
United States	410	66	344
Pakistan	220	16	204
El Salvador	195	195	0
Jamaica	152	152	0
Trinidad and Tobago	113	113	0
South Africa	110	99	12
Guatemala	86	85	1
EU-27 (excl. intra-EU trade)	82	70	12
Costa Rica	75	75	0
Developing countries	3687	3372	204
Imports			
All countries (excl. intra-EU trade)	4306	3419	832
United States	1363	1283	79
EU-27 (excl. intra-EU trade)	975	856	120
Canada	354	21	333
Japan	253	253	0
El Salvador	216	216	0
Trinidad and Tobago	162	162	0
Korea, Rep.	159	107	51
Jamaica	140	140	0
India	58	0	58
Developing countries	1278	923	279

** Data shown in this column may be higher than the sum of the data shown in the next two columns because some countries report data at the 4-digit HS level only.*

Brazilian exports of undenatured ethyl alcohol (HS 220710) in the period 2004 through 2009 are shown in Annex Table A.16. The value of total exports increased from USD 460 million in 2004 to USD 2.4 billion in 2008, largely due to large increases in exports to the EU, the United States and countries in the Caribbean and Central America with preferential access to the US markets. The value of exports fell more than 40 percent in 2009 (compared with 2008). The value of exports to the United States fell by more than 80 per cent, largely for the reasons indicated below. However, exports to the EU and countries in the Caribbean and Central America also fell (by around 45 per cent).

Effective July 2008, the HTSUS includes 10-digit codes for US imports of undenatured and denatured ethyl alcohol for fuel use (2207.10.60.10 and 2207.20.00.10 respectively). US imports under these items accounted for around 71 per cent (in value terms) of total US imports under the provisions of HS 2207 in the period July 2008-March 2010, but this portion has been falling – from over 90 per cent in the third quarter of 2008 to only around 20 per cent in the last two quarters Table 11). Direct imports from Brazil represented around 50 per cent of US imports during the third quarter of 2008, but practically disappeared since then — the result of a decision to stop allowing importers to draw back the duty on ethanol by exporting an equivalent volume of jet fuel.[90] Total US imports of fuel ethanol fell from USD 545 million in the third quarter of 2008 to only around USD 82 million per quarter, on average, in the period 2008-IV to 2010-I). The United States also imported ethyl alcohol for fuel use from Costa Rica, El Salvador, Jamaica and Trinidad and Tobago.[91]

Table 11: US imports of ethyl alcohol, including fuel ethanol, 2008-III to 2010-IV, in USD million

		2008 III	2008 IV	2009 I	2009 II	2009 III	2009 IV	2010 I
220710	Undenatured ethyl alcohol	578	139	64	104	193	158	113
2207103000	- For beverage purposes	3	3	4	2	9	5	7
2207106010	- For fuel use	538	107	41	78	152	31	10
2207106090	- Other	36	29	20	24	33	122	96
220720	Ethyl alcohol, denatured	9	10	15	19	22	8	10
2207200010	- For fuel use	6	8	13	16	19	5	8
2207200090	- Other	3	2	2	3	3	2	2
2207	Ethyl alcohol	587	150	79	122	216	166	123
	- For fuel use	545	116	54	94	171	37	19
	Fuel ethanol as a portion of total imports of ethyl alcohol (%)	93	77	68	77	80	22	15

Source: Data compiled from USITC, using the USITC Trade and Tariff DataWeb.

Biodiesel

Unlike bio-ethanol, biodiesel is an industrial product in the WTO context. Biodiesel is part of HS 382490, which includes a very large number of unrelated chemical preparations. As from 1 January 2012, the HS will have a new provision within heading 27.10 for mineral oils mixed with biodiesel and a new heading for biodiesel in Chapter 38 (heading HS 38.26: Biodiesel and mixtures thereof, not containing or containing less than 70 per cent by weight of petroleum oils or oils obtained from bituminous minerals).[92]

The availability of specific national and regional tariff lines for biodiesel in the EU and the United States already makes it possible to identify imports of biodiesel into these markets. Some other countries, including Australia, New Zealand and South Africa also have specific tariff lines for biodiesel.

In the EU a separate code for biodiesel (CN 38249091) was introduced effective January 2008. This code covers fatty-acid mono-alkyl esters (FAMAE). EU import statistics indicate that biodiesel imports under the provisions of CN 38249091 accounted for almost half of total EU imports under the HS 382490 in 2008 and 2009. The bulk of EU biodiesel imports come from only a few countries, in particular the United States, Argentina, Malaysia, Canada and India (Table 12). Imports from the US have fallen dramatically since antidumping and countervailing duties were implemented in 2009. In the case of EU imports, HS 382490 is a good indicator of biodiesel imports from countries such as Argentina, Indonesia and Malaysia, but a very poor indicator of imports from most other trading partners.

Table 12: EU-27 imports of biodiesel and other products included in HS 382490

	Imports (USD million)						Biodiesel as a share of all HS 382490 imports (%)
	HS 382490			Biodiesel (CN 38249091)			
	2008	2009	Average	2008	2009	Average	
All (excl. intra-EU)	2811	2071	2441	1334	1000	1167	48
Argentina	76	545	310	65	537	301	97
Canada	14	94	54	2	77	40	74
India	18	23	20	7	14	10	51
Indonesia	133	114	124	116	94	105	85
Malaysia	53	100	77	28	70	49	64
United States	1854	542	1198	1105	189	647	54
All other	663	653	658	11	19	15	2

Source: EC Export Helpdesk (http://exporthelp.europa.eu/index_en.html)

In the United States, the 10-digit HTSUS code for biodiesel is 382490.40.20. US biodiesel imports accounted for almost one-third of the value of all US imports under the provisions of HS 382490 in the period 2006 through 2009. Most biodiesel imports came from Argentina, Indonesia and Malaysia. Biodiesel accounted for approximately 95 per cent of the value of all imports under the provisions of HS 382490 from these countries (Table 13).

Table 13: US imports of biodiesel and other products included in HS 382490

	Imports of biodiesel (HTS 382490.40.20), USD m				Annual averages 2006-2009		
	2006	2007	2008	2009	Imports of biodiesel USD m	All imports under HS382490 USD m	Biodiesel as a share of all HS 382490 imports (%)
World	**140.5**	**382.5**	**1364.1**	**273.9**	**540.3**	**1684.4**	**32**
Argentina	**0.0**	**33.9**	**756.7**	**62.7**	**213.3**	**217.5**	**98**
Indonesia	**18.6**	**137.7**	**275.1**	**11.9**	**110.8**	**118.4**	**94**
Malaysia	**42.6**	**99.8**	**74.0**	**64.2**	**70.2**	**77.5**	**91**
Canada	**16.0**	**28.7**	**92.0**	**85.7**	**55.6**	**257.1**	**22**
Singapore	**2.6**	**25.5**	**111.1**	**7.7**	**36.7**	**38.9**	**94**
Norway	**6.5**	**8.6**	**9.9**	**12.5**	**9.4**	**9.6**	**98**
All other	**54.2**	**48.3**	**45.3**	**29.3**	**44.3**	**965.3**	**5**

USITC Interactive Tariff and Trade DataWeb

Biodiesel likely represents only a very small part of developing country imports of all products included in the 6-digit code HS 382490.

5.2 Tariffs, NTBs and Incentives

5.2.1 Tariffs: MFN applied rates by modes of transport

MFN applied tariffs for road transport vehicles are high, particularly in developing countries. On the contrary, tariffs applied to railway locomotives, airplanes and ships are generally low in both developed and developing countries (Table 14).

MFN applied rates for passenger vehicles (HS 870321-HS 870390) are quite high in most developing countries (the simple average for developing countries is close to 25 per cent). Tariffs applied to "other vehicles" (HS 870390), which include electric cars, are analysed in more detail below.

In the railway subsector, most countries have MFN applied rates for locomotives of between zero and 5 per cent. Very few countries have MFN applied tariffs of 10 per cent or more (the MFN applied rates is 14 per in Brazil and 10 per cent in both India and Nigeria). Most countries apply zero tariffs to airplanes, under the WTO plurilateral agreement on trade in civil aircraft.[93] In the shipping sector, MFN applied rates for vessels included in HS 8901 (Cruise ships, excursion boats, ferry boats, cargo ships, barges and similar vessels for the transport of persons or goods) are, on average, low. Brazil, Canada and Mexico have MFN applied rates of over 10 per cent.[94]

Table 14: Average MFN applied tariffs in the transport sector

Subsector	HS codes	All countries			Developed countries			Developing countries		
		Av	Min	Max	Av	Min	max	Av	Min	Max
Rail locomotives	8601; 8602	3.3	3.3	3.4	2.5	2.3	2.7	3.7	3.7	3.7
Road transport vehicles	8702; 870321-90 870421-90	16.7	11.0	21.3	5.5	4.1	6.6	20.7	13.4	26.6
- vehicles	870321-90	18.7	11.5	24.9	4.8	3.4	5.9	23.5	14.2	31.6

Table 14: *Continued*

Subsector	HS codes	All countries			Developed countries			Developing countries		
		Av	Min	Max	Av	Min	max	Av	Min	Max
Airplanes	880220-40	1.2	0.9	1.5	0.6	0.6	0.6	1.4	1.1	1.8
Ships	8901	3.4	2.5	4.5	4.2	3.2	5.1	3.3	2.2	4.4
LDVs	870321-90 870421 870431	17.9	11.2	23.6	5.2	3.7	6.3	17.0	10.4	22.5

Source: WTO Tariff Download Facility

Electric cars

In almost all countries, applied rates for vehicles included in HS 870390 (Table 15) are largely the same as for vehicles with a spark-ignition ICE (HS 870321 - 870333). Therefore, lowering tariffs on electric vehicles could, in principle, help to make electric cars more attractive vis-à-vis petroleum-based vehicles (although even allowing electric cars to be imported duty free in most countries would not compensate for the high costs of electric cars).

