



Fuel Economy State of the World 2014

The World is Shifting into Gear on Fuel Economy



Acknowledgements

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The EC is supporting cleaner and more efficient vehicles projects through UNEP, with an emphasis of supporting countries establish clean and efficient vehicles standards and policies.



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1 Introduction

Over the past two years it has become clear that the world is shifting into gear on fuel economy: more and more countries are acknowledging the need for strong policies, and more are investigating, developing and implementing those policies. Fuel economy trends are beginning to show real signs of progress. Yet there is still a long way to go to reach the Global Fuel Economy Initiative (GFEI) 2030 target of a 50% reduction in new car fuel consumption (L/100km) compared to 2005 levels.

During 2012-2013 some of the major news included:

- The US and Canada became the first countries to set fuel economy standards towards 2025, and Mexico set its first standards.
- There were updated, tightened and extended light-duty fuel economy standards in the EU, China and Japan.
- Standards were developed though not yet implemented in India, while discussions on standards are underway in some Southeast Asian and Latin American countries.
- Mauritius developed and implemented what appears to be the first fuel economy/CO₂-based feebate system in the developing world.
- Chile introduced its first ever fuel economy labelling policy.



Truck fuel economy standards were implemented in the US, Canada, Japan and China, with the EU still moving toward adopting a system. In many of these countries this progress builds on years of hard work, and on previously implemented standards and other fuel economy policies.

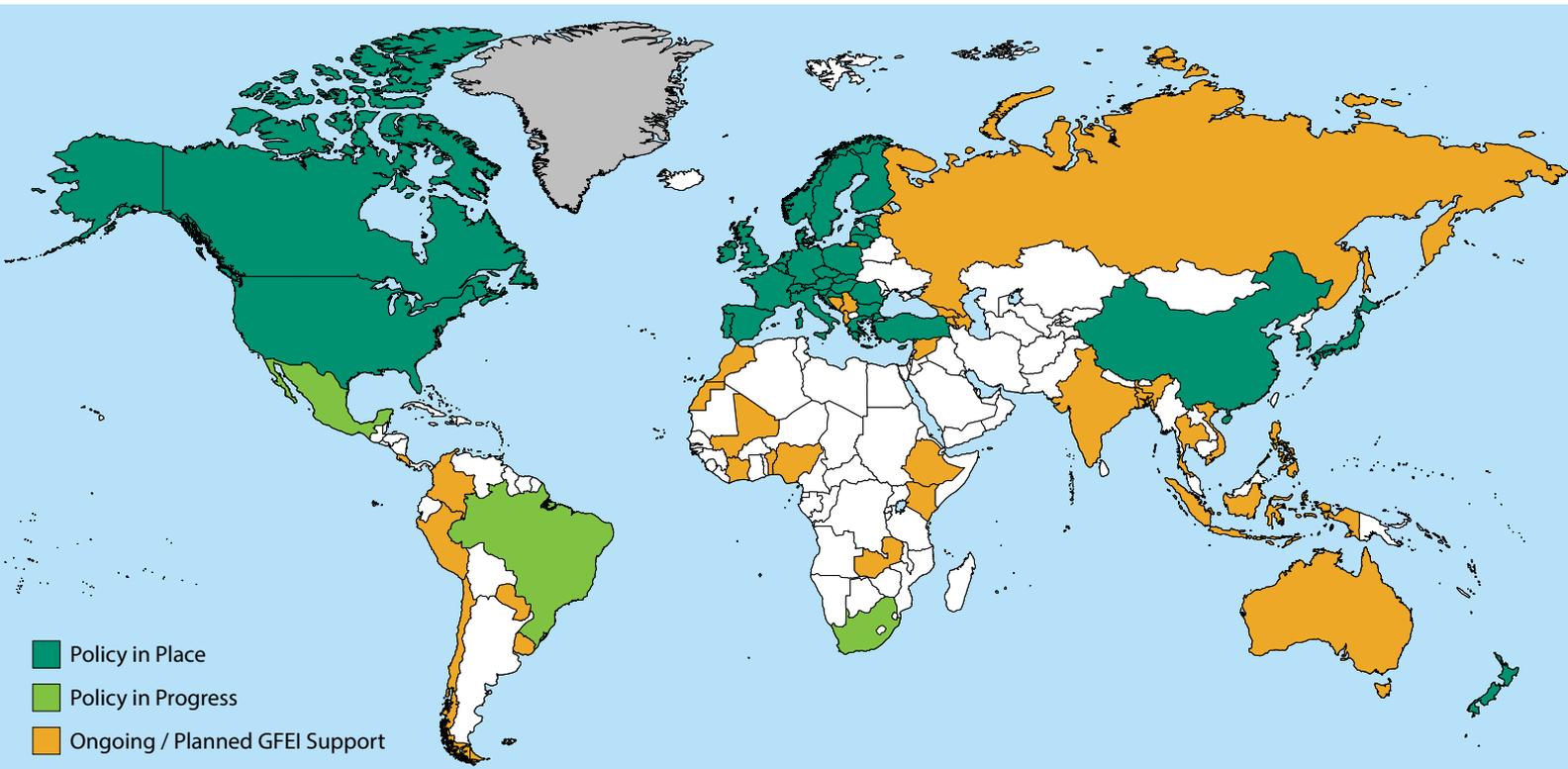
Although fuel economy data for new car sales in most countries is not yet available beyond 2011, the rate of fuel economy improvement in major countries around the world was faster between 2008 and 2011 than it was between 2005 and 2008, an encouraging sign, though the news on fuel economy trends is mixed:

- Average new light-duty-vehicle (LDV) fuel economy in the OECD improved by 2.7% per year between 2008 and 2011 while in non-OECD countries it improved by only 0.6% (based on an IEA sample of countries including most major markets). This caused average OECD fuel economy to surpass non-OECD possibly for the first time, with 2011 averages of 7.0 L/100km in OECD and 7.5 in non-OECD.
- Overall the global average of 7.2 L/100km represents a 0.8% annual improvement since 2005 slower than the pace needed to reach 4 L/100km by 2030. From the position in 2011, a 3% per year improvement will be needed to get there.



This report reviews the recent progress and remaining challenges. It highlights the new developments, trends, and examples of progress that the GFEI has helped to bring about. It also reminds us that reaching a global reduction of 50% in new car fuel use by 2030 compared to 2005 levels will take a stronger push than the planet has set in place thus far. More policies in more countries will be needed, as will the extension and strengthening of policies even in those countries that have already undertaken major initiatives and set strong policies.

FIGURE 1 UNEP Policy Progress Map

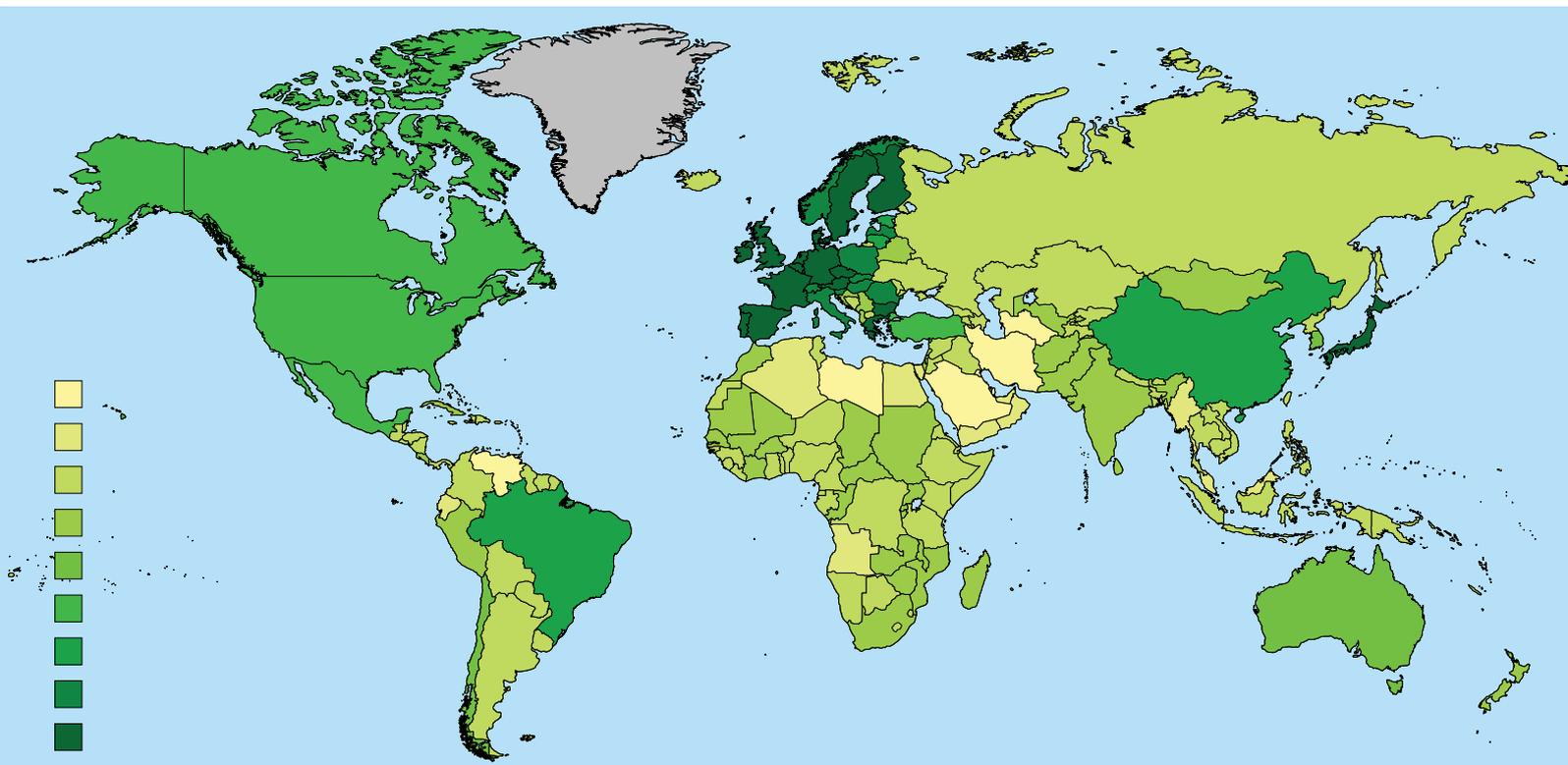


Few countries have “the full package”, although perhaps not all countries need this. A full package would include fuel economy labelling systems (and complementary systems to ensure consumers are aware of these labels and can easily make comparisons between existing models when they are considering buying a car); fuel economy standards requiring manufacturers to make improvements to their new models; and pricing systems to encourage consumers to purchase the most efficient models, such as CO₂-based vehicle taxation or fee/rebate (feebate) systems. Fuel taxation also sends a very important signal in this regard and many countries still subsidize motor fuel. GFEI partners use various tracking systems to monitor. As Figure 1 shows the UNEP GFEI Progress map, related to the implementation of fuel-economy related policies around the world as of Summer 2013. The IEA has created a complementary “Fuel Economy Readiness Index” (Figure 2) that shows the intensity and completeness of policies in each country, taking into account the elements mentioned above. Both of these show that while many countries have taken some actions, much more needs to be done.



Rob de Jong, UNEP, speaking at the FIA Foundation's Annual General Meeting in Paris, December 2013

FIGURE 2 IEA Fuel Economy Readiness Index



This report covers all these trends and issues in detail, and also provides background on the GFEI, summarizes its progress and events during 2012-2013, and highlights important research findings coming from GFEI partners. Some of our key achievements and findings during the year, as presented in the following sections, include:

- Engagement with a wide range of governments around the world, particularly in developing countries.
- Reports that compare fuel economy in different countries, including analysing the underlying reasons for differences, relating both to market structure and technology uptake.
- Reports on the net costs and benefits of fuel economy improvement, in particular a new report showing that reaching the GFEI 2030 target could result in a net \$2 Trillion savings to consumers around the world.
- Coverage of issues ranging from managing 2nd hand car imports around the world to measuring in-use fuel economy, and interactions between fuel economy improvement and pollution emission reductions.

The report is organized as follows:

Section 2 reviews GFEI activities around the world in 2013;

Section 3 covers recent trends in fuel economy and policy making, as well as a major study on future fuel economy potential that supports the GFEI 2030 50% target;

Section 4 provides extended summaries of GFEI partner research reports released during 2013;

Section 5 presents some on-going GFEI projects with interim findings; and finally an Annex provides further information on and links to GFEI and partner reports and activities.



GFEI partners at the second GFEI Global Networking Meeting, Paris 2013 - I-r Sheila Watson (FIA Foundation), Sylvie Lemmet (UNEP), Stephen Perkins (ITF), Lew Fulton (UC Davis), Peter Mock (ICCT), Francois Cuenot (IEA), Rob de Jong (UNEP), Alex Korner (IEA)

2 GFEI: Progress in 2012-2013

Over the past 2 years, GFEI partners have been engaged in a range of activities ranging from research and publications, stakeholder dialogue efforts and events, and outreach to governments and other policy makers around the world. The following sections cover many of these activities, with a particular focus on efforts during 2013.

FIGURE 3 GFEI contact countries

Asia	Bangladesh	China	India	Philippines	Vietnam	Indonesia	
Central and Eastern Europe	Macedonia	Montenegro	Armenia	Azerbaijan	Georgia	Russia	
Latin America and the Caribbean	Jamaica	Peru	Brazil	Colombia	Mexico	Costa Rica	Chile
Africa	Cote D'Ivoire	Mauritius	Benin	Ethiopia	Kenya		

2.1 Background

The last year has been a significant one for the GFEI, which is now actively working on fuel economy policy in a further 20 countries (Figure 3) This is a huge step forward for the work of GFEI, which is focused on practical in-country policy support, particularly in non-OECD countries.

The GFEI has invested substantial effort in building the network of GFEI countries. The initiative is already working in Indonesia, Thailand, Ethiopia, Chile, and Kenya, and this work is already paying dividends. For example, on the 1st of February 2013 the Chilean Government launched the first fuel economy labeling system in Latin America and the Caribbean region. This was a joint initiative developed between the Ministries of Transport, Energy and Environment. The GFEI provided considerable support to each Ministry in terms of supplying information relating to similar international experiences in fuel economy labeling processes, publishing the fuel economy standard and CO₂ index for the national vehicle fleet, and proposing a feebate system designed in collaboration with the Environment and Financial Ministries.

There have been several regional GFEI meetings to reinforce and develop more local cooperation. For example:

- **East Asia:** Approximately 50 participants, drawn primarily from ASEAN countries, attended a fuel economy breakout session co-sponsored by Hong Kong Environmental Protection Department (EPD), the Ministry of Environmental Protection of the People's Republic of China (MEP), the Hong Kong Polytechnic University (Hong Kong PolyU) and the Global Fuel Economy Initiative (GFEI), at the Clean Air Asia air quality Conference in December 2012.
- **East Africa:** October 2012 saw the launch of the GFEI in Africa. Close to fifty participants from twenty African countries attended the regional launch in Nairobi. The results from the two African pilot countries show that African countries are not taking advantage of the on-going improvements in vehicle fuel economy. For example, Ethiopia's average fuel efficiency remained stagnant in the 2005 and 2008 period – at 8.70L/100km compared to the global average improvement from 8.07L/100km to 7.67L/100km during the same period. The workshop concluded by recommending that a sub-regional approach should be taken to tackling vehicle fuel efficiency as well as action to increase public awareness of the GFEI's goals.



GFEI panel including Lew Fulton of UC Davis, KG Duleep of HD Systems, Alex Korner of IEA and Sheila Watson of the FIA Foundation at the ITF conference in the Leipzig

- Caucuses:** In May 2013, the International Fuel Economy Conference took place in Tbilisi. International fuel economy experts, representatives from governmental structures from Georgia, Armenia and Azerbaijan and stakeholders came together to discuss the way forward for improving fuel economy and reducing CO₂ emissions from the transport sector in the South Caucasus region.
- Europe:** Also in May 2013, a packed auditorium at the ITF conference in the Leipzig Conference Centre, were treated to exciting new evidence on the trends in global fuel economy, from a GFEI panel including KG Duleep of HD Systems; Alex Korner of IEA; and Lew Fulton of UC Davis. In November 2013, GFEI took part in 'Transport Day' at the Warsaw COP 19 meeting.



GFEI holds high level seminar in Tbilisi

Further stakeholder and policy support meetings are being planned for 2014, in Jamaica, Russia, China and the Middle East.

The GFEI's existing approach to policy development - to carefully assess the evidence, to focus on key issues and areas of interest, and then to work with national policymakers to tailor policy solutions to local factors - depends on good evidence and research.

These research findings are all published as part of the GFEI's working paper series, and some are described in more detail later in this report. This series will soon be supplemented by further studies into youth mobility trends in China, and the significance of car imports in non car-producing countries in the campaign to improve fuel economy.

At a more practical level, the secretariat - which is hosted at the FIA Foundation - have also invested substantial effort into new publications, films, newsletters and other promotional materials to support the work of the Initiative. These materials can be accessed at www.globalfueleconomy.org.



Participants at the Second Global Meeting of the GFEI Network in Paris, 23-24 June 2013

2.2 The GFEI Second Global Networking Meeting in Paris, 23-24 June 2013

The GFEI hosted its annual Global Networking meeting in Paris in June 2013. At this event, which was hosted at the United Nations Environment Programme (UNEP), representatives of over 25 countries gathered to exchange experience, to network, and to hear the latest expert evidence on fuel economy.

The 2-day meeting was opened by Sylvie Lemmet, Director of the Division of Technology, Industry and Economics at UNEP, who identified the importance of fuel economy as a key issue in addressing sustainable development, environmental degradation and energy security. In the sessions which followed, delegates heard presentations from experts on fuel economy trends, policies and impacts, whilst representatives from Asia, Africa, Latin America, Eastern Europe and the South Caucasus were able to report on and share experience on the issue from their perspective.

The second day saw a more in-depth master-class in the workings of the GFEI in-country toolkit,

establishing a baseline, and the contribution regulations and financial mechanisms can make to solving the issue. The International Energy Agency (IEA) also presented their latest analysis of global fuel economy trends, which confirmed that, although there have been improvements in fuel economy levels in OECD countries over the period 2008-2011, those improvements have not been mirrored in non-OECD countries. This analysis was supplemented by The International Council on Clean Transportation's (ICCT) survey of the range of fuel economy policy tools – from feebates to regulations – and their relative benefits and dis-benefits. In the discussion which followed, a key issue raised was the difficulty of engaging Governments where reduced fuel use might also mean lost resources. The issues of energy security, balance of payments, and the equivalent savings in subsidies where these are in place were also considered.

In a feedback session at the end of the meeting, the attendees concluded that the event had been an excellent opportunity to strengthen the GFEI global network, as well as reinforcing the regional groupings which are essential in order to secure far greater impact from the limited resources which are currently available for this work. The GFEI plan to host a similar meeting in 2014, when there will be a core of over 20 countries working on fuel economy policy within the Initiative.



High level delegates at the UN Open Working Group Session involving UNEP and GFEI

2.3 GFEI UNEP-led GEF and EU Projects Updates

Under the GFEI's Global Environment Facility (GEF-4) project, UNEP and the GFEI partners have developed guidelines on fuel economy-related best practices and baseline data-setting methodology, while expanding public-private partnerships and working with strategic partners at the national and regional levels around the world. Since September 2010, UNEP has supported Ethiopia, Kenya, Indonesia, and Chile in developing their own fuel economy policies with GEF resources by undertaking an analysis of the existing and future vehicle fleet and initiating a multi-stakeholder dialogue with governments and other relevant groups to develop and implement fuel economy policies. In addition to GEF-supported countries, UNEP and the GFEI partners have also assisted a range of other countries. GEF-5 support will begin in early 2014 for global and national activities focusing on Côte d'Ivoire, Jamaica, Macedonia, Mauritius, Montenegro and Peru.¹ Regional summaries are provided below.



Jane Akumu of UNEP and the Ethiopian Minister of Transport, Getachew Mengistie at the Ethiopia National Stakeholder Workshop on 6 Nov 2012

Africa

In Ethiopia, together with the Ethiopian Transport Authority and the Addis Ababa Institute of Technology, draft fuel economy regulations were developed and submitted to government. These policies include a) mandatory fuel efficiency and emission certificate requirement for all vehicles (imports and locally assembled), b) eco-driving awareness raising, c) ban on importation of old used-vehicles, d) introduction of tax incentives for hybrid and electric vehicle, and e) improvement of vehicles maintenance infrastructure. In Kenya, the Energy Regulatory Commission (ERC) in partnership with the University of Nairobi are carrying out a baseline vehicle fleet analysis, including vehicle imports, and in 2014 will undertake a cost and benefit analysis on fuel economy and cleaner fuels and vehicle policies. In Mauritius, UNEP and its partners are assisting the government in the review of the implementation of its Excise Bill (2011) that sets forth a CO₂ levy on motor cars or the granting of a CO₂ rebate from the excise duty payable on motor cars and for this policy to be in line with the objectives of the GFEI. This is probably the first "feebate" system in the developing world.

Asia

In Indonesia, the Ministry of Environment and Komite Penghapusan Bensin Bertimbel (KPBB) have completed the cost-benefit analysis on cleaner fuels and fuel economy in Indonesia and are in the process of a campaign for development and implementation of specific policies. This highlights a US\$70 billion (IDR 803.6 trillion) net benefit and potential fuel saving for the next 26 years when fuel efficiency standards are adopted. A vehicle labeling system is being developed and will be proposed to relevant government agencies. The government of Indonesia is also developing an eco-based vehicle taxation system.

In partnership with Clean Air Asia, efforts to develop and implement fuel economy policies are being supported in the Philippines, Thailand and Vietnam. In 2009, the Thailand Department of Alternative Energy Development and Efficiency (DEDE) of the Ministry of Energy developed fuel consumption limits (standards) for light-duty vehicles; however these standards were not adopted and are now being reviewed to align with the current Euro 4 vehicle emission standards. The revised draft fuel economy standards are expected to be completed before the end of 2013.

Working with the Vietnam Register of the Ministry of Transport, the third round of review of the draft National Fuel Consumption Limits for Motorcycles, Mopeds and Light Duty Vehicles were completed and have been submitted to the Directorate for Standards, Metrology and Quality (STAMEQ) for review and will be enforced pending the approval of the Minister for Science and Technology. In addition,



Clean Air Asia is working with other ASEAN partners to promote the development and harmonization of fuel economy policies. As a result, an ASEAN focused forum on cleaner and more efficient fuels and vehicles is organized with support from the ASEAN and its member countries and other development partners including GIZ was organized in November 2013 to fast-track development and strengthen policies.

In India, through the Low Carbon Mobility Planning project of UNEP, a national and city fuel efficiency study is being undertaken and is aimed to support the Bureau of Energy Efficiency in the finalization of its draft fuel efficiency standards for light-duty vehicles. The Indian draft fuel efficiency standards, which seeks to improve fuel efficiency of cars by about 18%, from the average of 14.1 km/litre (7.1 L/100km) of petrol to 17.3 km/l (5.8 L/100km) and from 15.5 km/litre (6.4 L/100km) to 19.9 km/litre (5.1 L/100km) for diesel cars by 2015, is currently still being reviewed by the government.

Indonesia

The government of Indonesia has developed and passed a taxation scheme favouring producers of affordable "eco-cars"/"low cost green cars", which are tax exempt. The inexpensive, fuel efficient cars are divided into two categories: cars with gasoline engines of up to 1,200 cc and diesel and semi-diesel engines of up to 1,500 cc. Both types of cars should be able to run at least 20 kilometres per litre of fuel. The makers of other "eco-cars", referred to as "low-carbon emission cars", will also benefit from the tax cut whenever they utilise a variety of engines, such as advance diesel/gasoline, biofuel, hybrid and gas, with efficient energy consumption.



And producers of vehicles that can run between 20 to 28 kilometres per litre of fuel can obtain a 25 per cent discount on the sales tax, while makers of cars that can travel more than 28 kilometres per litre of fuel will enjoy a 50 per cent cut.



GFEI Executive Secretary Sheila Watson and High Commissioner for the Republic of Trinidad and Tobago Garvin Nicholas

Latin America and the Caribbean

In Chile, the GEF-supported national pilot project has provided information about FE average of Chilean market. The figures shows a relative low FE, due to the growing market share of light duty trucks and SUVs. This information, together with conferences and workshop, has supported the national authorities in the definition and adoption of a fuel economy label system, that is mandatory since last February. It is the first of its kind in Latin America and the Caribbean region. An innovative fiscal fuel economy 'feebate' policy has been developed. This proposal that incentivizes car buyers to choose more efficient, lower emission vehicles, based on the French "bonus-malus" system is linked to a fuel economy labeling system and the vehicle emission standard. The proposal has been submitted to different stakeholders, and it will be part of the tax reformulation discussion programmed for 2014.

In Peru, development of a National Clean and Efficient Vehicles Strategy, including fuel economy labelling for vehicles, is being undertaken with support from



The GFEI briefing at the High Commission of Trinidad and Tobago

an agreement between the Ministry of Environment and UNEP signed in 2012. Fuel economy policy discussions have also started with Jamaica, Paraguay and Uruguay, with a regional dialog on fuel economy in the Caribbean hosted by Jamaica in early 2014. The activities of UNEP and GFEI in the region are led by the Centro Mario Molina Chile.



International Fuel Economy Conference, May 2013, Tbilisi

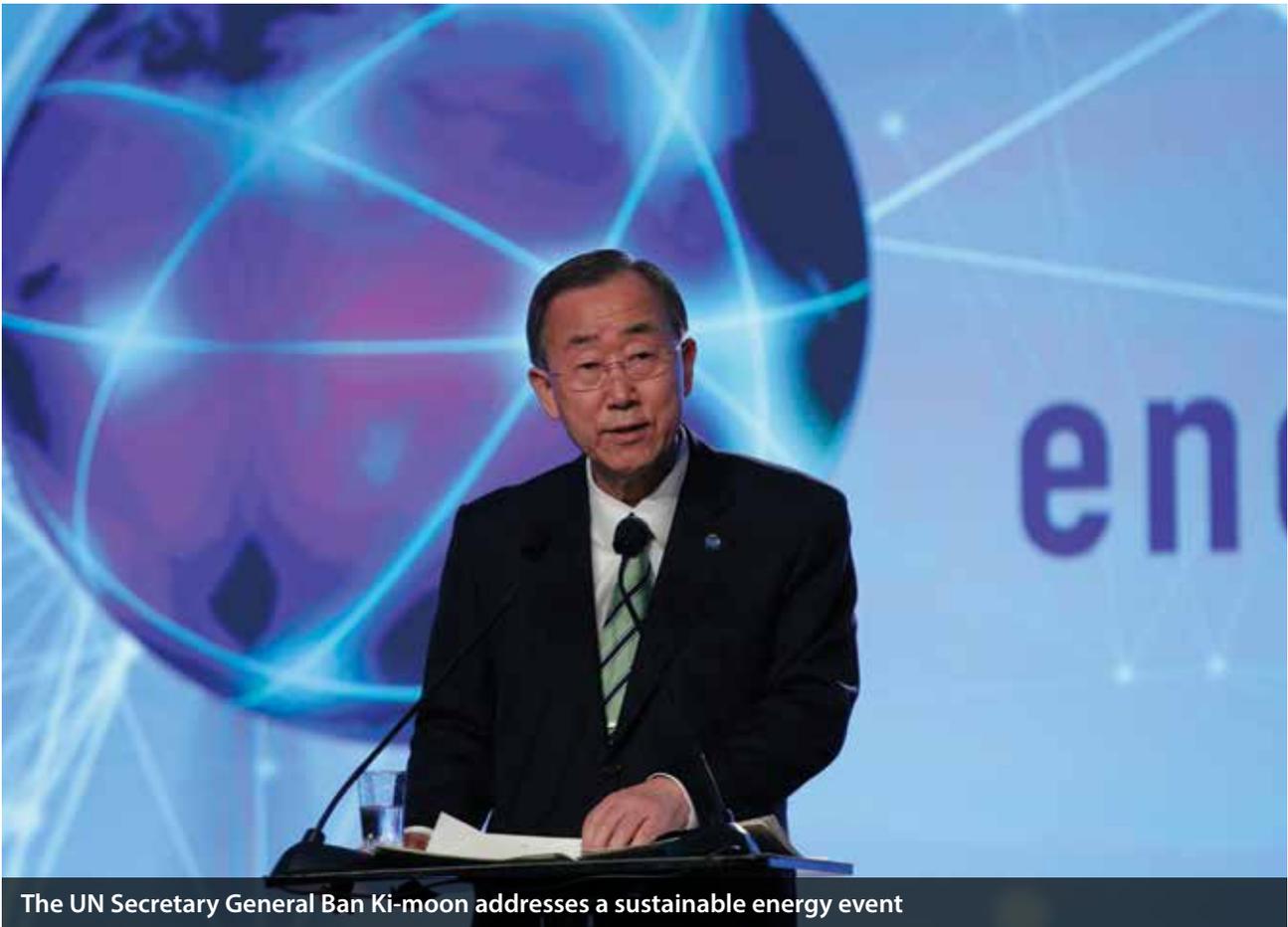
Eastern Europe and the Caucasus

UNEP together with its GFEI partners - the Regional Environmental Center for Central and Eastern Europe (REC) Office in Montenegro - have started preparatory activities like fuel economy baseline studies in Montenegro and Macedonia prior to GEF-5 support expected in early 2014. A regional meeting held in Tbilisi, Georgia in May 2013 and attended by senior government representatives from Georgia, Armenia and Azerbaijan helped raise the interest in developing fuel economy policies in these countries. For Georgia, the main policy instruments discussed for improving auto fuel economy were a feebate or progressive taxation of imported vehicles according to fuel economy/CO₂ ratings, and a vehicle fuel economy labeling scheme. GFEI and its partners are assisting in the drafting of recommendations on fuel economy and cleaner fuels for government consideration.