Table 15: Table MFN applied and bound tariffs on imports of "other vehicles" (HS 870390)

Reporter	MFN applied rates			Bound rates (%)
	Number of national tariff lines	Simple average (%)	Range (%)	
Australia	3	6.7	5-10	15.0
Canada	1	6.1		6.1
EU	2	10.0		10.0
Japan	1	0.0		0.0
New Zealand	3	8.3	12.5-33.3	32.5 (10-55)
Norway	2	0.0		5.3
United States	1	2.5		2.5
Argentina (2004)	1	35.0		35.0
Brazil (2009)	1	35.0		35.0
Chile (2009)	4	6.0		25.0
China (2008)	1	25.0		25.0
Colombia (2009)	2	35.0		40.0
Costa Rica (2009)	14	0.0		100.0
Ecuador (2007)	2	19.0	3-35	40.0
Egypt (2009)	4	56.3	10-135	137.5
Hong Kong, China (2009)	1	0.0		
India (2008)	6	56.7	10-100	
Korea, Republic of (2009)	2	8.0		8.0
Kuwait (2009)	1	5.0		100.0
Malaysia (2008)	45	24.2	5-35	
Mexico (2009)	3	36.7	20-50	50.0
Morocco (2002)	4	41.9	17.5-50	40.0
Pakistan (2009)	1	100.0		
Philippines (2008)	29	19.8	0-30	
Qatar (2009)	1	5.0		15.0

Table 15: *Continued*

Reporter	MFN applied rates			Bound rates (%)
	Number of national tariff lines	Simple average (%)	Range (%)	
Saudi Arabia (2008)	1	5.0		7.0
Singapore (2009)	13	0.0		
South Africa (2007)	2	25.0	20-30	50.0
Taipei, Chinese (2009)	3	20.0	0-30	11.7
Thailand (2009)	13	74.6	10-80	80.0
Tunisia (2008)	32	9.6	0-27	29.0
Turkey (2008)	2	10.0	10	19.5
United Arab Emirates (2007)	1	5.0	5	15.0

Source: WTO Tariff Download Facility

Biofuels

Several countries apply high MFN rates of duty to ethanol imports. The United States, applies an ad valorem tariff of 2.5 per cent, but there is a secondary duty of 14.27 US cents per litre (USD 0.54 per gallon). The MFN applied (and the bound) tariff for imports of undenatured ethyl alcohol applied by the European Union is 19.2 euro cents per litre (EUR 19.2 per hectolitre); for denatured ethyl alcohol it is 10.2 euro cents per litre. The ad valorem equivalents of EU tariffs have been estimated at 63 and 39 per cent respectively (Erixon, 2009).[95] Australia applies a 5 per cent ad valorem tariff plus an AUD 0.38143 (USD 0.34) per litre excise tax on imported ethanol, which is refunded to domestic producers but not on imported volumes. In April 2010, Brazil reduced its MFN applied rate from 20 per cent to zero

MFN applied rates on biodiesel are much lower. In the United States the general rate of duty for imports of biodiesel (HTSUS code 3824.90.4020) is 4.6 per cent ad valorem. In the EU, the third-country rate of duty for biodiesel (CN 38249091) is 6.5 per cent ad valorem. The same rate is applied by Canada. In India the MFN applied rate of duty is 7.5 per cent. Imports into Malaysia and Norway are duty free.

5.2.2 Tariffs in the EGS context

In the context of the EGS negotiations, Japan has submitted a proposal to liberalise trade in a very large range of motor vehicles that use specific climate-related technologies, in particular NGVs, hybrid vehicles, electric vehicles, clean-diesel vehicles and FCVs. The proposal covers practically all categories of motor vehicles that may incorporate such technologies (i.e. vehicles for the transport of persons (HS 8702 and HS 8703), vehicles for the transport of goods (HS 8704) and special-purpose vehicles (HS 8705)). The value of world exports (excluding intra-EU trade) in all vehicles included in the 6-digit HS items listed by Japan was USD 435 billion in 2008, but vehicles actually incorporating these climate-related technologies accounted for only a very small (although unknown) portion of this. With the possible exception of electric vehicles, it is not possible to gain any insights on the value and direction of imports and exports, based on existing tariff classifications and trade databases, including at the national and regional levels. Proposals have also been made to include certain batteries and fuel cells.

Ethanol is not an industrial product in the WTO context. Nonetheless, Brazil has proposed to include ethanol in the EGS negotiations.

The removal or reduction of import duties in key markets could have significant impacts on trade in fuel bioethanol (see above). Singapore has proposed to include biodiesel in the EGS negotiations.

Qatar has proposed to include several fuels: Gas-to-Liquids (GTL) light oils (jet fuel and naphtha, ex HS 271011); several GTL oils that are part of HS 271019 (distillate and residual fuel oils, including blended fuel oils), in particular lube oils, kerosene, paraffin, gas oil (for ships); base oils (ex HS 271019); liquefied natural gas (LNG, HS 271111), GTL LPG (Propane (HS 271112) and butane (HS 271113)); natural gas (HS 271121) and GTL Dimethyl ether (HS 290911), based largely on environmental benefits of these products.

5.2.3 Incentives and NTBs

Alternative fuel vehicles and advanced batteries

Several countries are implementing policies and measures to encourage the market penetration of AFVs. Several OECD countries provide grants and tax credits for the purchase of AFVs. Various countries, including developing countries, provide incentives for investment in infrastructure and fuel delivery systems. Regulatory measures also play an important role. In some developing countries, for example, measures have been implemented that make it mandatory to convert urban buses to NGVs with the aim of reducing urban air pollution. In some countries government procurement guidelines favour the acquisition of AFVs.

Some governments also provide subsidies and other incentives aimed at strengthening manufacturing capacities. For example, the American Recovery and Reinvestment Act (ARRA) has allowed the US Department of Energy to invest more than USD 5 billion to electrify the US transportation sector: USD 2.4 billion for the establishment of 30 electric vehicle battery and component manufacturing plants and USD 2.6 billion in the form of loans for the establishment of electric-vehicle manufacturing facilities (under the Advanced Technology Vehicle Manufacturing (ATVM) Loan Program).

Government support may have implications for patterns of production, competitiveness and international trade flows (for example in the case of trade in batteries). For example, the US Department of Energy expects that ARRA support will allow US-based companies to achieve economies of scale and to significantly increase their share in world production (US Department of Energy, 2010):

> "In 2009, the United States had only two factories manufacturing advanced vehicle batteries and produced less than two per cent of the world's advanced vehicle batteries. By 2012, thanks in part to the Recovery Act, 30 factories will be online and the U.S. will have the capacity to produce 20 per cent of the world's advanced vehicle batteries. By 2015, this share will be 40 percent".

Biofuels

Biofuel markets are affected by government support measures and trade restrictions. Biofuels subsidies have been justified on multiple grounds, particularly in energy security, environmental concerns, rural development and job creation. However, biofuel subsidies have also been an issue of concern. The Global Subsidies Initiative (GSI) found that by 2006 government support for biofuels in OECD countries (in particular for biofuel facilities, production-related payments and exemption of biofuels from fuel-excise taxes) had reached USD 11 billion a year (Steenblik, 2007).

Standards and certification requirements may affect markets for biofuels. Governments are seeking to ensure that only biofuels with high GHG savings potential be counted against biofuel targets and that only these may benefit from support measures. The US Renewable Fuel Standard (RFS), which mandates increasing amounts of "renewable" fuels in the U.S. gasoline supply (almost entirely ethanol), includes sub-standards for cellulosic ethanol and “advanced biofuels”, which are defined as those that decrease greenhouse gas emissions by at least 50 per cent compared with gasoline. In 2010, the EPA confirmed that sugarcane ethanol from Brazil qualified as an advanced biofuel (EPA calculations showed that sugarcane ethanol from Brazil reduces GHG emissions compared to gasoline by 61 per cent, using a 30-year payback for indirect land use change (ILUC) emissions).

In the EU, the 2009 Renewable Energy Directive - which commits each Member State to reach the target of a 10 per cent share of renewable energy in total energy consumption in the transport sector by 2020 - only permits biofuels with high GHG savings to be counted for the national targets and to benefit from lower excise tax rates.[96] The initial threshold of 35 per cent savings compared with petrol and diesel will rise to 50 per cent by 2017 and to 60 per cent for new facilities.

Biofuel certification will be an increasingly important factor in the biofuel market.[97] A key question is whether certification will facilitate trade in sustainable biofuels or act as an NTB.[98] The European Commission encourages industry, governments and NGOs to set up voluntary certification schemes to guarantee that biofuels sold under a label are sustainable and produced under the criteria set by the Renewable Energy Directive (European Commission, 2010). This certificate will apply to biofuels produced in the EU and imported biofuels. Biofuels can still be imported without a certificate but these biofuels cannot receive national public support such as tax relief.

6. CONCLUSIONS

This paper has discussed technology options for reducing CO_2 emissions and increasing fuel efficiency in the transport sector. Successful implementation of these options helps address climate change and improve energy security (by reducing oil imports in importing countries – which is of particular importance in a sector that depends on oil for 95 per cent of its fuel needs).

6.1 Technology Options and Their Linkages With Trade

Technology options in the road, rail, aviation and shipping subsectors basically focus on increasing efficiency and diversifying the fuel mix. Road transport is responsible for almost three-quarters of the transport sector's total CO_2 emissions and offers the largest potential for future CO_2 savings.

One key objective of this paper is to explore linkages between technology options and international trade. The point is made that whereas most identified technology options will have potential implications for trade and competitiveness, trade instruments may play some role in harnessing only a few of these options. For example, a range of engine and non-engine technology options has been identified for reducing CO_2 emissions and increasing fuel efficiency, but mandatory standards[99] and fiscal measures are far more effective in promoting the deployment of incremental technological improvements.

A number of factors may influence the nature of technology-trade linkages in the transport sector:

- Many manufacturers of transport equipment, in particular road vehicles, are transnational corporations (TNCs) operating in different countries and working with networks of first-tier and second-tier suppliers (probably also in different countries). Consequently internal TNC policies and their supply management practices may play an important role in the penetration of technologies.
- Transport equipment (e.g. heavy-duty vehicles,[100] locomotives, airplanes and ships) often has a very long total life span. This slows opportunities to improve fuel efficiency and emissions performance through the introduction of newly-manufactured (and generally more efficient) equipment.
- The automobile sector involves significant trade in parts and components. Trade in critical components for the production of cleaner and more fuel-efficient vehicles may play a key role in the deployment of climate-related technologies in the transport sector.

The WTO negotiations on EGS – which seek to reduce or eliminate tariff and non-tariff barriers to trade - may be particularly relevant in the case of biofuels. Certain Alternative Fuel Vehicles (AFVs) and certain components used in AFVs (such as batteries for electric cars) could be defined as environmental goods, even though none of these products have a perfect match in a 6-digit HS code. However, trade liberalisation alone is unlikely to boost the deployment of AFVs.

6.2 AFVs

Lowering tariffs on AFVs could, in principle, help to make these vehicles more attractive vis-à-vis petroleum-based vehicles. However, liberalising trade in AFVs may not have significant effects, at least in the short run. There are several reasons for this:

- AFVs only have marginal market shares.
- The penetration of AFVs may require extensive investments in new infrastructure and fuel delivery systems.
- Certain AFVs (in particular electric cars and FCVs) can contribute significantly to CO_2 reductions only if the alternative fuels are obtained from low-CO_2 technologies. These may not be available in many countries.

- Even if import duties were to be reduced, certain AFVs, in particular electric vehicles, would still require extensive subsidies to increase their market penetration. Other policies and measures may be more effective than tariffs in stimulating demand for AFVs.
- Some categories of AFVs (such as NGVs) largely comprise of converted gasoline or diesel-fueled vehicles (based on local after-market conversions). Tariff reductions may have implications only for AFVs produced by original equipment manufacturers (OEMs).
- The experience of autonomous tariff reductions in some developing countries shows that certain developing nations with experience in automotive production focus on facilitating imports of parts and components that are critical for the production of more efficient and cleaner cars, including AFVs, rather than on facilitating imports of completely-built AFVs.

Key countries provide subsidies and other incentives to promote the market penetration of AFVs. Subsidies consist of both market-creation measures (e.g. subsidies for the purchase of an AFV) and measures on the supply side (e.g. grants and low-interest loans to support investment in new or larger domestic manufacturing capacities). Subsidies play a key role, particularly in the development of battery technologies and the deployment of PHEVs and EVs. Such subsidies may have significant impacts on patterns of world production and international trade (e.g. in the case of advanced batteries).

6.3 Biofuels

The analysis presented suggests that the elimination of tariff and NTBs, as well as greater discipline in the areas of subsidies may be particularly relevant in the area of biofuels. Tariffs on fuel ethanol[101] are high in important markets, such as the United States and the European Union.

The larger use of certain biofuels raises questions about the magnitude of their savings in GHG emissions based on a life cycle approach and about their environmental sustainability. Therefore, biofuel standards and certification may constitute important instruments to facilitate the further increase in the use of biofuels. On the other hand, standards and certification may act as NTBs. Since biofuel markets are driven largely by Government initiatives, Governments should seek to ensure that certification programmes (including voluntary private-sector certification programmes that determine access to government targets and incentives), are fair and transparent. For example, the European Commission encourages industry, governments and NGOs to set up voluntary certification schemes to guarantee that biofuels sold under a label are sustainable and produced under the criteria set by the Renewable Energy Directive. Biofuels will still be able to be imported without a certificate but cannot receive national public support such as tax relief (European Commission, 2010).

6.4 Tariff Classification Issues

This paper has paid considerable attention to tariff classification issues. AFVs and certain biofuels could, in principle, be considered as environmental goods in the context of the EGS negotiations, but none of these products (or any other product associated with the deployment of climate-related technologies identified in the technology mapping study) finds a perfect match in 6-digit HS codes.

Since AFVs and biofuels are important for the implementation of climate-mitigation policies in the transport sector, national and regional (EU) authorities have, in some cases, already taken or are considering taking steps to add specific subheadings to the common 6-digit HS codes in their national or regional tariff schedules:

- In the area of biofuels, effective July 2008 the US created new 10-digit HTS codes for US imports of ethyl alcohol for fuel use. The United States has a separate 10-digit code for biodiesel and the EU introduced a dedicated 8-digit tariff line for biodiesel (CN 3824.90.91) in January 2008.[102] Some other countries, for example Australia, New Zealand and South Africa also have separate national tariff lines for fuel bioethanol and biodiesel.

- With regard to electric vehicles and their components, the EU uses a more detailed tariff line (CN 8703.90.10) for "cars with electric motors". The US does not have a separate tariff line for electric cars, but has specific 10-digit codes for batteries and motors "of a kind used as the primary source of electrical power for electrically-powered vehicles of subheading 8703.90". The CN of the EU included more detailed tariff lines for certain batteries included in HS 850780, in particular nickel-metal-hybride (NiMH) batteries (CN 8507.80.20) and lithium-ion (CN 8507.80.30) batteries (although these are not exclusively used for electric vehicles).

As of 1 January 2012, the HS will have a new heading for biodiesel in Chapter 38 (heading HS 38.26) and a new provision within heading 27.10 for mineral oils mixed with biodiesel.

EVs and PHEVs are only starting to be commercialised and current international trade is still insignificant. Yet with the growing importance of government policies to support EVs and PHEVs and the expected increase in market shares in alternative policy scenarios, it may be desirable to consider possibilities for creating more detailed tariff lines at national and regional levels, or perhaps even at the 6-digit HS level. Currently, the HS essentially classifies LDVs according to their power system (further subdivided according to cylinder capacity): (i) spark-ignition ice; (ii) compression-ignition ice (diesel or semi-diesel) and (iii) "other". It may be possible in the future to create a dedicated subdivision for cars with an electric power system (which currently form part of "other").

ENDNOTES

1 The technology mapping study for the transport sector has been prepared for ICTSD by the Energy Research Institute, China (Kejun, 2009).

2 Sustainable transport strategies include both technology options and other approaches. The Avoid-Shift-Improve (ASI) framework for exploring options for reducing transport GHG emissions outlines three different approaches (which may be implemented in combination): avoid the need to travel, *shift* to more sustainable modes and *improve* the efficiency of modes (Dalkmann and Brannigan, 2007). There is a shift in thinking on how to best mitigate climate change in the transport sector away from a focus on technology options to include measures aimed at modal shift and avoidance of travel (Huizinga and Bakker, 2010). A recent report by the US Department of Transportation analyses 4 strategies for reducing transport GHG emissions: introducing low-carbon fuels, increasing vehicle fuel economy, improving transportation system efficiency, and reducing carbon-intensive travel activity. It analyses 5 categories of policy actions for implementing these strategies: an economy-wide price signal, efficiency standards, market incentives, transportation planning and investments to achieve GHG reduction, and research and development (US Department of Transportation, 2010).

3 Other WTO issues may nevertheless arise, e.g. in the areas of subsidies and public procurement.

4 Many countries apply zero tariffs to aircraft and parts under the WTO plurilateral agreement on trade in civil aircraft.

5 Certain developing countries (e.g. Thailand) have reduced tariffs on imports of parts and components that are critical for the production of more efficient and cleaner cars and have introduced incentives to attract foreign direct investment (FDI), with a view to gaining a competitive edge in the production and export of fuel-efficient cars. The Philippines is allowing duty-free imports of components, parts and/or accessories for assembly of AFVs.

6 Standards focus on performance rather than on the use of specific technologies.

7 Strictly speaking non plug-in hybrid vehicles are not AFVs, because they do not promote the use of alternative fuels. However, in this paper HEVs are included among AFVs. Hybrid-electric vehicles use a battery-powered electric motor, a gasoline (or diesel) ICE and a concept known as regenerative braking to power the vehicle. Their primary power comes from the ICE, although they use the electric motor when accelerating or climbing hills. The electric motor does not need an external power supply for recharging, because its batteries are recharged by regenerative braking.

8 Proposals on transport-related EGs tabled in the context of the EGS negotiations so far focus on these categories of goods.

9 Hybrid motor vehicles have two or more distinct power or fuel sources. When an internal combustion engine (ICE) provides the vehicle’s power system its essential character, a hybrid vehicle is normally assigned to the same HS position as a motor vehicle (with the same ignition type and cylinder capacity) whose sole power or fuel source is an ICE. Electric cars, which have an electric motor that provides the essential character of the vehicle’s power system, form part of HS 870390.

10 Non-PHEV hybrid vehicles do not require any change in infrastructure.

11 Components may play a large role in the penetration of more efficient and cleaner technologies in the automobile sector. For example, patents may play a relatively important role in innovation in hybrid-electric vehicles, but patent applications have focused on several components of hybrid cars (rather than on hybrid cars) as the hybrid concept itself is a modular technology for which no all-embracing patents can be expected (Doll, 2009).

12 Calculations by the US Environmental Protection Agency (EPA) show that sugarcane ethanol from Brazil reduces GHG emissions compared to gasoline by 61 per cent, using a 30-year payback for indirect land use change (ILUC) emissions.

13 Even higher emissions would result in the case of biodiesel originating from palm oil plantations established on drained peatland (UNEP, 2009).

14 Intelligent transportation systems (ITS) include a wide range of information and communication technologies.

15 The IEA, in its World Energy Outlook 2009 (Figure 4.4), estimates that G20 stimulus packages committed in 2009 (for a total of USD 2.6 trillion) had a “low-carbon” or “green energy” component (covering green energy generation and EE) of USD 242 billion (this includes only additional commitments to stimulate investment, newly announced in 2009). Apart from the transport-related commitments, USD 67 billion is to be invested in the buildings sector and USD 20 billion in renewable energy. An HSBC report indicates that China accounts for the lion’s share of stimulus investment in rail transport (USD 98.9 billion out of USD 121.8 billion), followed by the United States, the Republic of Korea and Europe (HSBC, 2009).

16 Drivers will not find AFVs attractive without ready access to fuel, parts, and repair services, but energy producers, automakers and governments will not invest in AFV technology and infrastructure without the prospect of a large market.

17 For example, special incentives for hybrid vehicles may sometimes encourage the development of vehicles that are nominally hybrid but not necessarily the most fuel efficient. Policies designed to encourage very efficient vehicles are more likely to encourage adoption of very efficient hybrid designs, as well as other very efficient designs and technologies (IEA, 2009b).

18 NAMAs are voluntary emission reduction measures undertaken by developing countries that are reported by national governments to the UNFCCC. They are expected to be the main vehicle for mitigation action in developing countries under a future climate agreement, and can be policies, programs or projects implemented at national, regional, or local levels.