In May 2013, the International Fuel Economy Conference took place in Tbilisi. International fuel economy experts, representatives from governmental structures from Georgia, Armenia and Azerbaijan

and stakeholders came together to discuss the way forward for improving fuel economy and reducing CO₂ emissions from the transport sector in the South Caucasus region.

The conference was organized by CENN and the Partnership for Road Safety Foundation within the scope of a GFEI regional programme and with the support of UNEP. The conference heard that the number of cars on Georgian roads has tripled over the last 10 years and transport has become the main contributor to global warming in the region. However, fuel economy is not a developed field in the region and key indicators, such as the average age of the car fleet (above 15 years), prove the lack of progress in this field. This conference was therefore an opportunity to highlight how pressing the issue is in the region. Key experts who played an important role in reducing transport based CO₂ emissions worldwide were present. During the conference, fuel economy policies were debated and their relevance to the regional context was assessed.



The UN Secretary General Ban Ki-moon addresses a sustainable energy event

2.4 Fuel economy in the UN Post-2015 Development Agenda

The global transport sector contributes one quarter of the energy related global greenhouse gas emissions. This is rising faster than any other sector. The number of vehicles on the planet is set to triple by 2050 - the vast majority in non-OECD countries. We need to act together to reconcile legitimate aspirations for mobility, and the developmental benefits which can ensue, with an ambitious reduction in fuel use and CO₂ from cars worldwide.

Vehicle fuel economy has an important contribution to make to this objective, whilst also addressing energy security and sustainable mobility. In May 2013, the UN High Level Panel on the Post-2015 Development Agenda, co-chaired by Mr. Yudhoyono (President of Indonesia), Ms. Sirleaf (President of Liberia) and Mr. Cameron (Prime Minister of the United Kingdom), released their report which sets out a universal agenda to eradicate extreme poverty

by 2030, and deliver on the promise of sustainable development. The Report adopts doubling of fuel efficiency as one of its indicators as part of Goal 7 – Secure Sustainable Energy. The Report has also cited the considerable momentum already achieved by the Sustainable Energy For All (SE4ALL) initiative and the need to further support this initiative and encourages public-private partnerships to support transport, energy efficiency.

GFEI is keen to ensure that fuel economy is an integral and important part of the post-2015 Sustainable Development Goal (SDG) framework. This is why the recommendation of the UN High Level Panel on the Post-2015 Development Agenda, for a specific goal on energy efficiency in transport - in line with the GFEI's targets for a 50% improvement in vehicle fuel economy in new LDVs by 2030 and across the total global car stock by 2050 – is so significant. This is based on work carried out by SE4ALL. GFEI is part of SE4ALL as a 'High Impact Opportunity' and is its leading initiative on fuel economy. World leaders and Governments at the UN will use the HLP's recommendations as a platform as they take negotiations forward over the months ahead on the Post-2015 agenda.



In June 2012, the Global Fuel Economy Initiative made a \$1 million+ 'Voluntary Commitment' to promote global efforts to improve fuel economy, at the Rio+20 'Earth Summit' in Rio de Janeiro. The Commitments made at the Rio+20 summit provide a platform for campaigns and advocacy calling for safe and sustainable transport to be part of the UN's Post 2015 Development Agenda. Since then, an influential report by the Partnership on Sustainable Low Carbon Transport (SLoCaT) has highlighted the progress of the VCs, including progress made on fuel economy policies and regulations in Africa, Asia, Latin America and the Caribbean, commending the work done by GFEI.

In November 2013 the GFEI presented its work at a meeting on energy efficiency initiatives during the 6th Open Working Group in New York.

Also in the meeting were Achim Steiner, Executive Director of UNEP, Geir Pederson the Danish UN Ambassador, Octavio Errázuriz the Chilean UN Ambassador, as well as senior representatives of the World Bank and SE4ALL. During the meeting the GFEI was thanked for its support for fuel economy



policy development in countries such as Chile; and the issue of fuel economy was identified as being key in addressing the pressing energy challenges facing less developed countries in particular.

The GFEI will build upon its involvement in the process so far, continuing to feed its input on fuel economy into the Post-2015 agenda. The GFEI will contribute its research and advice and will highlight the situation in countries and regions. Of particular importance, for example, is recent research undertaken for the GFEI which highlights that across emerging and developing countries progress must be accelerated in efforts to achieve a 50% improvement in vehicle fuel economy.



3. Update on Fuel Economy developments in 2013

Over the past year the GFEI has monitored trends and indicators related to fuel economy and produced a range of analysis. This has included both light-duty and heavy duty vehicles. The following sections provide key updates and insights and in some cases summarize the findings of longer reports available on the GFEI or partner websites.

3.1 International comparison of light-duty vehicle fuel economy

In 2013 the GFEI, led by the International Energy Agency, released the report “International comparison of light-duty vehicle fuel economy: An update using 2010 and 2011 new registration data.”

Key findings from the report are provided below.

In the first edition of this report, the main finding highlighted that global fuel economy improved by an average of 1.7% per year between 2005 and 2008, far below the required 2.7% annual improvement rate to reach the GFEI target of halving new light duty vehicle fuel economy (in l/100km or gCO₂/km) by 2030 (GFEI, 2011).

New data analysis presented in this report highlights that the pace of improvement has slightly accelerated between 2008 and 2011, but at 1.8% annual improvement rate is still lagging behind the overall GFEI target (table 1). Improving fuel economy from 8 Lge/100km to 4 Lge/100km between 2005 and 2030 required an average annual improvement of 2.7%. Given the slower rate of improvement between 2005 and 2011, average fuel economy from 2012 to 2030 needs to improve by 3% per year. Reaching this target at a global level is ambitious but appears achievable. For example, the enacted fuel economy standards around the globe require rapid annual improvements, up to 4.7%. Such improvement rates will hopefully become evident in future updates, but in any case many countries do not yet have standards.

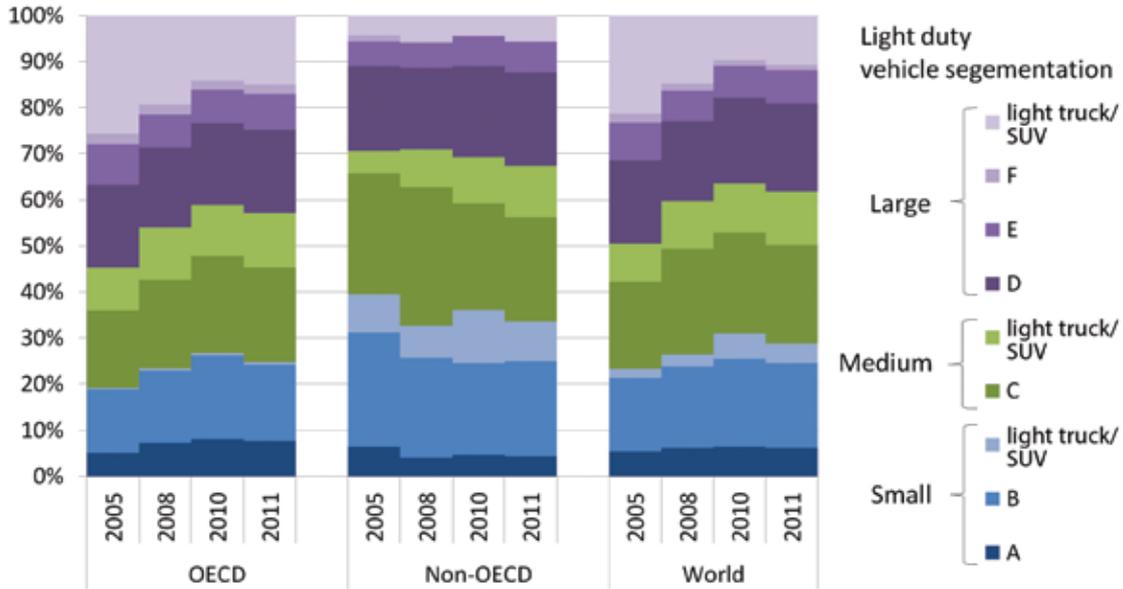
In particular, non-OECD countries have not been making sufficient progress towards better fuel economy over the 6-year period, and as non-OECD market growth is increasing much faster than OECD markets, most focus in the near future should be placed in helping non-OECD countries to develop and deploy more stringent fuel economy policies. OECD countries are on the right track but need to slightly accelerate the trend to meet the GFEI target in 2030, which will be more and more challenging as the target gets closer. The technical potential to reach the GFEI target has been demonstrated, but policies are needed to ensure these technologies are widely adopted in the mass market (IEA, 2012a and IEA, 2012b).

Most countries covered in this analysis have shown continuous fuel economy improvement, and the global trend is towards improvement of average new light-duty vehicle fuel economy (Table 1). Tremendous progress has been made in recent years regarding the interest, development and deployment of fuel economy policies and related vehicle technologies. This trend nevertheless needs to be sustained and accelerated in the near future in order to reach the GFEI target of 4Lge/100km for the average new vehicle sold around the world in 2030. The overall trend is encouraging, even though some countries are showing very limited progress over the 6-year period. The major non-OECD markets (Brazil, India, China) are working on fuel economy policies that should change this picture and provide results in the coming years. GFEI will pursue the tracking of average new vehicle fuel economy efforts. Data consistency and transparency still need to be improved to give a clearer picture of the worldwide average vehicle fuel economy and how it evolves over time.

TABLE 1 Fuel economy evolution compared to GFEI target

		2005	2008	2011	2030
OECD average	average fuel economy (Lge/100km)	8.1	7.6	7.0	
	annual improvement rate (% per year)	-2.2%		-2.7%	
		-2.4%			
Non-OECD average	average fuel economy (Lge/100km)	7.5	7.6	7.5	
	annual improvement rate (% per year)	0.4%		-0.6%	
		-0.1%			
Global average	average fuel economy (Lge/100km)	8.0	7.6	7.2	
	annual improvement rate (% per year)	-1.7%		-1.8%	
		-1.8%			
GFEI target	average fuel economy (Lge/100km)	8.0			4.0
	annual improvement rate (% per year)	-2.7%			
		2012 base year →		-3.0%	

FIGURE 4 Vehicle size evolution, major regions, 2005-2011



Evolution by vehicle size

Vehicle size is a key determinant of fuel economy, with weight and engine power also important, but closely related to the vehicle size itself. The data used in this analysis needed to be post-treated to assign each model to the appropriate vehicle segment (GFEI, 2011). The analysis shows that vehicle size has significantly evolved over the last six years (Figure 4). OECD countries started with much larger vehicles than non-OECD, but show a strong reduction in size over the time period. The slight rebound towards larger vehicles between 2010 and 2011 is mainly due to the fact that the US sales increased whereas the EU and Japan new vehicles' markets shrunk substantially in 2011. Still the overall trend is towards smaller vehicles.

In non-OECD countries, the opposite trend is present, towards bigger vehicles, together with higher penetration of light trucks (comprising SUVs, pick-ups, minivans and light commercial vehicles). Light trucks are often not very aerodynamic and are usually heavier than a typical passenger car, with bigger and more powerful powertrains. The global trend seems to indicate that a convergence is

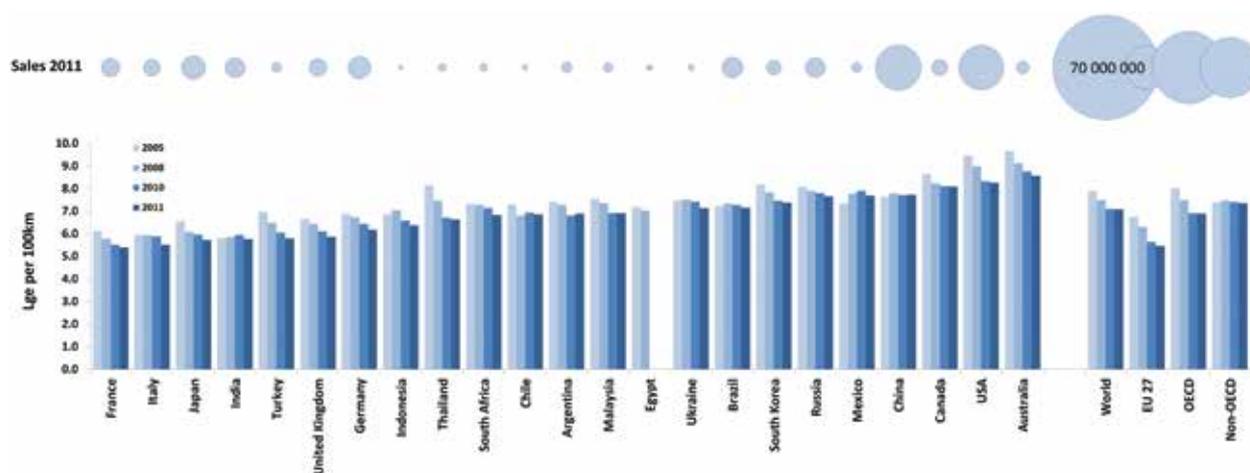


occurring towards markets with approximately one-third small vehicles, one-third medium size vehicles, and one-third large vehicles. Whether this continues will be monitored in future updates of this analysis.

When looking at fuel economy evolution by vehicle size, the biggest fuel economy improvements have taken place among larger vehicles (Figure 4). In OECD, the combined effects of the individual vehicle size class improvements together with a trend towards smaller vehicles led to the significant overall improvement of 2.5% per year over the six year time frame. In non-OECD countries, fuel economy in each of the individual vehicle size classes has only slightly improved, and this efficiency gain was then counterbalanced by a shift towards bigger vehicles. As a result non-OECD countries showed a near-constant fuel economy trend between 2005 and 2011. However, large vehicles within OECD countries are still less fuel efficient than in non-OECD countries, suggesting that

there is a size difference for large vehicles between OECD and non-OECD countries. On the other hand small vehicles in OECD countries are considerably more fuel-efficient than in non-OECD countries, probably indicating that more advanced technologies are fitted in small cars in the OECD countries.

FIGURE 5 Average new LDV fuel economy evolution by country 2005-2011



Note: Due to market characteristics and data availability, Canada, USA and Australia include all light duty vehicles. Egypt data is no longer available after 2008. Canada and Korea are only available from 2010. Only the major EU markets are shown.

3.2 Review of International Light-duty vehicle fuel efficiency policy developments 2012-13

Since the launch of the GFEI in March 2009, there have been substantial developments in passenger light-duty vehicle fuel efficiency standards globally. This section, provided by ICCT, briefly reviews the most recent developments during 2012 and 2013. The largest change has happened in the United States which has now become the first country to set fuel economy/GHG standards for passenger vehicles all the way to 2025. The new Canadian standards mirror the US standards, and together these countries aim to double the fuel economy of their new passenger vehicles by 2025 compared with the 2010 baseline. As shown in the table and figures below, this will put them on a similar trajectory as other OECD countries.