19 The sector accounts for approximately 15 per cent of overall greenhouse gas (GHG) emissions. The contributions to CO_2 and GHG emissions are estimated on a “source” basis. When estimated on an “end-user” basis, the contribution of the transport sector would be 28 (rather than 23) per cent. End-user calculations allocate CO_2 and greenhouse gas (GHG) emissions in the energy sector to end-use sectors. For example, emissions from transport fuel refinery operations would be allocated to the transport sector (in source calculations these emissions would be part of the energy sector). End-user calculations are less accurate.

20 Over the same period, transport-sector GHG emissions in Europe increased by 28 per cent, compared with a reduction of 11 per cent in emissions from the non-transport sectors and

5 per cent across all sectors. The increase occurred even though fleets improved their energy efficiency as transport volumes increased (European Environment Agency, 2010).

21 The Reference Scenario assumes that governments make no changes to their existing policies and measures.

22 The recent downturn in economic activity has caused a significant drop in transport-related emissions. According to the International Transport Forum (ITF, an intergovernmental organisation within the OECD) the increase in global CO_2 emissions from transport until 2020 may be lower than estimated in the Reference Scenario, depending on the strength of the economic recovery. The increase until 2030 may be 40 per cent (International Transport Forum, 2010).

23 The IEA publication lists several reasons for this. Oil and oil products such as gasoline and diesel fuel are extremely effective transport fuels, with high energy density and relatively easy handling and transportation characteristics. Oil prices have been low on average compared with available alternatives over the past 20 years. In addition, most alternative fuels require new types of vehicles and extensive investments in new infrastructure and fuel-delivery systems that make it difficult for them to compete, given the extensive oil-based vehicle stock and infrastructure already in place. But petroleum fuels also have at least two major drawbacks: potential supply limitations, including for many countries significant geopolitical dependencies, and high CO_2 emissions (IEA, 2009b).

24 Similar efficiency improvements may be possible for other modes, although the estimation of technology potentials for trucks, ships and aircraft is not as accurate as it is for LDVs (IEA, 2009b).

25 The analysis presented in this paper focuses on government policies and measures. Many manufacturers of transport equipment, e.g. road vehicles, are transnational corporations (TNCs) operating in different countries and working with networks of first-tier and second-tier suppliers (often in different countries). Consequently, the internal policies of TNCs and their supply management practices may play an important role in the penetration of climate-friendly technologies. However, an analysis of such policies is beyond the scope of this paper.

26 It can be argued that incentive measure should be ultimately supportive of a hierarchy of sustainable transport systems. For example, public transport should get preference over individual/private transport and vessel and rail transport should be preferred to vehicle and airplane transport;

27 In September 2009, leaders of the Group of Twenty (G-20) made a commitment to reform their fossil-fuel subsidies.

28 The target is to reduce transport GHG emission by 33-37 per cent by 2002, compared to a business-as-usual scenario (Park, 2010).

29 The original transport-sector target was envisioned to be met entirely with biofuels. It was later modified to include all types of energy from renewable sources, including electricity. In addition, biofuels will be considered to meet the objectives of the Directive when they meet sustainability criteria. Furthermore, from 2017 onward, the GHG emission savings of biofuels produced in existing production plants must be at least 50 per cent compared with fossil fuels. The GHG emissions of biofuels produced in new installations will have to be at least 60 per cent lower than those from fossil fuels.

30 For example, in the EU, the 2009 Directive on the Promotion of Clean and Energy Efficient Road Transport Vehicles requires that lifetime impacts of vehicles shall be taken into account in purchase decisions, including least energy consumption and CO_2 emissions. Similarly, the United Kingdom has a Low Carbon Vehicle Procurement Programme (LCVPP), which is funded by the Department for Transport to help public-sector organisations procure low-carbon vehicles (http://www.cenex.co.uk/programmes/lcvpp).

31 For a survey of vehicle scrapping schemes in Europe, see IEA (2009b), Box 4.4.

32 The US programme provided a rebate of either USD 3,500 or USD 4,500 per car (with a ceiling of USD 3 billion). Under the programme, nearly 700,000 "clunkers" were taken off the roads and replaced by more fuel-efficient vehicles. Cars purchased under the programme are, on average, 19 per cent above the average fuel economy of all new cars currently available, and 58 per cent above the average fuel economy of cars that were traded in (United States Department of Transportation, 2009).

33 According to the IEA, imported second-hand vehicles represent a significant share of newly registered vehicles in a number of countries, particularly in Eastern Europe and Africa. About 90 per cent of all internationally traded used vehicles come from OECD countries. The United States and European countries export used vehicles to a few, often close, regions. Japan exports used vehicles all over the world, except where this is prevented from happening, e.g. through import restrictions (IEA, 2009b).

34 In the United States, for example, a limited tax deduction is available for individuals and businesses for the cost of a clean-fuel vehicle. The maximum amount of the deduction is USD 2,000 for cars and smaller vehicles, and USD 5,000 or USD 50,000 for trucks or vans meeting certain size requirements http://en.openei.org/wiki/Deductions_for_Clean-Fuel_Vehicles_and_Refueling_Property_(Federal).

35 The Chinese government aims for 5 per cent of total car sales to be for "new energy cars" by 2011 (This will be more than 600,000 vehicles as 13.8 million cars and commercial vehicles were sold in China in 2009 (Table A.6)).

36 In the United States, a tax credit is available for the cost of installing alternative fuelling equipment placed into service after 31 December 2005. Qualified alternative fuels are natural gas, liquefied petroleum gas, hydrogen, electricity, E85, or diesel fuel blends containing a minimum of 20 per cent biodiesel. The credit amount is up to 50 per cent, not to exceed USD 50,000 for equipment placed into service on or after 1 January 2009. In the United Kingdom, under the Infrastructure Grant Programme of the Department for Transport, funding is available for hydrogen, electric, natural gas or biogas stations and gas blends (http://www.cenex.co.uk/programmes/igp).

37 This obligation applies in fiscal year 1999 and beyond where the fleets have 20 or more vehicles, are capable of being centrally fuelled, and are operated in a metropolitan statistical area with a population of more than 250,000 based on the 1980 census.

38 Argentina, Bolivia, Brazil, China, Colombia, Dominican Republic, India, Jamaica, Kenya, Republic of Korea, Malaysia, Paraguay, Peru, Philippines, Africa, Thailand and Uruguay. In addition, some countries, such as Chile and South Africa, have future indicative targets. For details see Renewables 2010 Global Status Report (REN21, 2010), Table R12.

39 The Global Subsidies Initiative (GSI) has carried out a comprehensive and critical analysis of subsidies and other support measures in OECD countries and some key developing countries.

40 Excise tax exemptions are a key support measure for biofuels in almost all EU Member States.

41 NAMAs are voluntary emission reduction measures undertaken by developing countries that are reported by national governments to the UNFCCC. They are expected to be the main vehicle for mitigation action in developing countries under a future climate agreement, and can be policies, programs or projects implemented at national, regional, or local levels.

42 In October 2009, the executive board of the CDM approved a methodology (ACM0017) for the production (not consumption) of biodiesel for use as a fuel (biodiesel from waste oil and waste fats had already been approved by the board to generate carbon credits). The new methodology will allow for the generation of carbon credits from crops that are specifically grown as feedstock for biodiesel, but only on dedicated plantations that are established on degraded or degrading lands. The methodology is only eligible for biodiesel produced and used within the host country and for vehicles.

43 The loads on the vehicle consist of the force needed to accelerate the vehicle, to overcome inertia; vehicle weight when climbing slopes; the rolling resistance of the tyres; aerodynamic forces; and accessory loads.

44 Unlike CO_2, CH4 and N2O emission rates are affected by vehicle emissions control technologies.

45 In the case of electric and hybrid vehicles lightweight materials may help to offset the added weight of their batteries.

46 The Government of Thailand, for example, has provided tariff concessions to electronic fuel injection systems, automatic transmissions and continuously variable transmissions (CVT).

47 In the United States, alternative fuels and AFVs are defined in the Energy Policy Act of 1992 (EPA) and Section 2862 of the National Defense Authorization Act of 2008 (these Acts provide for AFV acquisition credits to be awarded to Federal agencies). EPAct defines the following alternative fuels: pure methanol, ethanol, and other alcohols; blends of 85 per cent or more of alcohol with gasoline; natural gas and liquid fuels domestically produced from natural gas; liquefied petroleum gas (propane); coal-derived liquid fuels; hydrogen; electricity; pure biodiesel (B100); fuels, other than alcohol, derived from biological materials; and P-Series fuel (a blend of natural gas liquids (pentanes plus), ethanol, and the biomass-derived co-solvent methyltetrahydrofuran (MeTHF), to be used in FFVs). The DOE is authorized to designate additional fuels as alternative fuels, provided that the fuel is largely non-petroleum, yields substantial energy security benefits, and offers substantial environmental benefits. The National Defense Authorization Act of 2008 includes new qualified fuel-cell motor vehicles, advanced lean burn technology motor vehicle and new qualified hybrid motor vehicle (as defined in section 30B(d)(3) of that Code) among the AFVs eligible for credits.

48 Full hybrid vehicles enable engine downsizing and better performance. Apart from full hybrid vehicles, the range of hybrids includes stop-start and mild-hybrid vehicle. Stop-start systems automatically stop the engine when the vehicle is stationary, for example at traffic lights; the engine is restarted as soon as the driver depresses the clutch pedal to select a gear. Stop-start technologies, which are relatively inexpensive, may bring some benefits in heavy urban traffic, but do not enable engine downsizing. Mild-hybrid vehicles have a small motor that supplements engine power, usually enabling some engine down-sizing.

49 To optimize performance, emissions, and fuel efficiency, a computer is used to manage the energy from these three systems. The computer senses the driving mode and the battery's charge and then directs energy from either the battery system or the gasoline engine to the most appropriate drive-train component, an electric motor or an engine drive shaft. Regenerative braking systems, which recover energy that is otherwise wasted, allow hybrids to be especially fuel-efficient in stop-and-go city driving. Some have argued that by utilizing these hybrid technologies, fuel economy can be improved by up to 25 per cent over conventional automobiles (Auto Alliance, Alternative Fuel Vehicles. Accessed at: http://www.autoalliance.org/)

50 According to the IEA, the share of hybrids in the global fleet was only 0.15 per cent in 2007. The IEA expects that with existing support measures (which have been incorporated in the IEA Reference Scenario), the share of hybrid vehicles in the global vehicle fleet may reach 5.3 per cent by 2020 and 6.1 per cent by 2030.

51 A recent market report by SBI Energy estimates that over 700,000 hybrid electric vehicles (HEVs) were sold worldwide in 2009 (a 33 per cent increase over 2008), accounting for 1.5 per cent of the world passenger vehicle market in 2009, and almost 8 per cent of the passenger vehicle market in Japan (SBI Energy, 2010). Japan, with sales of 334,000 HEVs in 2009 (48 per cent of global sales), overtook the United States as the world's leading market (42 per cent respectively of global sales). In the United States, according to manufacturer-reported numbers (as posted on www.hybridcars.com/market-dashboard.html), 290 thousand HEVs were sold in 2009 (whereas the overall passenger vehicle market fell by 21 per cent, HEVs sales were only 8 per cent less than in 2008; this relatively favourable development could be attributed largely to incentives and the introduction of new models). The share of HEVs in the US market was 2.8 percent. In the period 2001-2009, over 1.6 million HEVs were sold in the United States. Average annual sales in the period 2006-2009 were 300,000 HEVs (US Department of Energy, Alternative Fuels Data Center).

52 Data on "vehicles on the road" often simply add up annual sales over certain time periods without taking into account retirements of vehicles". For example, the figure given on HEVs in the United States (1.6 million) corresponds to accumulated sales in the period 1999-2009.

53 Another reason is that the two data series are defined differently: "Made available" means the sale or lease of a new AFV, or conversion of an existing vehicle to enable it to use an alternative fuel. Data on AFVs in use represent accumulated acquisitions less retirements, as of the end of each calendar year.

54 While the production of hybrid vehicles and their most critical components, such as batteries, takes place largely in Japan and the US, Doll (2008) found that EU27 countries hold around 60 per cent of patents for hybrid propulsion systems and their components. Doll analysed patents applications for several components of hybrid cars at the European Patent Office (EPO) and the World Intellectual Protection Organization (WIPO) in the period 2000-2004. His study concentrates on components of hybrid cars as the hybrid concept itself is a modular technology for which no all-embracing patents can be expected. Key components analysed are: electric motors; battery technology and combustion engines (Doll did not find specific patents for transmission or gear systems and power regulation electronics). Germany alone accounted for 40 per cent of all patent applications in the period 2000-2004. Doll suggests that this could be explained by its key role in innovation in electric motors, brake systems for energy recuperation and combustion engines. Japan accounted for 29 per cent of all patent applications and the United States 12 per cent.

55 Yet, the company only managed to sell about 100 cars to government institutions. http://www.hybridcars.com/news/china-byd-offers-plug-hybrid-individual-buyers-27587.html.

56 The awards cover the following areas: (i) USD 1.5 billion in grants to US-based manufacturers to produce batteries and their components and to expand battery recycling capacity; (ii) USD 500 million in grants to US-based manufacturers to produce electric drive components for vehicles, including electric motors, power electronics, and other drive train components ; and (iii) USD 400 million in grants to purchase thousands of plug-in hybrid and all-electric vehicles for test demonstrations; deploy them and evaluate their performance; install electric charging infrastructure; and provide education and workforce training to support the transition to advanced electric transportation systems.

57 ATV and ATV components manufacturers may be eligible for direct loans for up to 30 per cent of the cost of re-equipping, expanding, or establishing manufacturing facilities in the United States to produce qualified ATVs or ATV components.

58 It is expected that most early introductions of pure EVs will occur in small LDV market segments (IEA, 2009b). Smaller and lighter vehicles need fewer batteries to go a given distance than larger vehicles.

59 Car batteries may allow utilities to more effectively manage their electricity generating by providing storage capacity that can be used to absorb “excess energy” that routinely occurs in utility systems (“excess energy” may be particularly relevant in the case of renewable energy, which is inherently variable). Car batteries can thus provide a buffer to lighten the load on the grid during peak times and potentially provide back-up power to homeowners. Intelligently-managed EV charging approaches may become a key element of utility smart grid strategies. Put otherwise, growth in renewable energy, like solar and wind power, will drive additional demand for storage capacity, especially with increased smart grid electricity deployment all over the world.

60 This section draws on WhatGreenCar (http://www.whatgreencar.com/lpg.php)

61 In the United States, some 151,000 LPG cars were in use in 2008, accounting for 19 per cent of AFVs in use in the country. This is less than the number of LPG cars in use in the past. For example, there were 173,000 LPG cars in use in 1995, accounting for 70 per cent of AFVs in use in the United States. The number of LPG cars in use peaked in 2003 (90,000 or 36 per cent of all AFVs in use in the United States). Vehicles in use represent accumulated acquisitions less retirements as of the end of each calendar year.

62 According to the US Department of Energy, advanced diesel vehicles using EPA-mandated ultra-low sulfur diesel (ULSD) fuel are among the most fuel-efficient vehicles available today (US Department of Energy, Alternative Fuels Data Center).

63 In India, in response to a citizen lawsuit initiated in 1985 over poor air quality in New Delhi, the Supreme Court issued a series of resolutions instructing the government to ensure that all public transportation, buses, taxis, three-wheeler switch to clean alternative fuel.

64 This is an established technology. Biogas is a mixture of biomethane CH4 (65-70 per cent), CO_2 (30-35 per cent) and small amounts of other gases. Biogas can be used in stationary reciprocating engines or gas turbines to generate electricity and heat, but is not suitable as a vehicle fuel. To be used as a transport fuel biogas has to be upgraded to at least 95 per cent methane by volume. Separating out the carbon dioxide and the contaminants from biogas leaves biomethane, which chemically is the same as natural gas.

65 The 10 millionth FFV was delivered in March 2010.

66 By the end of 2008, FFVs represented 24 per cent of all 27.8 million passenger cars in circulation in Brazil. Cars running only on biofuels represented another 10 per cent and cars fuelled by diesel 8 per cent. Only 58 per cent of cars in circulation were fuelled only by gasoline (InfoMoney, 2009).

67 More than a million E85 FFVs were "made available" (meaning the sale or lease of a new AFV, or conversion of an existing vehicle to enable it to use an alternative fuel) every year in the period 2006 through 2008 (US Department of Energy, Onroad Alternative Fuel Vehicles Made Available. http://www.afdc.energy.gov/afdc/data/vehicles.html).

68 Biodiesel is a renewable diesel fuel that is also known as FAME (fatty-acid methyl ester). Normally, it can substitute diesel only after a process called inter-esterification. A wide number of raw materials can be used for the production of biodiesel. Rapeseed oil methyl ester (RME) is produced largely in Europe. Palm oil methyl ester (PME) is produced principally in Indonesia and Malaysia. Soya bean oil methyl ester (SME) is produced in the United States and Latin America (Argentina and Brazil). The production of biodiesel made from used cooking oil, known as used cooking-oil methyl ester (UCOME), suffers from supply constraints. There has been increased attention for biodiesel produced from jatropha (a non-edible oil). The plant can grow on marginal lands and may provide opportunities for farmers in places such as India and Africa. According to a report published by FAO and the International Fund for Agricultural Development (IFAD), jatropha has the potential to contribute towards pro-poor development, sustain rural income and improve livelihoods. However, its chief weaknesses relate to the fact that it is an essentially wild plant that has undergone little crop improvement (Brittaine and Lutaladio, 2010).

69 Second-generation biofuels hold the potential to deliver significant energy and GHG benefits, while reducing the risk of competition with food and feed production. However, the prospects and timing of full-scale commercialization of these technologies are uncertain. In addition, due to economies of scale, a number of logistical and economic barriers need to be addressed, including the availability of large scale biomass resources (ICTSD, 2008a).

70 The remaining 10 per cent was pure vegetable oil consumed in Germany, Ireland and the Netherlands and biogas in Sweden.

71 In the United Kingdom, the Renewable Transport Fuels Obligation (RTFO) requires suppliers of petrol or diesel to include small proportions of, respectively, bioethanol or biodiesel blended into their products. These proportions are to increase gradually to 5 per cent in 2013/2014.

72 Ethanol fuel mixtures have "E" numbers which describe the percentage of ethanol in the mixture by volume, for example, E10 is 10 per cent anhydrous ethanol and 90 per cent gasoline. Other common blends include E5 and E7.

73 When blended with petroleum-based diesel, the percentage of biodiesel is specified following the letter "B". So, B5, a common blend level, contains 5 per cent biodiesel and 95 per cent petroleum diesel. Other commonly available blends include B2, B10 and B20. B100 designates pure biodiesel

74 Some diesels are modified to use higher concentrations, such as B20 or B100.

75 The report expects that the market will increase to USD 12.6 billion in 2014, with revenues in the American and European markets accounting for 28.6 per cent and 55.6 per cent of the total respectively.

76 However, Brazil's current ethanol infrastructure was extremely costly to create and required decades of subsidies before it became economically viable (ICTSD, 2008a).

77 General Electric is designing a hybrid diesel-electric locomotive that will capture the energy dissipated during braking and store it in a series of sophisticated batteries. That stored energy can be used by the crew on demand – reducing fuel consumption by as much as 15 percent and emissions by as much as 50 percent compared to most of the freight locomotives in use today.

78 High speed rail may consume more power and hence be less carbon efficient than conventional rail.

79 For example, Alternative Hybrid Locomotive Technologies (AHL-TECH) is developing ethanol-electric hybrid locomotives.

80 Set forth in 49 U.S.C. 24405(a).

81 Table A.5 includes renewable energy technologies. According to the Second IMO GHG Study 2009, renewable energy is technically feasible only as a partial source of replacement power, due to the variable intensity and the peak power of wind and sunlight. Also, current solar-cell technology would, on average, only be sufficient to cover a fraction of the auxiliary power even if the complete deck area was covered by photovoltaic cells (IMO, 2009).

82 See also UNCTAD (2008).

83 One ambitious IEA ("BLUE Map") scenario assumes that, with sufficient policy support and further R&D, low-GHG biofuels could achieve a 30 per cent market share by 2050. These could be either advanced BTL biodiesel blended into petroleum fuel or some "biocrude" type fuels (IEA, 2009b).