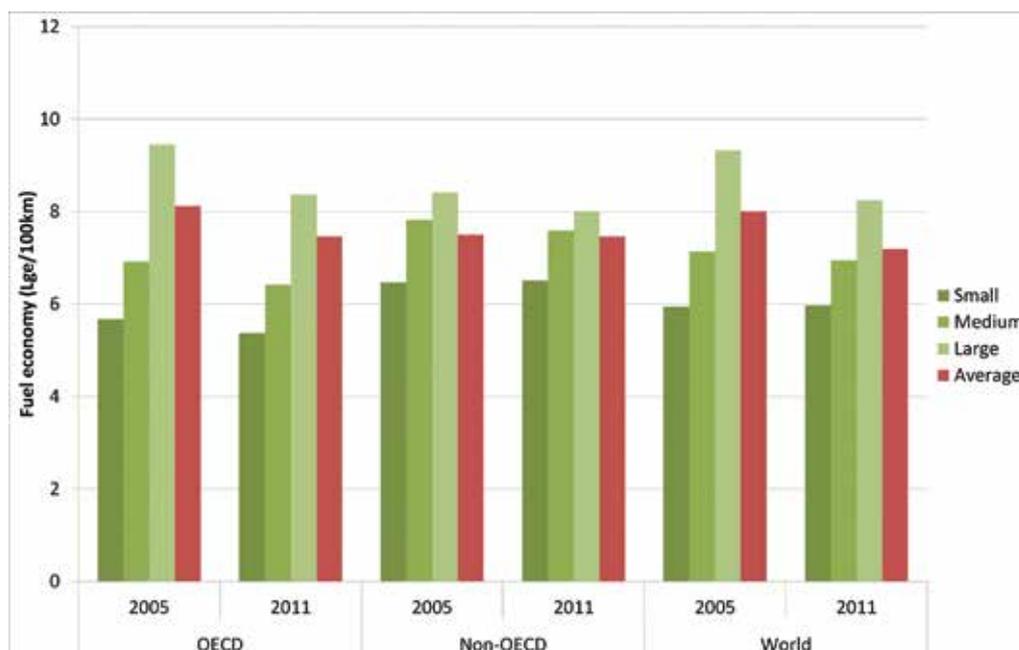
Due to the first ever fuel economy standards finalized by Mexico in June 2013, the North American continent now has a broadly harmonized fuel economy standard design framework and similar levels of regulatory stringency for years 2012-2016. It is also expected that Mexico will extend its standards beyond 2016 to

match the US and Canada programs for years 2017-2025. All three North American programs include light-commercial vehicles (pickup trucks and vans) along with passenger vehicles (cars, SUVs and minivans).

In October 2012, the Brazilian government approved by decree a new program to encourage vehicle technology innovation. Inovar-Auto fosters industry competitiveness by encouraging automakers to produce more efficient, safer, and technology-advanced vehicles while investing in the national automotive industry. Inovar-Auto provides these incentives in two ways. It first increases a tax on industrialized products (IPI) by 30% for all light-duty vehicles (LDVs) and light commercial vehicles. Second, it imposes a series of requirements for automakers to qualify for up to 30% discount in the IPI. In other words, IPI taxes will remain unchanged for those manufacturers that meet the requirements, thus incentivizing investments in vehicle efficiency, national production, R&D, and automotive technology. The program is expected to bring about a 12-19% reduction in fuel consumption reduction from 2013-2017.

The European Commission proposed the 2020 CO₂ standards for passenger cars as well as light-commercial vehicles in 2012. The light-commercial vehicles standards of 147 gCO₂/km have since been finalized.

FIGURE 6 Fuel economy trend by vehicle size, major regions, 2005-2011



As of June 2013, a deal between the European Parliament, and the European Council on the Commission proposal of 95 gCO₂/km appeared imminent. However recent developments are less promising.

The EU cars 2020 standard has since been a subject of intense scrutiny and debate over the automaker demands for greater flexibility to achieve the standards mainly through super-credits for electric vehicles.

In Asia, Japan continues to lead the way on LDV efficiency. The market share of hybrid vehicles in Japan exceeded 19% in FY2012-13. As a result, the average fuel efficiency of new vehicles in Japan already exceeds the 2015 standard, and leaves Japan only 12% fuel consumption reduction before reaching its proposed 2020 target of 20.3 km/L (JC08 test cycle).

As of model year 2011, the Republic of Korea's average GHG emissions for passenger vehicles were 152 gCO₂/km, well on track to meet the 2015 target of 140g CO₂/km. South Korea is also expected to set fuel efficiency and CO₂ targets for 2020 that broadly align with the EU and Japan 2020 standards.

China is currently implementing the Phase III of their fuel consumption standard with a goal of reaching 6.9 l/100km in 2015, compared with 7.34 l/100km in 2012. The country has also started regulatory activity to finalize the Phase IV fuel consumption standards to be set at 5 l/100km.

Fuel consumption standards for passenger vehicles is under discussion in India as well as ASEAN countries such as Vietnam and Thailand. The Bureau of Energy Efficiency (BEE) in India had earlier proposed fuel economy standards for 2015 and 2020, but subsequently the implementation dates of these standards has been pushed back by at least one year, and are still awaiting final notification. The standards aim to achieve a 20% reduction in fuel consumption (from 6 l/100km in 2009 to 4.8 l/100km in 2021) over twelve years.

India, along with Australia and Russia now remain the three largest markets without an official fuel efficiency target.

The fuel efficiency standards adopted thus far have exhibited a great deal of diversity in the design of the standards. Table 2 summarizes the specific policy approaches adopted by different regions. Many further details regarding LDV efficiency policies and trends are contained throughout this report.

TABLE 2 Overview of Regulation Specifications

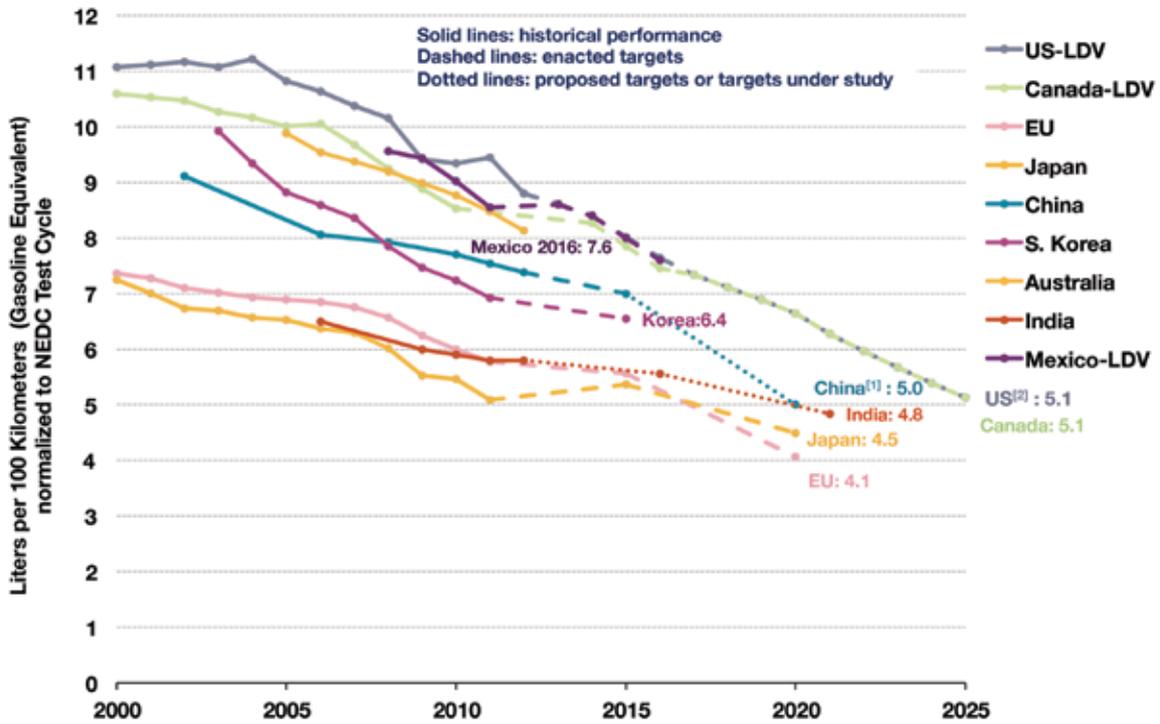
Country or Region	Target Year	Standard Type	Unadjusted Fleet Target/Measure	Structure	Targeted Fleet	Test Cycle
U.S.(include California) (enacted)	2016	Fuel economy/ GHG	34.1 mpg* or 250 gCO ₂ /mi	Size-based corporate avg.	Cars/Light trucks	U.S. combined
U.S. (enacted)	2025	Fuel economy/ GHG	49.1 mpg** or 165 gCO ₂ /mi	Sizebased corporate avg.	Cars/Light trucks	U.S. combined
Canada (enacted)	2016	GHG	153 (157)*** gCO ₂ /km	Size-based corporate avg.	Cars/Light trucks	U.S. combined
EU (enacted) EU (proposed)	2015 2020	CO ₂	130 gCO ₂ /km 95 gCO ₂ /km	Weight.-based corporate average	Cars/SUVs	NEDC
Japan (enacted) Japan (enacted)	2015 2020	Fuel economy	16.8 km/L 20.3 km/L	Weight-class based corporate average	Cars	JC08
China (enacted) China (under study)	2015 2020	Fuel economy	6.9 L/100km 5 L/100km	eight-class based per vehicle and corporate average	Cars/SUVs	NEDC
South Korea (enacted)	2015	Fuel economy/ GHG	17 km/L or 140 gCO ₂ /km	Weight-based corporate average	Cars/SUVs	U.S. combined
Mexico (enacted)	2016	Fuel economy/ GHG	35.1 mpg or 157 g/km	Size-based corporate avg.	Cars/Light trucks	U.S. combined
Brazil (enacted)	2017	Fuel economy	1.82 MJ/km	Weight-based corporate average	Cars	U.S. combined
India (proposed)	2016 2021	CO ₂	130 g/km 113 g/km	Weight-based corporate average	Cars/SUVs	NEDC

* Assumes manufacturers fully use A/C credit.

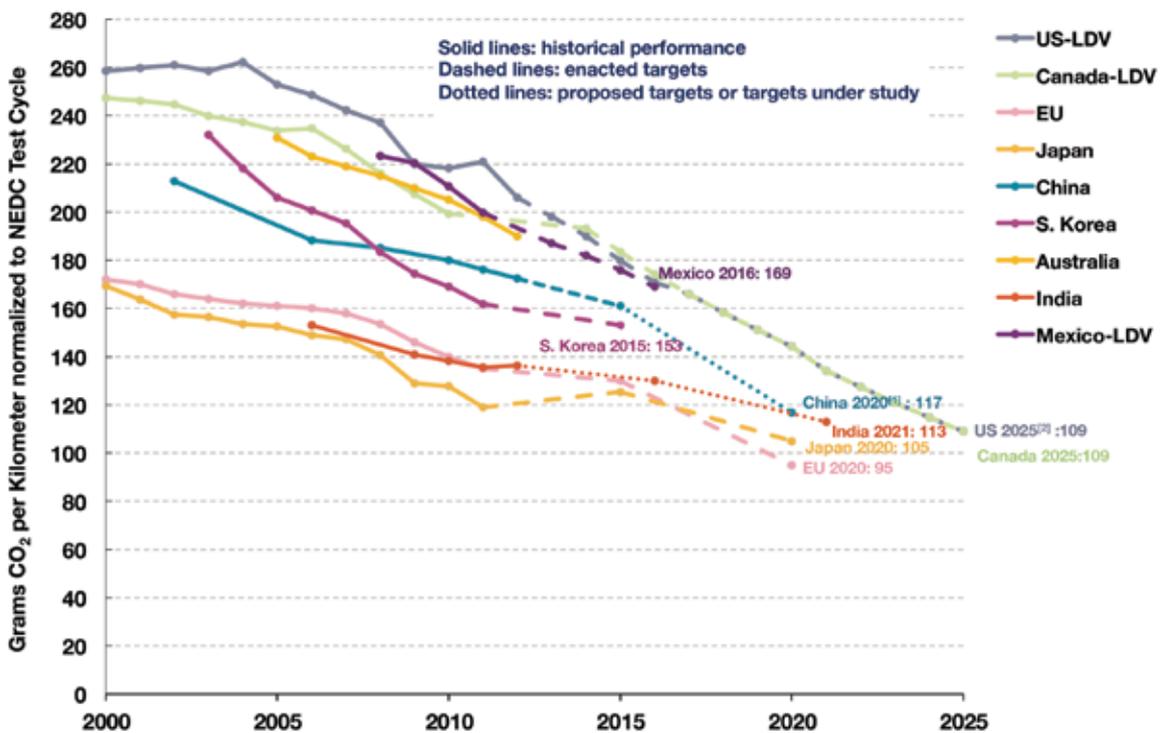
** Proposed CAFE standard by NHTSA. It is equivalent to 163g/mi plus CO₂ credits for using low-GWP A/C refrigerants.

*** In April 2010, Canada announced a target of 153 g/km for MY2016. Value in brackets is estimated target for MY2016, assuming that during 2008 and 2016 the fuel efficiency of the light-duty fleet in Canada will achieve a 5.5% annual improvement rate (the same rate as the U.S.).

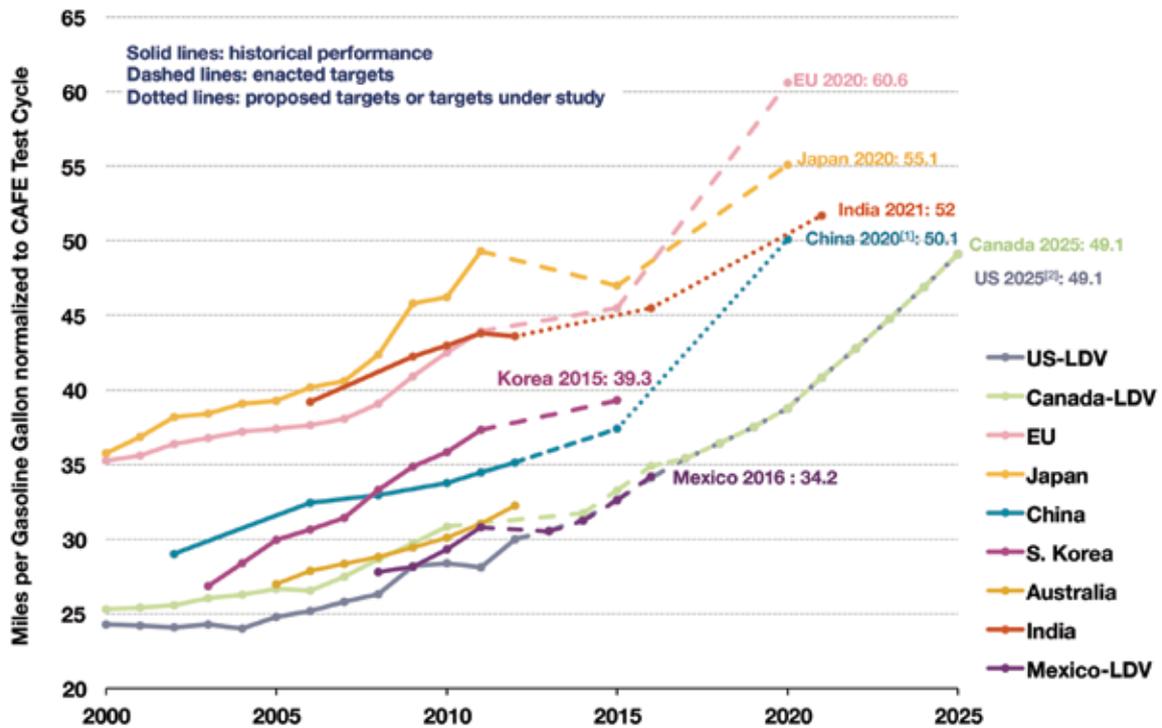
FIGURE 7 Fuel economy Targets and Requirements - From Four Different Perspectives
 These figures show the same information four different ways, in four different units. All are useful and provide a tool for comparison.