84 A designated sea area established by the International Maritime Organisation (IMO); ships operating in an ECA are required to comply with the more stringent geographical standards (compared with global standards) for fuel sulphur and engine NOx limits. Annex VI to the International Convention on the Prevention of Pollution from Ships (MARPOL)) consists of two sets of standards to control emissions from ships. The global standards for the sulphur content of fuel and nitrogen oxides (NOx) emissions from engines apply to ships at all times. In recognition that some areas may require further control, Annex VI also contains geographic-based standards.

85 The value of world exports of engines and engine parts for the transport sector (excluding intra-EU trade) was USD 167b in 2008 (Table A.13).

86 This may raise a number of issues not addressed in this paper, such as the cost and long-term availability of key materials (e.g. lithium used in batteries) and the environmentally safe disposal of batteries. While lightweighting results in reductions in fuel use and CO_2 emissions during the use of the car, the impacts of fabrication and recycling of lightweight materials may be substantial relative to steel.

87 This problem also arose in the context of the ICTSD studies on the renewable energy supply and, particularly, the residential and commercial buildings sector. However, in these sectors it was possible to identify a representative number of HS codes, including more detailed national and regional tariff schedules, allowing for a reasonably accurate analysis of trade flows associated with certain technologies.

88 For US imports but not for US exports. The HTSUS also has a dedicated code (8501.32.45) for imports of “electric motors of a kind used as the primary source of mechanical power for electrically powered vehicles of subheading 8703.90”.

89 Trade in biodiesel may not fully reflect rising demand for biodiesel, as some countries may import feedstocks for domestic processing into biodiesel. Whereas processing of oils into biodiesel may take place in countries different from those where the feedstocks are grown, fuel bioethanol is generally manufactured in countries which also cultivate the feedstocks (UNCTAD, 2006).

90 The US Farm Bill of 2007 eliminated duty drawback on re-exports of fuels and mixtures that do not contain ethanol, effective 1 October 2008. Previously, exported fuels and mixtures were eligible for duty refund on imported ethyl alcohol or an ethyl alcohol mixture even if the re-exported article upon which a drawback claim was based did not contain ethyl alcohol or a mixture of ethyl alcohol (e.g. jet fuel).

91 These countries are granted preferential access to the US market under either the Caribbean Basin Economic Recovery Act (CBERA) or the Central America Free Trade Agreement (CAFTA): up to 7 per cent of the US ethanol market may be supplied duty-free by ethanol containing no local feedstock. In this case, hydrous (“wet”) ethanol produced in other countries, such as Brazil, can be shipped to a dehydration plant in a CBERA country (or Costa Rica or El Salvador, under CAFTA) for reprocessing. Dehydration plants were operating in all four countries

92 Izaak Wind, personal communication.

93 The WTO plurilateral agreement on trade in civil aircraft, which entered into force on 1 January 1980 and has 30 signatories, eliminates import duties on all aircraft, other than military aircraft, as well as on all other products covered by the agreement — civil aircraft engines and their parts and components, all components and sub-assemblies of civil aircraft, and flight simulators and their parts and components.

94 Malaysia applies 25 per cent tariffs to some items.

95 In the period 2006-2009, almost half of EU imports of undenatured alcohol came from Brazil (at MFN rates of duty). Imports from Pakistan, the second largest import source over the same period, were also subject to MFN rates of duty. Other important suppliers were Guatemala (the second largest supplier in 2009), Peru, Bolivia, Nicaragua, Costa Rica and Egypt. These countries enjoyed duty-free access.

96 The 2009 Renewable Energy Directive (which will come into effect in December 2010) aims to achieve a 20 per cent share of energy from renewable sources in the Community’s gross final consumption of energy and a 10 per cent share of energy from renewable sources in each Member State’s transport energy consumption by 2020.

97 The Roundtable on Sustainable Biofuels (RSB) is an international initiative coordinated by the Energy Center at the EPFL (École Polytechnique Fédérale de Lausanne) that brings together farmers, companies, non-governmental organizations, experts, governments, and inter-governmental agencies concerned with ensuring the sustainability of biofuels production and processing. In May 2010, the RSB released a set of biofuels sustainability standards for pilot-testing.

98 Private-sector initiatives also play a role in assuring the supply of verified sustainable ethanol. An example is the Verified Sustainable Ethanol Initiative developed by Sekab - a leading European supplier of renewable fuels in Sweden - and four Brazilian sugarcane ethanol producers (ICTSD, 2008b).

99 Standards focus on performance rather than on the use of specific technologies.

100 Most heavy duty trucks operated in developing countries are imported when they are five to ten years old, and retired much later than in North America and Europe. This slows the rate of technology penetration (IEA, 2009b).

101 Bioethanol is considered as an agricultural product in the WTO context.

102 According to the "EU Strategy on Biofuels", the Commission will assess the advantages and disadvantages, as well as the legal implications, of putting forward a proposal for separate nomenclature codes for biofuels (Commission of the European Communities, 2006).

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ANNEX

Table A.1: Road transport technologies, light-duty vehicles (LDVs)

Technology	Sub-category	Products and components
Engines and transmissions	Advanced Direct Injection (DI) gasoline / diesel transmissions.	Advanced DI engines
	More efficient transmissions	Continuously variable transmission (CVT) Six-speed, seven-speed transmission
	Hybrid-electric drive trains	Electric motor/generator and Battery (or ultracapacitor)
	Recovery of energy from exhaust gases	Turbo-charging engines
Non-engine technologies	Light-weighting	High-strength steel (HHS); stainless steel; other advanced steels; aluminium; magnesium; plastic and plastic composites
	Auxiliary equipment	More-efficient air conditioners, lighting
	Tyres	Rolling-resistant tyres
	Aerodynamics improvement	
Alternative fuel vehicles (AFVs)	Natural gas vehicles (NGVs)	NGV parts
	Clean-diesel vehicles	Ultra-low sulphur diesel (ULSD)
	Hybrid-electric vehicles	ICE plus an electric motor
	Plug-in hybrid vehicles	Conventional hybrid-electric vehicle Plug to connect to the electric grid
	Electric vehicles	Batteries
	Fuel-cell vehicles	Fuel cells
Fuels	Bio-ethanol	Bioethanol Flex-fuel vehicles (FFV)
	Biodiesel	Biodiesel
	Natural Gas (CNG / LNG / GTL)	Compressed natural gas Natural-gas vehicles (NGV)
	Electricity	Plug-in hybrids and electric cars Batteries (nickel-metal-hybride (NiMH) and lithium-ion (Li-on))
	Hydrogen	Fuel cell systems and energy-storage systems

Source: IPCC (2007), IEA (2009b), Kejun (2010).

Table A.2: Road transport technologies, heavy duty vehicles (HDVs)

Technology	Sub-category	Products and components
Engines and transmissions	Recovery of energy from exhaust gases	Turbo-charging engines
	Hybridisation	Electric hybrid engines Hydraulic hybrid engines

Table A.2: *Continued*

Technology	Sub-category	Products and components
Non-engine technologies	Light-weighting	Less dense materials, such as aluminium and carbon fibre
	Auxiliary equipment efficiency	Efficient pumps, fans, air compressors, and heating, air conditioning and power-steering systems
	Aerodynamic improvements	
Alternative fuels	Biofuels	
	CNG	
	LPG	

Source: IPCC (2007), IEA (2009b)

Table A.3: Rail transport technologies

Technology	Sub-category	Products and components
Engines	More efficient engines	
	Regenerative braking	
	Fuel injection	Diesel engines
Non-engine technologies	Light-weighting	E.g. aluminium instead of conventional steels
	Auxiliary equipment	E.g. more efficient air conditioning
Fuels	Electrification Low GHG biofuels	Electricity (to replace diesel)

Source: IPCC (2007), IEA (2009b), Kejun (2010

Table A.4: Aviation technologies

Technology	Sub-category	Products and components
Engine technologies	Improving propulsion and thermal efficiency	Open rotor engines
Non-engine technologies	Using lightweight materials for airframes and engines:	For airframes: Carbon-fire reinforced plastic (CFRP) Fibre metal laminate (FML) For engines: Composite materials with high-temperature tolerances
	Improved aerodynamics	
Fuels	Low GHG biofuels	Biodiesel-type fuels (hydro-treated renewable jet fuel (HRJ jet fuel), FT biomass-to-liquid (BTL) fuels Liquid hydrogen

Source: IPCC (2007), IEA (2009b), Kejun (2010

Table A.5: Shipping technologies

Technology	Sub-category	Products and components
Engines	Diesel electric drives	
	Combined diesel-electric and diesel mechanical drives	
	Waste heat recovery	
Non-engine technologies	Lightweight construction	Lighter weight alternatives to replace steel in non-structural elements of vessel design
	Optimum hull dimensions	
	Propulsion system options	
	Wind power (harnessing wind power for forward propulsion)	Flettner rotor (a spinning vertical rotor that converts prevailing wind into propulsive energy). Traditional sail configurations with advanced fabric or composite materials and/or kites
	Solar power (generating electricity and heat via on-deck solar panels reduces fuel consumption related to auxiliary power and heating requirements)	Solar panels
Fuels	Low GHG biofuels	LPG Biocrude Higher quality biodiesels such as biomass-to-liquids (BTL) fuels are assumed to be blended into petroleum fuel

Source: IEA (2009b), IPCC (2007), and Kejun (2010).