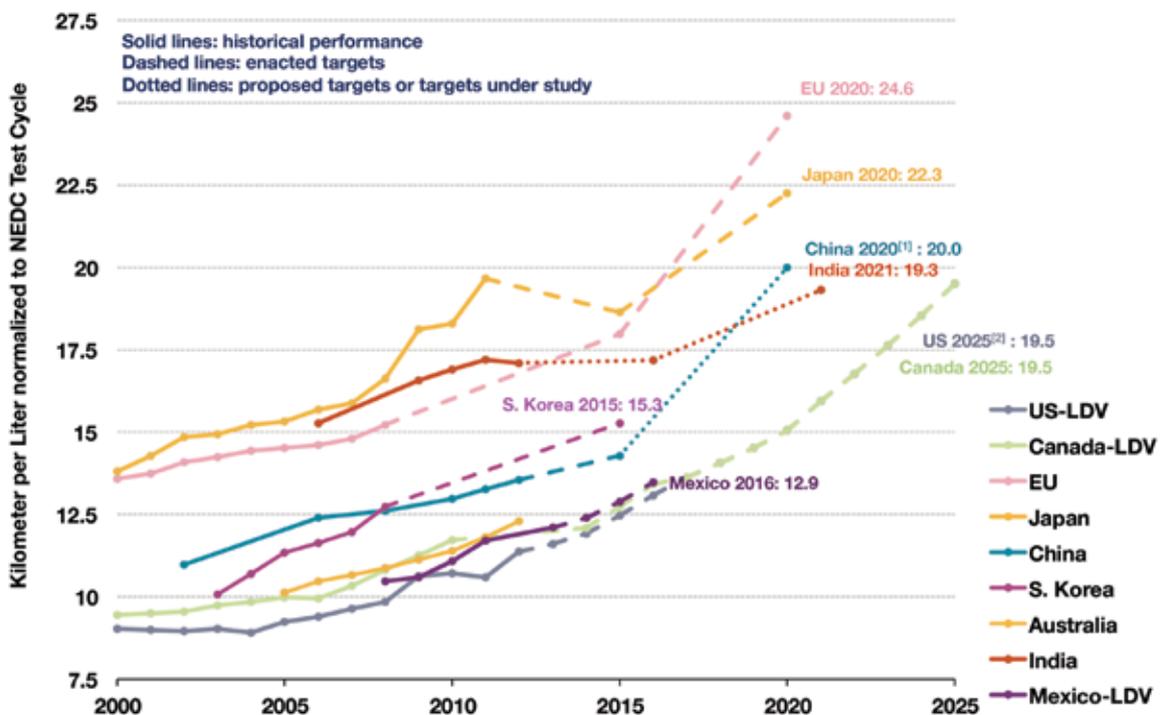
[1] China's target reflects gasoline vehicles only. The target may be higher after new energy vehicles are considered.
 [2] US, Canada, and Mexico light-duty vehicles include light-commercial vehicles.
 [3] Supporting data can be found at: <http://www.theicct.org/info-tools/global-passenger-vehicle-standards>.



[1] China's target reflects gasoline vehicles only. The target may be higher after new energy vehicles are considered.
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[1] China's target reflects gasoline fleet scenario. If including other fuel types, the target will be higher.
 [2] US and Canada light-duty vehicles include light-commercial vehicles.
 [3] Supporting data can be found at: <http://www.theicct.org/info-tools/global-passenger-vehicle-standards>.



3.3 Review of International Heavy-duty Vehicle Fuel Efficiency Policy

In nearly every major economy medium and heavy-duty freight vehicles (including urban and long-haul trucks) account for a significant share of the fuel consumption from transportation. This section, provided by ICCT, reviews the most recent truck efficiency and policy-related developments during 2012 and 2013.

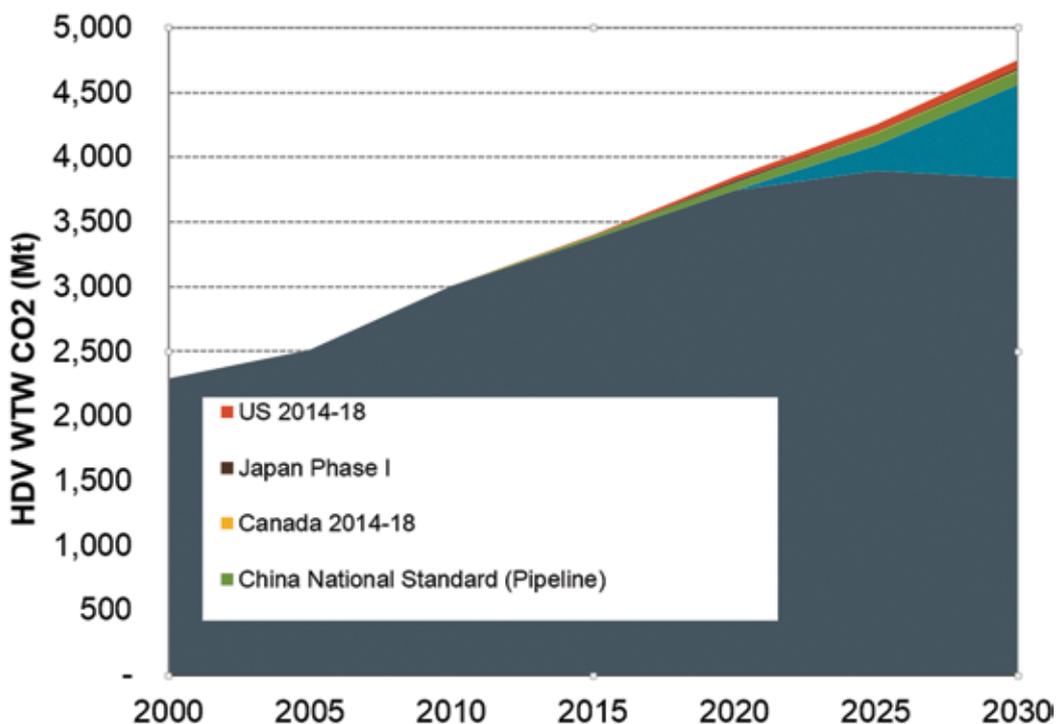
Heavy duty vehicles account for even more fuel use and greenhouse gas emissions than light duty vehicles in some countries (such as China, India, and Mexico). As can be seen in Figure 8, global heavy-duty vehicle CO₂ emissions are expected to rise rapidly in the future, but potential efficiency improvements could cause this to level off by 2030." To date, most countries' efforts to reduce energy consumption through improved vehicle efficiency have been focused primarily on passenger light-duty vehicles. PLDV standards have had a visible and significant impact on fuel efficiency and greenhouse gas emissions and help drive vehicle manufacturers to produce more fuel-efficient vehicles

through the increased deployment of more efficient engines and transmissions, improved aerodynamics, tires with lower rolling resistance, and hybrid vehicle.

Efficiency standards for heavy-duty vehicles (HDVs) likewise hold potential to promote advanced technologies for energy savings in engines, transmissions, tires, and aerodynamics. A number of countries are at various stages in the process of developing and implementing HDV policies and regulations:

- Japan adopted the world's first HDV efficiency standard and test procedure in 2005, with standards to be fully implemented from April 1, 2015.
- In 2011 the US followed with its own HDV standard for model years 2014 through 2018.
- China finalized the first stage of its HDV efficiency program in 2012.
- The European Union is finalizing a certification procedure that could lead to a potential labeling program for HDV efficiency, with future standards anticipated.

FIGURE 8 Global HDV GHG emissions under different policy scenarios, 2010-2030 (ICCT Roadmap Model Scenario)



- Canada finalized a greenhouse gas (GHG) emission standard for heavy-duty trucks in March 2013 that is closely aligned with the United States' HDV Fuel Consumption and GHG standards.

Furthermore, the US, Japan, and China have all begun preliminary work on "Phase II" efficiency requirements for model year 2020+ vehicles.

Establishing these standards is challenging, for a number of reasons. The HDV market represents a wide range of uses, from transporting goods across the country in long haul trucks, to moving people around cities in transit buses, to hauling refuse. The complexity of decisions of which vehicle types to regulate, how to set standards, and even how to test for compliance to established standards have led to a patchwork of national approaches. Countries set varying methods and conditions on which they measure vehicle and engine emissions (commonly referred to as test cycles), treat engine-specific and whole-vehicle testing for trucks differently, and employ various modeling techniques to reduce the amount of testing that each vehicle manufacturer must undertake. Table 3 summarizes some of the key differences in HDV test protocols that are being

developed in the US, China, Japan, and EU. It can be seen that the given approaches vary across regions. There are efforts underway to look for opportunities for alignment of these standards, however it is unlikely that we will see a closely harmonized standard for HDV efficiency (as we have for HDV engine emissions).

The potential impact is huge, both in terms of emissions and international understanding. Standards have the potential to significantly reduce projected CO₂ emissions (Figure 8). The entire coloured area of the chart shows projected global emissions from all heavy-duty vehicles, taking into account anticipated increases in heavy-duty vehicle usage in the next 15-20 years. The different coloured wedges represent the predicted impact that current policies from various countries will have on CO₂ emissions, while the light blue wedge represents potential reductions that could be gained from stronger policies based on the potential of available technologies in the near-term. As the chart shows, implementing stronger policies could stabilize greenhouse gas emissions from heavy-duty vehicles between 2020-2025, and from 2025-2030 begin to reduce emissions

TABLE 3 Test procedure comparison for tractor trucks²

Feature		U.S./ Canada	Japan	China	EU
Test Cycles and Weighting		Transient 5%, 55-mph cruise 9% and 65-mph cruise 86% for sleeper cab tractor trucks.	Transient 90% Highway (with grade) 10% for heavy tractor trucks	Tractor trucks: Road (rural) 10% Highway 90%	Mission-based cycles (may include road grade, altitude, stops)
Test Payload		19 short tons (17.2 tons)	20 tons (half payload)	Full payload (maximum allowed)	Average payload
Test Method		Simulation using standard engine and transmission; standard trailer depending on roof height	Simulation using engine fuel consumption map and transmissions specs; standard trailer	Chassis test required for baseline. Simulation or chassis for improved model	Simulation based on actual vehicle values
Aerodynamic drag (Cd)		Manufacturer testing to determine Cd (coastdown preferred)	Standard value	Manufacturer testing to determine Cd (coastdown preferred) or standard value	Manufacturer testing to determine Cd (constant speed test preferred)
Rolling Resistance (Crr)		OEM or tire manufacturer testing to determine Crr for steer and drive tire	Standard value	Manufacturer testing to determine Crr, or default values used	Standard values from tire labels
Technologies Credited	Engine	Through separate engine standards	Yes	Yes	Yes
	Transmission	Optional; by demonstration outside of standard protocol	Somewhat	Yes	Yes
	Aero/Tires	Yes	No	Yes	Yes
	Trailers	No	No	No	No

FIGURE 9 HDV Global Regulatory Landscape
(Items in blue are ICCT expectations (not public announcements))

Country/Region	Regulation Type	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Japan	Fuel economy	Phase 1 regulation implemented starting MY 2015										
United States	GHG/ Fuel efficiency	Standard proposal	Final rule					Regulation implemented starting MY 2014 (mandatory DOT program starts MY 2016)				Phase 2 implementation
China	Fuel consumption	Test procedure finalized	Industry standard proposal	Industry standard implemented	National standard adopted			Regulation implemented starting MY 2015				
European Union	CO2 test procedure	Technical studies				Impact assessment/ Test procedure finalized				Policy implementation		
Canada	GHG			Standard proposal	Final rule		Regulation implemented starting MY 2014				Phase 2	
Korea	Fuel efficiency	Technical studies				Impact assessment	Test procedure finalized	Poicy implementation (second half of 2015)				
Mexico	Fuel efficiency				Proposal			Regulation implemented starting MY 2016				Phase 2 implementation
California	End-user requirements	Requirements for new tractors, trailers (2011+)				Additional reqs. for existing tractors and trailers (<MY 2010)			Additional reqs. for existing trailers and reefers (<MY 2010)			

absolutely despite the significant growth in heavy-duty vehicle usage that is predicted over the next two decades. Reductions of this magnitude from the HDV sector would be a huge win in the efforts to minimize climate change. Figure 9 illustrates the current global landscape of countries and regions that are working towards HDV efficiency regulations.

The following sections detail updates on recent developments in the area of HDV efficiency standards over the past year.

In the United States the first joint GHG emissions and fuel consumption standards for heavy- and medium-duty vehicles were adopted in August 2011. In 2010, President Obama requested that the National Highway Traffic Safety Administration (NHTSA) and the US Environmental Protection Agency (EPA) work to jointly establish greenhouse gas (GHG) emissions and fuel efficiency standards for medium- and heavy-duty highway vehicles. This is the first time that either

heavy-duty GHG emissions or fuel efficiency have been regulated in the United States. The regulation covers model years (MY) 2014-2018 and applies to all on-road vehicles rated at a GVW \geq 8,500 lbs.

The rule is best understood as three separate regulatory programs linked to specific provisions for tractor-trailer trucks, pickup trucks and vans, and vocational vehicles (vocational vehicles are categorized as all vehicles >8,500lbs that don't fall into one of the previous two categories). In addition, the engines that power tractor trucks and vocational vehicles are regulated in a separate program. Overall, the stringency of the program ranges from 6% to 23% reduction in fuel consumption in the MY 2017 timeframe, as compared to a MY 2010 baseline. The stringency levels vary according to vehicle subcategories that are based on weight classes and vehicle attributes. For example, the stringency for tractor trucks ranges from 9-23% depending on cab type and roof height, whereas the stringency for vocational vehicles ranges from 6-9% based on weight class.



Currently, work is underway to support the next phase of the standard, a proposal for which is expected in the second half of 2014, with the standard predicted to go into effect in the 2020 timeframe. Major research to support this proposal includes improving the accuracy of the fuel use simulation model as well as making sure that more advanced technologies will be credited. Such things as advanced transmission or improved trailer aerodynamics were not credited through the standard protocol in the first phase. Improvements to the simulation model will likely include such things as an increased number of user-defined inputs, more real-world duty cycles, and improved engine and transmission models.

In California, the California Air Resources Board (ARB) adopted a new regulation in December 2008 to reduce greenhouse gas emissions by improving the fuel efficiency of heavy-duty tractors that pull 53-foot or longer box-type trailers. Fuel efficiency

is improved through improvements in tractor and trailer aerodynamics and the use of low rolling resistance tires. The rule went into effect in 2010 and is being phased in through 2017. The tractors and trailers subject to this regulation must use U.S. Environmental Protection Agency SmartWay certified tractors and trailers, or retrofit their existing fleet with SmartWay verified technologies.

In addition to these end user requirements, California has drafted a proposal to harmonize with the 2014 US GHG standard. This standard is due to be presented to the board in December 2013. California has also committed to coordinating with the US EPA on Phase 2 GHG regulation.

Canada announced a proposed greenhouse gas (GHG) emission standard for the heavy-duty sector on 13 April 2012. The standard was finalized on 13 March 2013 and is closely aligned with the United



States' HDV Fuel Consumption and GHG standards. The standard will be implemented beginning with MY2014 vehicles and engines, and will be fully phased-in by 2018. The regulatory design mirrors that of the US HDV program. In addition to harmonizing with the US standard, Canada has committed to coordinating with the US on Phase 2 regulation.

The China Phase I standard (the Industry Standard) was implemented for new vehicle type approvals on July 1, 2012. The standard is a precursor to a more comprehensive National Standard (Phase II) currently in the final stages of development. In the fall of 2012, the national standard was open for public commenting. The proposed standard stipulates a set of limits on the fuel consumption for new commercial trucks, dump trucks, tractors, coaches and buses with gross vehicle weight over 3,500 kg. It is expected to be released formally in late 2013 and begin taking effect in 2014.

In the European Union over the past three years the European Commission has developed a test procedure to accurately predict HDV CO₂ emissions. In general terms the test procedure involves a simulation methodology with user defined inputs that will give whole vehicle HDV CO₂ emissions. Currently, the procedure is being applied to three vehicle types (tractor-trailer trucks, regional delivery, intercity buses), which account for 50% of HDV CO₂ emissions in the EU. DG Clima (the Directorate-General for Climate Action for the European Commission) has prepared legislation that would regulate measurement, certification and reporting of HDV CO₂ emissions and, in addition, would make those results publically available. The draft is currently being considered internally at the European Commission. The timeframe on finalization of this legislation is uncertain and could be anywhere from 6 months to 2 years. In the longer term, the EC will determine if standard setting for HDV CO₂ is appropriate.

3.4 National Academy of Sciences (NAS) report on LDV fuel economy potential to 2050

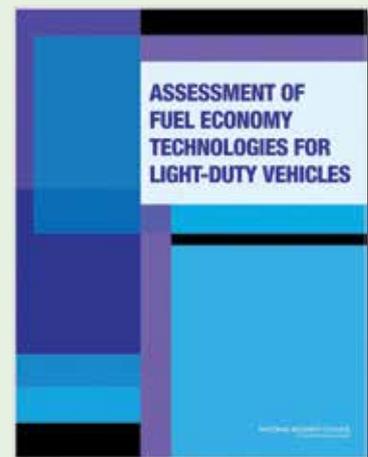
During 2013, the U.S. National Research Council (NRC) released a comprehensive study of the technology potential for cutting oil consumption and GHG emissions by 80% across the U.S. light-duty vehicle fleet in 2050, relative to a 2005 baseline. The committee, which included John German from ICCT, examined the technologies that could significantly contribute to these goals and the barriers that may hinder their adoption. The committee developed scenarios to identify promising combinations of fuels and vehicles to meet the goals and the policies that would be required to attain them. Its assessment: Cautious optimism, tempered by a realistic acknowledgment that achieving those related but distinct goals will demand vigorous and sustained public-sector support through “policies emphasizing research and development, subsidies, energy taxes, or regulations.”



The study, which is the product of more than two years' work by a committee drawn from industry, government, and the academy, focused on four general technology pathways: highly efficient conventional vehicles (including conventional hybrids), biofuels, plug-in hybrid and battery electric vehicles, and hydrogen fuel cell vehicles. The analysis also takes in natural gas, various crosscutting vehicle and fuels technologies, and certain relevant external factors, such as prospects for decarbonizing the electric power sector.

KEY FINDINGS OF THE NAS REPORT

- The goal of reducing oil use by 80% could be met by several combinations of technologies that achieve at least the mid-range level of estimated success. But it will demand continued improvement in vehicle efficiency beyond what is required by the 2025 CAFE standards, as well as increased production and use of biofuels, and/or the successful introduction and large-scale deployment of compressed natural gas vehicles, battery electric vehicles (BEVs) with greatly improved batteries, or fuel cell vehicles, with all the additional new supporting infrastructure those imply.
- Reductions in annual GHG emissions from the LDV fleet on the order of 60% to 70% are achievable by 2050, but reaching the desired 80% reduction is less certain, and will in any case be more difficult than reducing oil consumption by the same 80%. Petroleum-based fuels would have to be largely eliminated and at least two of four pathways would be required, i.e., highly efficient conventional vehicles combined with vehicles operating on biofuels, electricity, or hydrogen produced with low net GHG emissions. This scenario involves significant uncertainties concerning performance and costs, and it implies an economy-wide transition away from GHG emissions.
- Because of the need for progress across multiple if not necessarily all technology pathways, and uncertainties over costs, rates of implementation, and consumer and manufacturer responses, an adaptive, “all of the above” type of policy framework is crucial.



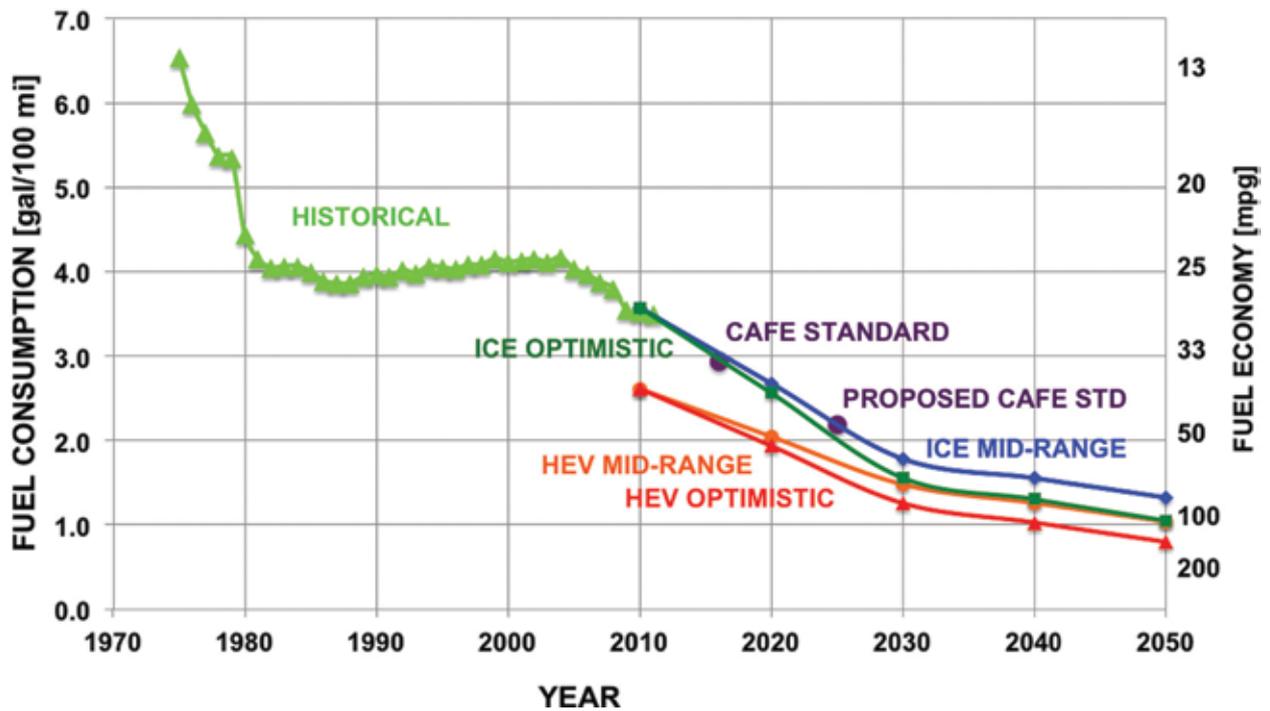


The groundbreaking aspect of the study is not necessarily obvious from overall summaries of the 2050 reductions. Forecasting technology development 40 years into the future is hazardous, at best.

Instead of trying to predict the development of individual technologies and their benefits, the committee evaluated existing energy losses through the entire drive train and the potential to reduce each of these losses in the future. The rate of progress in reducing those losses was assumed to slow dramatically after 2030, to about half the predicted rate from now until 2030. In addition, fundamental physical and chemical limitations were carefully assessed for each component and as these limits were approached, the rate of improvement was slowed down to ensure that the estimates stayed well short of the limits. The Committee also made great care to apply consistent assumptions across all of the technology types.

Two important results of the study deserve particular attention. First, the potential for enhancing the efficiency of conventional vehicles is far greater than commonly believed. Figure 10 shows the projected trends in car and light truck fuel economy and compares them to historical trends. “What jumps out is how fuel-efficient internal-combustion engine vehicles with hybrid systems are expected to become: about 95 mpg (2.5 L/100km) in a fairly conservative (“mid-range”) scenario, to over 120 mpg (2.0 L/100km) in a somewhat more optimistic one. For cars alone—excluding light trucks—which the chart doesn’t show, those numbers are even more eye-popping: about 112 mpg (2.1 L/100km) in the moderate case, 145 mpg (1.6 L/100km) optimistically.” This degree of efficiency gain is possible primarily with aggressive extensions of technologies already available in the market, such as lightweight materials, lower aerodynamic drag and tire rolling resistance, downsized highly-boosted engines, automated manual transmissions, and hybrid-electric systems—if we choose regulations that push the envelope of efficiency standards.

FIGURE 10 Historical and projected light-duty vehicle fuel economy
 (All data is new fleet only using unadjusted test values, not in-use fuel consumption)



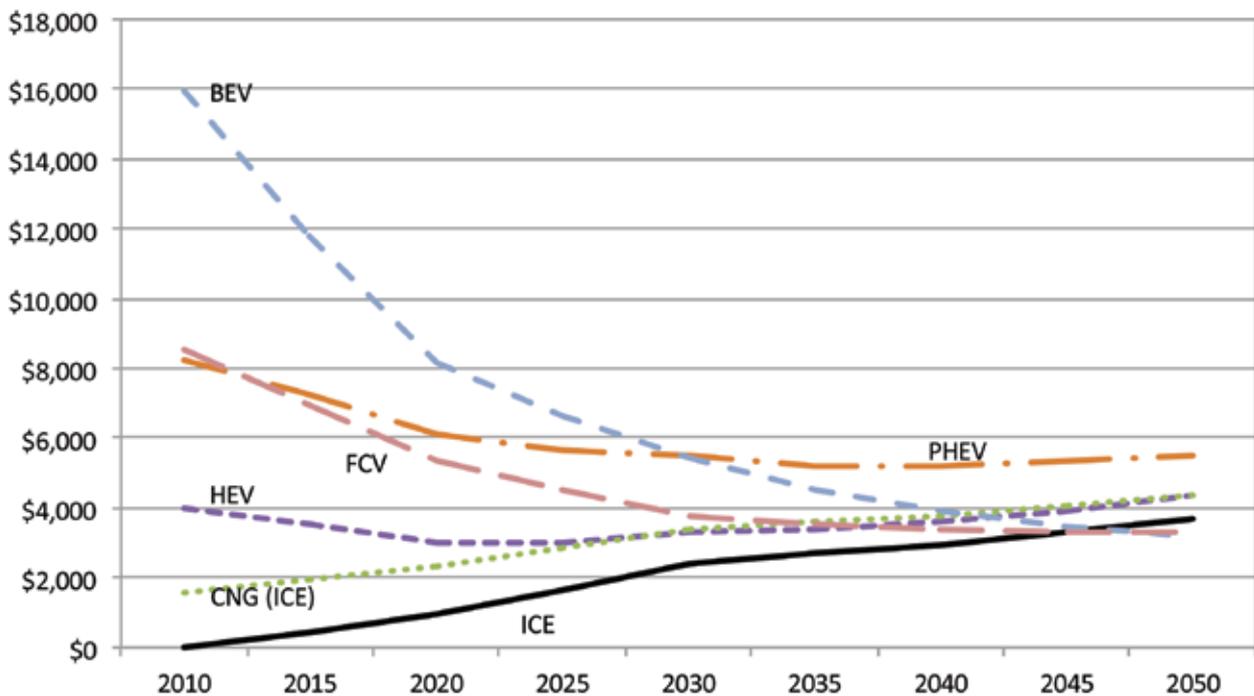
All of the study's projections assume the same full mix of vehicle types and sizes as consumers are accustomed to today. The implications for the U.S. and the rest of world are profound: more time to transition to battery electrics and fuel cell vehicles, more emissions reductions and oil savings from conventional technologies.

As shown in Figure 11, assuming high volume production, the study projects that the costs of the different technology platforms—battery and hybrid electrics, fuel cells, ICEs—converge around 2040 (the exception is plug-in hybrids, which are going to remain relatively expensive). And shortly after that point, battery electrics and fuel cells will become cheaper to build than ICEs. Again this is a midrange scenario; the optimistic case (not shown) puts that point of convergence about ten years earlier—around 2030-2035, or about twenty years from today. There are a number of reasons for this. Battery and fuel cell costs, which are falling in any case, are directly related to the loads on the vehicle, so that expected reductions in weight, aerodynamic drag, and tire rolling resistance result in much larger cost reductions for these vehicles than for conventional vehicles.



With lower electricity prices and very high efficiency, BEVs will be both cheaper to buy and cheaper to operate than conventional vehicles. However, to keep the cost of the battery pack down, the committee assumed that electric-range would be limited to 100 real-world miles. Combined with 20-30 minute recharge times, the committee's modeling suggests that BEV market share will likely be limited to about 20%.

FIGURE 11 Car incremental cost versus 2010 baseline (\$26,341 retail price) - Midrange case



In the long run, fuel cell vehicles will be significantly better than conventional vehicles with no compromises: lower purchase prices, comparable range and refill times, more efficient, quieter, with better drivability and low-end torque and more flexible packaging of drive train components for better space utilization. However, sustaining the trend in fuel-cell vehicle technology will depend on building, in advance, an entirely new delivery infrastructure and on finding a way to produce hydrogen at a price competitive with gasoline.



There is a lot of good news in the committee's report. Even if future barriers to alternative vehicle technologies are not overcome, there are a lot more improvements available with conventional technology than commonly believed. And if the barriers can be overcome, battery and fuel cell vehicles offer the promise of higher efficiency

at lower cost.