Table A.6: Production of cars and commercial vehicles by country, 2008-2009 (Thousand units, sorted by total production in 2008)

	2008			2009			Change from 2008 (%)
	Cars	Comm. Vehicles	Total	Cars	Comm. vehicles	Total	
Total	52,726	17,794	70,520	47,228	13,759	60,987	-14
Japan	9,928	1,648	11,576	6,862	1,072	7,935	-31
China	6,738	2,561	9,299	10,384	3,407	13,791	48
United States	3,777	4,917	8,694	2,249	3,463	5,712	-34
Germany	5,532	514	6,046	4,965	245	5,210	-14
Republic of Korea	3,450	376	3,827	3,158	355	3,513	-8
Brazil	2,546	670	3,216	2,577	606	3,183	-1
France	2,146	423	2,569	1,822	228	2,050	-20
Spain	1,943	599	2,542	1,813	357	2,170	-15
India	1,846	486	2,332	2,166	466	2,633	13
Mexico	1,217	950	2,168	939	618	1,557	-28

Table A.6: *Continued*

	2008			2009			Change from 2008 (%)
	Cars	Comm. Vehicles	Total	Cars	Comm. vehicles	Total	
Canada	1,195	887	2,082	822	667	1,490	-28
Russia	1,469	321	1,790	596	127	722	-60
United Kingdom	1,447	203	1,650	999	91	1,090	-34
Thailand	401	992	1,394	305	663	968	-31
Turkey	622	526	1,147	511	359	870	-24
Iran	941	111	1,051	692	60	752	-28
Italy	659	365	1,024	661	182	843	-18
Czech Rep.	934	13	947	968	7	975	3
Poland	842	104	946	819	60	879	-7
Belgium	680	44	724	510	13	523	-28
Indonesia	431	169	601	352	113	465	-23
Argentina	399	198	597	380	133	513	-14
Slovakia	576	0	576	461	0	461	-20
South Africa	321	242	563	224	156	380	-33
Developing countries	19,804	7,428	27,232	22,464	7,056	29,520	8
EU	16,100	2,497	18,597	14,028	1,306	15,334	-18

Source: International Organization of Motor Vehicle Manufacturers (OICA). Production statistics, 2008 and 2009 (http://www.oica.net/category/production-statistics/)
Notes:
Passenger cars are motor vehicles with at least four wheels, used for the transport of passengers, and comprising no more than eight seats in addition to the driver's seat.
Commercial vehicles include light commercial vehicles, heavy trucks, coaches and buses.
Figures include production of completely built up (CBU) vehicles, but exclude assembly of completely knocked down (CKD) or semi-knocked down (SKD) sets when vehicle parts originate from another country.

Table A.7: World exports of vehicles for road transport (excluding intra-EU trade), 2008 (USD billions)

HS Code	Description	Exports (USD)	Share in total (%)
8702; 870321-90; 870421-90	Vehicles, for road transport	447.4	100
8702	- Motor vehicles for the transport of ten or more persons, including the driver	11.0	2.5
870210	- With compression-ignition internal combustion piston engine (diesel or semi-diesel):	9.1	2.0
870290	- Other	1.8	0.4
870321-90	- Motor cars and other motor vehicles for the transport of persons (other than those of 8702)	372.2	83.2
870321-24	With spark-ignition internal combustion reciprocating piston engine	201.2	45.0
870331-33	With compression-ignition internal combustion piston engine (diesel or semi-diesel):	51.3	11.5
870390	Other	1.0	0.2
870421-870490	- Motor vehicles for the transport of goods	64.2	14.3

Table A.7: *Continued*

HS Code	Description	Exports (USD)	Share in total (%)
870421-32	- With compression-ignition internal combustion Piston engine (diesel or semi-diesel):	63.6	14.2
870490	- Other	0.6	0.1
870321-90; 870421; 870431	Light-duty vehicles (LDVs)	416.1	93.0
870422-23; 870432-90	Heavy-duty vehicles (HDVs)		
870290; 870390; 870490	"Other" vehicles, which include electric vehicles	3.4	0.8

Table A.8: Top exporters and importers of light duty vehicles (LDVs)

Exporters	USD m	%	Importers	USD m	%
World	425517	100.0	World	416139	100.0
Japan	118916	27.9	United States	135975	32.7
EU27	107295	25.2	EU27	55714	13.4
United States	51671	12.1	Russian Federation	31592	7.6
Canada	34412	8.1	Canada	30837	7.4
Korea, Rep.	33177	7.8	Australia	15818	3.8
Mexico	27240	6.4	China	14095	3.4
Turkey	12228	2.9	United Arab Emirates	11514	2.8
Thailand	10605	2.5	Mexico	11052	2.7
South Africa	5917	1.4	Switzerland	8983	2.2
Brazil	5816	1.4	Japan	6930	1.7
Argentina	4643	1.1	Brazil	6379	1.5
China	3592	0.8	Ukraine	6240	1.5
Australia	3131	0.7	Turkey	5478	1.3
India	2331	0.5	Norway	4964	1.2
Russian Federation	1141	0.3	Argentina	4423	1.1
Top 15	422115	99.2	Top 15	349994	84.1
Developing countries	107688	25.3	Developing countries	108071	26.0

Source: COMTRADE using WITS

Table A.9: Top exporters and importers of heavy duty vehicles

Exporters	USD m	%	Importers	USD m	%
World	26115	100.0	World	19763	100.0
EU27	7865	30.1	United States	2698	13.7
Japan	7395	28.3	Russian Federation	2632	13.3
China	2063	7.9	Canada	1716	8.7
United States	2013	7.7	Norway	931	4.7
Mexico	1589	6.1	Australia	921	4.7
Brazil	1132	4.3	United Arab Emirates	661	3.3
Belarus	960	3.7	Switzerland	601	3.0
Canada	944	3.6	Algeria	551	2.8

Table A.9: *Continued*

Exporters	USD m	%	Importers	USD m	%
Russian Federation	495	1.9	China	499	2.5
Turkey	409	1.6	Venezuela	490	2.5
Singapore	213	0.8	EU27	476	2.4
Switzerland	129	0.5	Chile	468	2.4
Korea, Rep.	124	0.5	Ukraine	466	2.4
Norway	118	0.5	Argentina	465	2.4
Ukraine	108	0.4	Israel	382	1.9
Top 15	25556	97.9	Top 15	33720	70.6
Developing countries	5969	22.9	Developing countries	8047	40.7

Source: COMTRADE using WITS

Table A.10: Top importers and exporters of engines to be installed in transport equipment

Exporters	USD m	%	Importers	USD m	%
World	167491	100	World	163413	100
EU27	56306	33.6	EU27	36795	22.5
United States	43954	26.2	United States	35783	21.9
Japan	20974	12.5	Canada	12349	7.6
Canada	7644	4.6	China	10178	6.2
Mexico	6449	3.9	Japan	7934	4.9
China	5807	3.5	Mexico	7178	4.4
Singapore	4422	2.6	Singapore	5715	3.5
Korea, Rep.	3620	2.2	Brazil	4750	2.9
Switzerland	2937	1.8	Hong Kong, China	4524	2.8
Brazil	2915	1.7	Turkey	4274	2.6
Thailand	2386	1.4	Korea, Rep.	3899	2.4
Turkey	1925	1.1	Thailand	2626	1.6
Russian Federation	1431	0.9	Russian Federation	2531	1.5
India	1204	0.7	Australia	2324	1.4
Norway	994	0.6	United Arab Emirates	1997	1.2
Top 15	162969	97.3	Top 15	142858	87.4
Developing countries	31036	18.5	Developing countries		

Source: COMTRADE using WITS

Table A.11: Top importers and exporters of engines to be installed in motor vehicles

Exporters	USD m	%	Importers	USD m	%
World	34778	100	World	34844	100
EU27	10534	30.3	United States	8190	23.5
United States	8475	24.4	Canada	5519	15.8
Japan	5839	16.8	Mexico	3587	10.3
Canada	2291	6.6	EU27	3166	9.1
China	1791	5.1	Turkey	2727	7.8
Mexico	1734	5.0	China	1858	5.3
Thailand	1134	3.3	Russian Federation	1464	4.2

Table A.11: *Continued*

Exporters	USD m	%	Importers	USD m	%
Brazil	1035	3.0	Japan	1347	3.9
South Africa	430	1.2	Argentina	882	2.5
Korea, Rep.	374	1.1	Thailand	847	2.4
Argentina	163	0.5	Ukraine	817	2.3
Russian Federation	162	0.5	Brazil	657	1.9
Turkey	109	0.3	Korea, Rep.	635	1.8
Malaysia	50	0.1	India	467	1.3
India	34	0.1	Australia	400	1.1
Top 15	34153	98.2	Top 15	32565	93.5
Developing countries	6957	20.0	Developing countries	13422	38.5

Source: COMTRADE using WITS

Table A.12: Top exporters of batteries that may be used in electric cars, 2008

All batteries, except lead-acid electric accumulators of a kind used for starting piston engines (HS 850720;30;40; and 80)		Other accumulators (HS 850780) (include nickel-hydride and lithium-ion accumulators)	
Exporter	$million	Exporter	$million
All countries	12440	All countries	8363
China	6973	Japan	3634
Japan	3886	China	3589
EU27	1206	EU27	
Taiwan	399	Taiwan	219
Mexico	379	Singapore	207
Malaysia	296	Malaysia	133
Singapore	266	Mexico	82
Developing countries	8503	Developing countries	5438

Source: COMTRADE using WITS

Table A.13: EU Imports of nickel-hydride batteries (CN 850780.20), 2007-2009

	2007	2008	2009	Average
China	166.7	166.4	127.8	153.7
Japan	70.7	89.3	87.5	82.5
Hong Kong, China	22.3	12.6	6.2	13.7
United States	5.9	6.6	6.0	6.2
Switzerland	5.8	6.0	2.3	4.7
Singapore	4.8	3.6	2.9	3.8
Malaysia	3.2	1.8	1.0	2.0
Taiwan	2.2	1.6	2.0	1.9
Total extra-EU imports	284.4	292.5	237.7	271.5
Intra-EU trade	181.5	194.2	185.0	186.9

Source: EC Export Helpdesk (http://exporthelp.europa.eu/index_en.html)

Table A.14: EU imports of Lithium-ion batteries (CN 850780.30), 2007-2009

	2007	2008	2009	Average
China	403.6	460.2	411.0	424.9
Japan	218.6	215.8	141.2	191.9
Taiwan	55.6	58.2	30.5	48.2
Korea ,Republic of	32.9	40.0	35.0	36.0
United States	9.4	25.8	17.5	17.6
Hong Kong	14.9	22.7	14.8	17.5
Malaysia	9.2	10.5	8.6	9.4
Indonesia	2.1	12.2	13.7	9.3
Total extra-EU imports	763.1	864.9	686.5	771.5
Intra-EU trade	276.5	264.3	227.1	256.0