The results, while focused on the US, are really broadly applicable around the world as the technology is global. As a result, the 50 by 50 goal set by the GFEI is likely to prove just the first step towards improving fuel economy of light-vehicles globally.

Another important consideration is that realizing the climate benefits of these advanced vehicle technologies will depend on low-carbon power to create electricity and hydrogen (which are both energy carriers). That is to say: new infrastructure investments are critical to the success of the investments already being made in alternative vehicle technologies.

The real question is: does the world have the will to enact regulations to cause these technology improvements to actually happen and to make the necessary investments for the transition to alternative vehicle technologies?³



4 Summaries of GFEI Partner Studies and Findings

The GFEI sponsored a range of studies during 2013 and this section provides summaries and key findings from several of these. They include studies both from GFEI partner organizations and other analysts that have been involved in collaborative efforts.

4.1 Comparisons of Vehicle Technology and Fuel Efficiency Across 10 Countries (K.G. DULEEP)

This report examines the new light-duty vehicle fleets for model year 2010 in six emerging market, non-OECD countries relative to the new vehicle fleets in USA, Australia, Germany and France, as four example OECD countries. The non-OECD countries include the BRIC nations (Brazil, Russia, India and China) as well as Malaysia and South Africa. This analysis updates an earlier analysis performed for the IEA using 2008 data to also include 2010 data, which allows for some examination of time trends.

While the OECD countries typically report the average fuel economy of new vehicles in each year, such information is generally not available publicly for most developing countries.

Developing country fleets typically have large percentages of small cars, which has led many to conclude that the fleets are fuel efficient. Through a detailed analysis of data, not only can the average fuel economy of new cars be measured with better accuracy, but other statistics of interest can also be assessed, such as fuel economy within and across market/size class and the presence of various technologies on vehicles (and the fuel economy effects of these technologies).

The analysis of vehicle specification and fuel economy data from the new light vehicle fleets of 9 countries shows the considerable diversity in fleet characteristics – and in local forces affecting these characteristics. The most obvious lesson from the data is that policies aimed at improving fuel economy have to be tailored to the forces in each country and that a single policy approach (such as a particular type and level of fuel economy standards) may not be uniformly effective or appropriate across all nations.

OECD COUNTRIES

The comparison across four OECD countries provides the following lessons:

- First, vehicle fuel efficiency technology is very similar across all developed countries, in spite of significant differences in fuel prices and incomes. This shows that fuel economy regulations in these countries play an important role in determining manufacturer technology introduction plans. (see Figure 12 below).
- Second, economic instruments such as fees and rebates (“feebates”) based on vehicle fuel efficiency can have significant market effects by drawing consumers to the most efficient vehicles, even when there are stringent fuel economy standards. There is also some evidence that manufacturers subject to feebates may “pull ahead” technology introduction to take advantage of the market response, based on France’s experience with the fee and rebate system called “Bonus Malus”.
- Third, developed nations that rely on imported vehicles for most or all of their vehicle fleet enjoy a

spillover effect of having the latest fuel economy technology since most vehicles are imported from the EU, Japan and Korea. Nations that do not have a domestic car industry typically do not have enough sales and economies of scale, especially at the individual vehicle make/model level, to justify a unique design for that country. The Australian situation shows that improvements in its light vehicle fleet have kept pace with the EU and US fleets even though there are no fuel economy standards. 85% of the Australian fleet is imported and its domestic manufacturers do not see any future for Australia specific designs. Fuel economy technology may lag the level in the EU or Japan by a modest one to two years due to the lag in the timing of new model introduction.

By 2011, all four countries showed a 17 +/- 0.7% reduction relative to 2002, which is remarkably similar given the differences in local fuel prices, vehicle taxes, fleet composition and the vehicles covered by regulation. One explanation is that the developed country markets are being supplied by the same set of major global auto-manufacturers, who are responding to regulatory pressure by adopting similar technology for all developed country markets (and, as shown in the next section, for many developing country markets).

DEVELOPING COUNTRIES

In the context of developing countries, there are additional specific findings

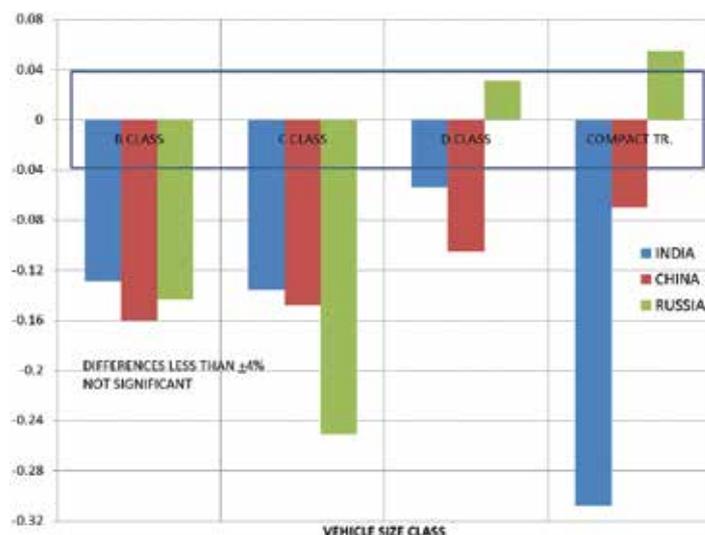
- In countries where most of the vehicles are imported or simply assembled from knock-down kits, the same spillover effect of obtaining the latest fuel efficiency technology from the EU and Japan is observed, as in South Africa. There is a modest time lag in technology introduction.
- The situation in countries with significant domestic production and/or restriction of imports, the situation is more complex. Products manufactured locally by global auto-manufacturers generally employ new technology but with a somewhat larger time lag of 4 to 5 years relative to OECD countries in many cases, but not always, depending on the local market's competitiveness. Products manufactured by purely domestic manufacturers, such as Tata in India, Lada in Russia, or Wuling in China typically feature older technology and are 15 to 25 percent less fuel efficient relative to their OECD counterparts of equal size and performance as indicated in Figure 12 below. However, these products are usually smaller, low performance vehicles and their fuel economy may be fairly good on an absolute scale.
- A major factor that may inhibit the adoption of new technology in the older design vehicles manufactured domestically is that these products are usually very low price models sold to the most cost sensitive buyers, at prices that are typically less than half the price of similar size vehicles sold in the OECD. The old technology models may also be perceived as easier to maintain and repair in a developing country environment.

The above findings are based on the 2008 and 2010 data, but the steep increase in global fuel price since 2009 is changing the picture. Sales of these older design models appear to be fading and it is possible that technology in developing countries will converge to the technology used in the OECD in the future with a modest time lag as consumer demand for more efficient products grows in developing countries.

A separate issue (not based on any of the data in this report) is the applicability of new technology being introduced in OECD countries to the developing country environment. The EU manufacturers have, in particular, adopted the technology of using downsized direct injection turbocharged gasoline engines as a primary method of meeting future fuel consumption or CO₂ standards, but the technology is better suited to high speed driving rather than low speed driving conditions prevalent in much of the developing world. It is possible that these types of technologies may diverge significantly between the EU and the developing world in the future. Future research should further investigate local driving conditions and the relevance and performance of different fuel economy technologies in different contexts.

FIGURE 12

Size class specific fuel consumption differences relative to Germany (adjusted for diesel penetration, weight and performance; negative percentages indicate worse FC)





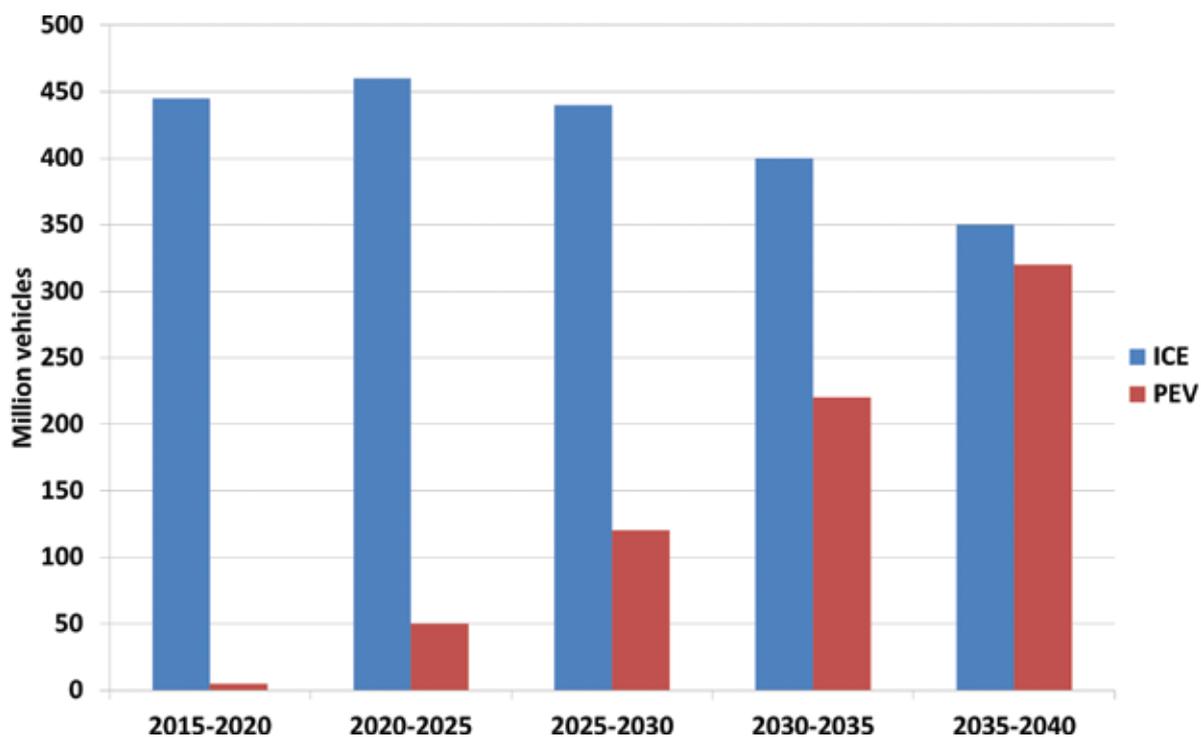
4.2 How Fuel Economy Improvements can save the world \$2 Trillion and help fund a transition to plug-in vehicles (LEW FULTON)

As shown in a number of recent studies (e.g. IEA ETP 2012), the trend in transport fuel use and greenhouse gas emissions around the world is upward and is projected to continue to increase in the future without strong policy interventions to change course. To achieve this, would take a combination of travel demand management and modal shift (“avoid/shift”) measures and technical solutions to vehicles (“improve” measures). Fuel economy improvement is a powerful approach, and in the IEA 2-degree scenario (2DS) provides nearly half of the overall reduction in CO₂ by 2050. Shifts to non-petroleum fuels also play an important role, particularly after 2030. Eventually, a transition to near-zero-carbon fuels will be central to achieving a very low emissions transport system.

The analysis summarized here (GFEI Working Paper #9) explores the relationship between fuel economy improvement of conventional light-duty vehicles (cars, SUVs, etc) and a transition to alternative-fuel vehicles, specifically plug-in electric vehicles (PEVs, including battery electrics and plug-in hybrids). Strong fuel economy improvements to conventional vehicles, including but not limited to hybridization, could achieve a 50% reduction in fuel use per kilometer for new cars by 2030, in line with GFEI targets. This would help achieve large CO₂ reductions as well, far more than is possible through introduction of PEVs in this time frame. However after 2030, strong growth in PEVs and other very low-carbon fuel vehicles will be needed to continue to decarbonize LDVs and save oil out to 2050 and beyond.

While PEVs are projected in the IEA 2DS to achieve 2/3 of sales by 2050, they account for a relatively small share through 2030. This is one reason it is very important to start selling these vehicles now; it may take several decades of steady increase in their collective sales share to reach a significant share of the stock of cars on the planet (currently around

FIGURE 13 Global sales of ICEs v. PEVs by 5 year period, IEA 2-degree Scenario (2DS)



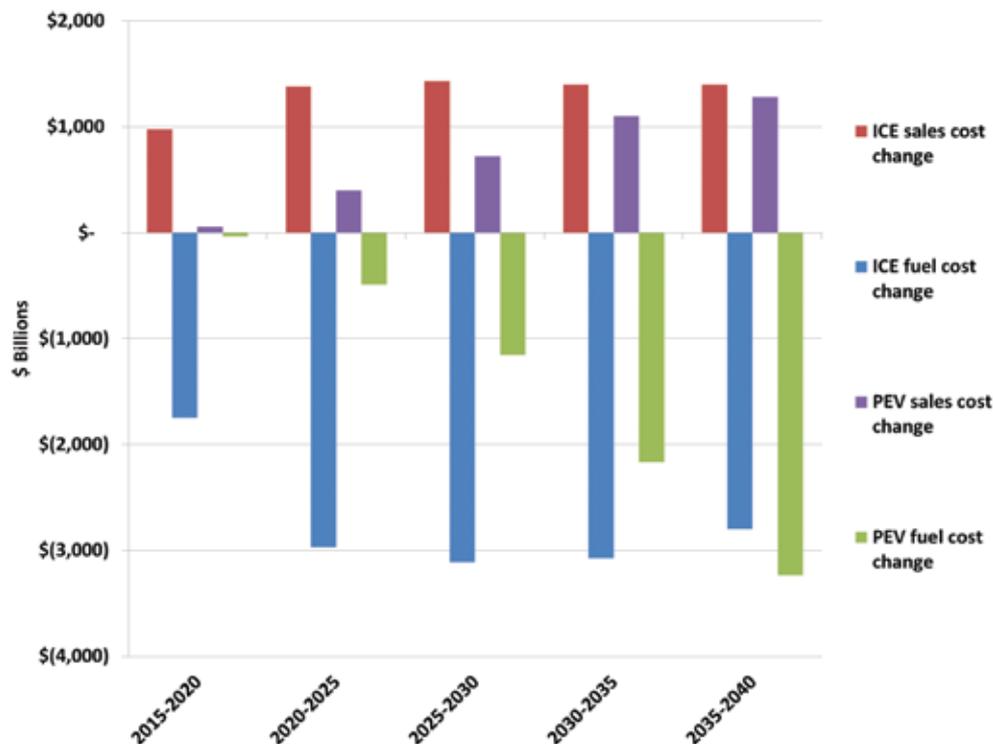
one billion). Figure 13 shows that despite very rapid sales growth, PEVs do not reach the same sales levels as non-PEV ICE vehicles until about 2040. In other words, to save oil and cut CO₂ emissions from cars before 2030, the story will be almost completely about improving the fuel economy of non-plug-in conventional ICE vehicles, and these conventional vehicles will remain an important part of sales until well after 2040.