Source: EC Export Helpdesk (http://exporthelp.europa.eu/index_en.html

Table A.15: Production of biofuels in the world in 2009

Biofuels			Fuel ethanol			Biodiesel		
Country	ktoe	Share (%)	Country	million litres	Share (%)	Country	million litres	Share (%)
United States	22014	42.5	United States	40130	54.3	Germany	2859	15.9
Brazil	13863	26.8	Brazil	24900	33.7	France	2206	12.3
Germany	2647	5.1	China	2050	2.8	United States	2060	11.5
France	2383	4.6	Canada	1348	1.8	Brazil	1535	8.6
China	1309	2.5	France	1250	1.7	Argentina	1340	7.5
Argentina	1080	2.1	Germany	750	1.0	Spain	967	5.4
Spain	1003	1.9	Spain	465	0.6	Italy	830	4.6
Canada	833	1.6	Thailand	401	0.5	Thailand	610	3.4
Italy	694	1.3	India	350	0.5	Belgium	468	2.6
Thailand	687	1.3	Colombia	310	0.4	Poland	374	2.1
Belgium	444	0.9	Australia	220	0.3	Netherlands	364	2.0
Colombia	419	0.8	Austria	180	0.2	Austria	349	1.9
Poland	381	0.7	Sweden	175	0.2	China	338	1.9
Austria	368	0.7	Poland	166	0.2	Colombia	330	1.8
India	352	0.7	Hungary	160	0.2	Rep. of Korea	300	1.7
EU	9954	19.2	EU	2854	3.9	EU	8733	48.7
Total	51769	100	Total	73954	100	Total	17929	100

Source: Biofuels Platform

Table A.16: Brazilian exports of undenatured methyl alcohol (HS 220710), 2004-2009 (USD millions)

	2004	2005	2006	2007	2008	2009
World	461	743	1437	1439	2366	1338
United States	80	73	752	387	846	147
EU	88	158	245	433	687	384
- of which the Netherlands	28	77	147	336	618	290
Jamaica	27	40	56	109	183	152
El Salvador	6	42	80	83	151	22
Japan	40	90	94	153	113	109
Trinidad and Tobago	2	11	31	65	99	48
Korea, Rep.	56	64	34	25	81	140
Costa Rica	23	38	35	70	47	32
Nigeria	20	34	19	49	42	49
India	86	110	5	0	32	125
Canada	7	8	9	2	20	0
Mexico	18	26	17	19	14	36
Ghana	2	2	3	15	11	7
Switzerland	6	3	1	0	6	25
United Arab Emirates	0	0	0	17	2	10
Philippines	1	1	1	2	2	18
Developing countries	270	422	368	495	708	669
Principal countries with preferential access to the US market*	58	131	202	328	480	255

** Jamaica, El Salvador, Trinidad and Tobago and Costa Rica*
Source: COMTRADE

Table A.17: EU imports of undenatured ethyl alcohol

	2006	2007	2008	2009	Structure in 2009 (%)
Brazil	93.7	241.8	342.3	163.4	35.9
Guatemala	19.3	24.2	19.6	52.0	11.4
Pakistan	22.5	32.7	44.7	29.7	6.5
Peru	9.1	17.6	23.6	25.7	5.7
Bolivia	10.0	2.4	23.4	24.2	5.3
Nicaragua	3.3	9.9	0.0	23.8	5.2
Costa Rica	7.3	14.0	14.8	21.7	4.8
Egypt	16.3	18.8	21.7	19.1	4.2
Argentina	0.8	3.5	6.5	13.1	2.9
United States	1.2	18.2	1.6	8.0	1.8
All other	71.9	107.4	117.6	74.2	16.3
Total	255.3	490.3	615.7	455.1	100.0

EC Export Helpdesk

Table A.18: HS codes and 2008 trade values for products analysed* (Excluding intra-EU trade)

HS code	Description	World exports USD m	Developing countries			
			Trade (USD m)		Shares (%)	
			Exports	Imports	Exports	Imports
LDVs						
870321	Cars with spark-ignition ICE, cylinder capacity < 1000 cc	5818	2187	4880	38	54
870322	Cars with spark-ignition ICE, cylinder capacity 1000 - 1500 cc	34975	11080	8841	32	27
870323	Cars with spark-ignition ICE, cylinder capacity 1500 - 3000 cc	169650	47596	41592	28	26
870324	Cars with spark-ignition ICE, cylinder capacity > 3000 cc	119355	7164	27131	6	23
870331	Cars with compression-ignition ICE (diesel), cylinder cap. < 1500 cc	4121	2351	1555	57	33
870332	Cars with compression-ignition ICE (diesel), cylinder cap. 1500 – 2500 cc	30866	11636	4895	38	17
870333	Cars with compression-ignition ICE (diesel), cylinder cap. > 2500 cc	18454	2109	3465	11	20
870390	Other motor cars (including electric vehicles)	1138	71	626	6	61
870421	Trucks with diesel engine, G.V.W. not exceeding 5 metric tons	24404	16381	9983	67	41
870431	Trucks with spark-ignition ICS, G.V.W. not exceeding 5 metric tons	16737	7113	5104	43	26
Subtotal						
HDVs						
870422	Trucks with diesel engine, G.V.W. 5 - 20 metric tons	13838	2874	4559	21	45
870423	Trucks with diesel engine, G.V.W exceeding 20 metric tons	11852	3047	3280	26	35
870432	Trucks with spark-ignition ICE, G.V.W. exceeding 5 tons	425	48	208	11	58
870490	Other trucks	481	51	562	11	93
Subtotal						

Table A.18: *Continued*

HS code	Description	World exports USD m	Developing countries			
			Trade (USD m)		Shares (%)	
			Exports	Imports	Exports	Imports
Buses (vehicles for the transport of 10 or more persons, incl the driver)						
870210	Buses, With compression-ignition ICE (diesel or semi-diesel):	9662	4251	4976	44	54
870290	Buses, Other	2197	424	1422	19	81
Subtotal						
Rail locomotives						
860110	Rail locomotives powered from an external source of electricity	10	4	123	42	13
860120	Rail locomotives powered by electric accumulators (batteries)	2000	449	12	22	42
860210	Diesel-electric locomotives	352	201	704	57	22
860220	Other rail locomotives;	2184	245	61	11	57
Subtotal						
Airplanes						
880220	Airplanes and other aircraft, of an unladen weight not exc. 2,000 kg	786	40	1306	5	69
880230	Airplanes and oth. aircraft of an unladen weight 2,000 kg - 15,000 kg	15445	1939	13243	13	55
880240	Airplanes and oth. aircraft of an unladen weight exceeding 15,000 kg	79508	7019	25692	9	48
Subtotal						
Ships						
890110	Ships principally designed for the transport of persons	6329	438	1385	7	51
890120	Tankers	39557	27978	1941	71	19
890130	Refrigerated vessels,	169	22	44	13	28
890190	Oth vessels for the transport of goods or of both persons and goods	47339	28443	9636	60	47
Subtotal						
Engines						
840710	Aircraft engines	2174	147	1741	7	82
840721	Marine propulsion engines, outboard motors	388	116	508	30	23
840729	Marine propulsion engines, other	93	76	146	82	29

Table A.18: *Continued*

HS code	Description	World exports USD m	Developing countries			
			Trade (USD m)		Shares (%)	
			Exports	Imports	Exports	Imports
840731	Spark-ignition ICEs of a cylinder capacity not exceeding 50cc	713	615	13	86	28
840732	Spark-ignition ICEs of a cylinder capacity of 50 – 250 cc	1026	139	101	14	52
840733	Spark-ignition ICEs of a cylinder capacity of 250 – 1000 cc	17915	3251	173	18	17
840734	Spark-ignition ICEs of a cylinder capacity exceeding 1000 cc	2249	763	4855	34	27
840790	Other engines, including gas (natural or LP) engines	5709	2072	570	36	25
840810	Marine propulsion engines	12783	2114	4099	17	74
840820	Engines of a kind used for the propulsion of vehicles	9037	1754	7710	19	59
840890	Other engines	1516	970	4313	64	47
840910	Parts for aircraft engines	16070	4822	935	30	63
840991	Parts suitable for use with spark-ignition ICEs	19786	7191	7230	36	42
840999	Parts for other engines	2702	131	7433	5	43
841111	Turbojets of a thrust not exceeding 25 kilonewtons (kN)	14601	882	265	6	18
841112	Turbojets of a thrust exceeding 25 kN	1078	21	4395	2	28
841121	Turbo-propellers of a power not exceeding 1,100 kW	1402	183	159	13	12
841122	Turbo-propellers of a power exceeding 1,100 kW	1332	58	399	4	31
841181	Other gas turbines of a power not exceeding 5,000 kW	7032	408	303	6	27
841182	Other gas turbines of a power exceeding 5,000 kW	30743	2003	2521	7	60
841191	Parts of turbojets or turbo propellers	17318	2001	7387	12	22
841199	Other parts	2174	147	5137	7	37
Subtotal						

Table A.18: *Continued*

HS code	Description	World exports USD m	Developing countries			
			Trade (USD m)		Shares (%)	
			Exports	Imports	Exports	Imports
Auxiliary equipment						
841520	Air conditioners used in vehicles	616	286	327	46	45
Subtotal						
Batteries						
850710	Lead-acid storage batteries, for starting piston engines	3975	2651	1300	67	33
850720	Other lead-acid storage batteries	3752	2420	1311	65	38
850730	Nickel-cadmium storage batteries	1340	757	1236	57	63
850740	Nickel-iron storage batteries	21	2	49	10	65
850780	Other batteries (includes NiMH and lithium-ion batteries)	11274	7069	7644	63	64
850790	Parts	1442	812	1218	56	79
Subtotal						
Fuel cells						
850680	Other primary cells and primary batteries	449	237	657	53	68
Fuels						
220710	Undenatured ethyl alcohol	3631	3400	930	94	27
220720	Denatured ethyl alcohol	673	273	281	41	34
271011	Light oils and preparations	191538	108749	85826	57	50
271111	Liquefied natural gas	58368	49560	33075	85	33
271121	Propane	12722	5957	8396	47	32
290511	Methanol (methyl alcohol):	3154	2344	3043	74	34
382490	Other chemical products and preparations (includes biodiesel)	24005	5372	12348	22	53

Source: COMTRADE
** This is not a list of products associated with climate-related technologies in the transport sector.*

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