Figure 14 presents the incremental costs and fuel savings from both fuel economy improvement and introduction of PEVs by 2040, based on a range of cost assumptions including a cost reduction in technologies over time consistent with the recent National Research Council report (NRC 2013) (a fuller explanation of the assumptions behind this figure is provided in the full paper). Several observations can be made about this figure. First, through 2025, fuel economy improvements could save drivers an estimated two trillion dollars, and much more in years after. This is due to the value of fuel savings being considerably greater than the technology costs of fuel economy improvement (specifically around \$5 trillion in fuel savings for an estimated \$3 trillion

in vehicle technology investments). In contrast, launching PEVs worldwide will probably require considerably more spending on vehicle technology than is saved from their reduced fuel costs at least through 2025. This includes an estimated \$500 billion in vehicle incremental costs world-wide, which (although partially offset by fuel savings) may require substantial subsidies to convince consumers to buy these vehicles in targeted numbers and build the market.

Another observation is that, over time, ICE incremental costs and fuel savings remain roughly constant, with fuel savings always significantly greater than vehicle costs; incremental costs and fuel savings for PEVs rise over time as their market grows, but the fuel savings increases faster since the incremental vehicle costs drop over time, whereas fuel savings per vehicle actually rise as gasoline prices rise. Up until about 2040, the net savings (fuel savings minus vehicle cost) from ICE fuel economy improvement is greater than that for PEVs, meaning fuel economy is more cost-effective in the aggregate; but around 2040 PEVs catch up. Since there is still some cost reduction associated with PEVs after

FIGURE 14 PEV and ICE incremental sales and fuel costs through 2025



2040, and the marginal costs of conventional vehicle fuel economy are likely still to rise after this date, the cost effectiveness of PEVs is likely to be better than ICEs after 2040.

The working paper considers these economics from the point of view of CO₂ as well. Using assumptions regarding CO₂ per kilometer from conventional vehicles (declining as they get more efficient) and PEVs (assuming average CO₂ emissions from electricity generation that improve over time, consistent with the IEA 2DS), fuel economy improvement saves far more CO₂ in the early time periods, but PEVs catch up by the 2035-2040 time frame, reflecting both growth in the numbers of vehicles and the decreasing carbon intensity of electricity generation. For fuel economy the net cost of CO₂ reduction is negative in each five year period before 2050, since the value of fuel savings is always greater than incremental vehicle cost (and this is the reason that fuel economy improvement is generally considered a very cost-effective option for CO₂ reduction). PEVs in contrast are fairly expensive in the 2015-2020 time frame but the cost drops rapidly, already to below \$0 in 2020-2025, using

the technology cost assumptions noted above. However it should also be noted that this cost per tonne remains higher than that for fuel economy improvement until after 2035, which means that compared to an increasingly efficient base ICE vehicle over time, switching to PEVs still yields a positive (greater than \$0) cost per tonne.

In summary, if these projections play out, the value of fuel savings from fuel economy improvements over this time frame would be four times greater than the required subsidies for PEVs. The paper explores how these could be linked – how the fuel savings from fuel economy improvement might be leveraged to help pay the buy-down costs until a self-sustaining market for PEVs is established. There are at least two ways to use fuel economy savings to fully fund a PEV launch, in both cases letting ICE drivers keep most (about three quarters) of their net savings from fuel economy improvements. These are via a higher vehicle tax of around \$500 for all vehicles sold (or a feebate system with this as an average tax rate), or via slightly higher fuel taxes, around \$0.07 per litre. Considerations in establishing such policies are discussed in the paper.



4.3 Fuel economy policies could spare Commonwealth governments from a fuels disaster (LEW FULTON)

The number of road vehicles, and road fuel use, in Commonwealth countries could double by 2030 and increase by a factor of four by 2050. Given that about half the Commonwealth's (and world's) oil is used in transport and oil accounts for about 95% of transport fuel use, this could spell economic disaster for the oil importing countries which make up the vast majority of the Commonwealth. Yet, one simple solution – improving vehicle fuel economy – could cut the cumulative oil bill of Commonwealth countries by GBP 200 billion by 2030, rising to GBP 2 trillion by 2050. Energy expert Lew Fulton sets out some alarming statistics on oil use and cost, and analyses the case of Kenya – a country that has already recognised the scale of the challenge it faces and the steps it needs to take to improve fuel economy. He argues that through inaction, Commonwealth countries are missing out on the opportunity to save billions of unnecessary expenditure on oil – a cost which could slow economic development in some countries. By setting out the core elements of a national policy on

fuel economy, he encourages all countries to work with the Global Fuel Economy Initiative (GFEI) and other experts. By adopting this high-impact low-cost policy solution, Commonwealth countries will, he argues, save their citizens billions of pounds and reduce their CO₂ emissions.

In 2011, Commonwealth countries consumed about 3 billion barrels of oil (about 8 million barrels per day, one tenth of the world total), with more than half of this for road transport. This cost over GBP 100 billion pounds last year. Worse, these costs have been increasing rapidly, both because of rising demand and rising world oil prices and could double over the coming decade if no action is taken. Commonwealth countries – and the world as a whole – are on an unsustainable path regarding oil use and its related environmental impacts such as CO₂ emissions. Oil use for transport is a key contributor to this unsustainability. About half the Commonwealth's (and world's) oil is used in transport and oil accounts for about 95% of transport fuel use. At the same time, vibrant transport systems are critical to economic development and healthy functioning of society. The question is how to deliver needed transport services while cutting their negative impacts.

If left unaddressed, this problem will only get worse: the number of cars and trucks is rising rapidly in many countries, particularly in Asia, where most



KENYA'S OIL FUTURE

In 2010, Kenya had a population of 41 million people, national GDP of about USD 30 billion, and a vehicle stock (cars and trucks) of around 1.2 million. That's only 30 vehicles per 1000 people, far below countries like the UK that have over 500 per 1000. But Kenyans already import about USD 2 billion of oil per year to fuel these cars and trucks). As the population increases (projected by the UN to rise to nearly 100 million by 2050), and incomes increase, the stock of vehicles, their use, and associated oil demand will naturally rise. Using modest growth assumptions, it appears likely that the stock of vehicles will at least triple by 2030 and increase by as much as 10-fold by 2050 to around 10 million (which is still only 100 per 1000 population). With faster economic growth, the vehicle numbers could be much higher.

New cars and light trucks in Kenya currently use about 8 litres/100km of fuel, but the actual fuel economy on road for all cars is certainly worse, probably above 10 litres/100kms. In this growth scenario, if the fuel economy of Kenyan vehicles does not improve, the USD 1.5 billion currently spent on fuel rises to USD 6 billion in 2030 and to USD 20 billion in 2050 (in constant dollars). The total cost to Kenyans between 2010 and 2030 could be close to USD 75 billion.



The effects of such oil costs on the Kenyan economy could be devastating – in fact they could serve to reduce growth and – ironically – preclude a faster economic growth scenario that would show an even greater rise in oil demand and costs. That is why the Kenyan government must take bold policy action now along the lines described below. Each year that goes by without strict government policies to control fuel use increases the risk of an extremely expensive oil-dependent future.

With the support of the GFEI, Kenya has begun to explore steps towards cutting this cost increase by at least a quarter by 2030 and by half by 2050. As mentioned, these savings could be even greater if they were combined with other transport policies, such as shifting vehicles to new fuels, and curbing car travel growth through sensible transport policies.



Commonwealth citizens reside. However it is also rising rapidly in Africa, as the case study of Kenya shows (see text box,). Combine this increased vehicle traffic with expected continuing increases in oil prices, and the total demand for and cost of fuel could increase several fold over the coming two to three decades. This could spell economic disaster for the oil-importing countries which make up the vast majority of the Commonwealth. Commonwealth countries use about a tenth of the world's oil, and this share will likely rise as many Commonwealth countries are growing faster than the world average (with India the notable giant in the group). Based on IEA projections the number of road vehicles, and road fuel use, in Commonwealth countries could double by 2030 and increase by a factor of four by 2050. With ongoing increases in world oil price, the expenditure on fuel will rise even faster and could approach GBP 1 trillion per year by 2050. Since nearly all Commonwealth countries import most of their fuel, this translates into hundreds of billions of pounds per year in lost foreign exchange. Conversely, if the vehicles sold in

these countries over the next 20 to 30 years exhibit strong gains in efficiency (by cutting new car fuel use per kilometre in half by 2030 for example), these import costs can also be cut dramatically. As a rough estimate, by 2035 the savings could approach GBP 200 billion per year. The total savings between 2010 and 2050, for both cars and trucks in the Commonwealth, could exceed GBP 2 trillion. This will include other key global benefits such as large cuts in vehicle-related CO₂ emissions.

So what must be done to capture all the fuel economy potential? Some countries like Japan, and the EU as a whole, are leading the way. In fact, most OECD countries now have a package of policies in place that appear likely to improve new car fuel economy substantially over the next five to 10 years. Approaches vary, but the basic elements include:

1. Measure vehicles and give consumers the information they need: implement a fuel economy labelling system, based on the tested score of each model available in the market.



2. Send price signals: the most important price signal that will spur consumers to save fuel is a tax on that fuel. Many countries, including Turkey, Japan and most European countries, already have fairly high fuel taxes. However many other countries, including some Commonwealth countries, have low taxes or even a negative tax – which amounts to a fuel subsidy.
3. Set fuel economy standards: the most reliable method to improve the fuel economy of new cars is to require that it happens. Most OECD countries now have mandatory fuel economy or CO₂ emission standards, though the form and stringency of these standards varies considerably.
4. Regulate vehicle imports: many countries, including most Commonwealth countries, import most of their vehicles. These countries are not in a position to regulate vehicle production, but can effectively encourage higher fuel economy by importing more efficient vehicles. Import regulations could involve minimum efficiency standards for all imported cars

and trucks, or import or registration fees based on vehicle fuel economy or CO₂ emissions ratings. Age restrictions on imported cars can also help.

Commonwealth countries will purchase millions of cars and trucks in the coming two decades, and will drive these vehicles billions of kilometres. It will take a lot of fuel to power all this mobility, and the cost of that fuel is startling. The right policy choices could cut road transport fuel consumption in half by 2050. Countries have it in their power to cut their fuel bills – and CO₂ emissions – dramatically, by nearly a factor of 2 over the coming decades, through sound fuel economy policies. Good policies can also save their citizens billions of pounds in import costs and slow climate change. But action is needed now. The Global Fuel Economy Initiative and other experts can offer expert advice and guidance, including in-country policy support to help countries make the right choices about their fuel use.



4.4 Report on Imported Second-Hand Vehicles

(CTS MEXICO, SUPPORTED BY FIA FOUNDATION AND ITF)

During 2013 CTS Mexico produced a report on imported second hand vehicles that provided an overview of international trade in these vehicles. This fits with GFEI's on-going work to better understand the role of second hand vehicles in affecting fuel economy in countries around the world.

The report highlights the significant 3.5 million vehicle increase in the world-wide flow from 1997-2007, and identifies major source and destination countries. The report goes into more detail in the US-Mexico case. It analyses the impact of NAFTA, as well as differences between these countries in terms of fleet characteristics, economic conditions and vehicle regulations.



Four types of policies were reviewed as possible measures to regulate the flow and quality of imported second-hand vehicles with the aim of minimizing environmental and health externalities. These are border controls, scrapping schemes, inspection and maintenance programs, and compulsory vehicle insurance. Analysis of alternative measures included design features, legal requirements and enforcement and compliance challenges. Costs and CO₂ emission reductions of such policies are explored for the case of Mexico, under specific design conditions.



Principal policy highlights:

- Border Inspection:** Border inspections, with environmental and safety certification requirements have significant advantages compared to other policy actions. Entrance controls focus exclusively on imported second hand vehicles and do not affect the rest of the national fleet. Therefore, they are easier to implement and execute. In comparison to a nationwide inspection and maintenance program or a compulsory vehicle insurance program, entrance barriers need less time, less administration (including enforcement costs) and provoke less public attention.
- Scrapping Program:** A scrapping programme is a good complement to border controls. Vehicles that fail border inspections or do not have environmental or safety certificates have a certain amount of time to comply with regulations. If they fail a second time, they are scrapped, thus eliminating the least fuel-efficient and least safe vehicles and excluding them from the national fleet.
- Inspection and Maintenance:** This measure also complements border inspections. If well implemented, such programmes improve maintenance levels for the national fleet, encourage vehicle renewal, reduce emissions, and create jobs. They can however face significant resistance from the public, require specialized equipment, and require stringent enforcement.
- Compulsory Vehicle Insurance:** Compulsory vehicle insurance is important because of the risk created by motorists for other traffic participants, and the danger borne by motorists to their own health and life. This danger of road accidents has to be internalized and compulsory vehicle insurance represents the best available measure for this. The proportion of cars driven without insurance in Mexico is high. Introducing this measure would increase the cost of owning and operating a vehicle, appropriately, and would therefore reduce the number of cars on the road and CO₂ emissions.

Since the report focused on Mexico, similar studies in other regions of the world are needed, particularly for parts of Asia and Africa where most vehicles are imported second hand.



5 Ongoing GFEI work and future plans

The GFEI sponsored a range of studies during 2013 and began on some other new projects. This section provides summaries and key findings from several of these. They include studies both from GFEI partner organizations and other analysts that have been involved in collaborative efforts.



5.1 Feebate project progress report

Many governments have put in place fuel economy policies. However, the majority of emerging economies with rapidly growing rates of vehicle ownership have virtually no policies in place to promote fuel economy. One of the main barriers to setting vehicle standards is the high level of knowledge and expertise required of the vehicles being sold, as well as the cost, benefit, and leadtime for a wide variety of vehicle technologies. As an alternative, properly designed feebates can offer most of the benefits of vehicle standards and can be effectively implemented at less cost and with a much lower level of knowledge and expertise. Thus, they can be a good way for developing countries to begin implementing efficiency and CO₂ vehicle policies.

In line with this, the ICCT and UNEP have launched a project to develop a simple-to-use feebate tool for use by governments to create financial incentives for

more fuel-efficient vehicles, without having to do the detailed technology cost assessment required by a traditional regulatory approach. Since much of the growth in vehicle travel and emissions are projected to occur in developing countries, it is important to make available the necessary tools and expertise required to decouple growing vehicle ownership from energy use and emissions.

The aim is to create an easy to use model that will allow an interested government agency to design a feebate program for a particular country with a modest amount of input data. The outputs of the tool would illustrate the vehicle and financial impacts; e.g., what are the fee and rebate levels for various vehicles types and what are the likely revenues to be generated or paid.

The timeline for delivery of this tool and its user guide is the end of March 2014, with a draft version by the end of November 2013 and beta testing with partner organizations and a selection of large, medium and small vehicle markets (both manufacturing and/or importing) scheduled to take place between November - December 2013.

5.2 Green Global NCAP Labelling

In recent years, a safety New Car Assessment Program (NCAP) has set a precedent in engaging manufacturers in performing tests that would not otherwise be performed, and in sharing testing results through an independent platform that now has effectively set the standard for crashworthiness.

An IEA workshop in April 2013 initiated an effort to create a "Green Global NCAP" campaign. The goal of

such a campaign would be to help set an independent and respected definition of what is a clean vehicle and how to classify clean vehicles, based on the vehicle efficiency and the tailpipe emissions.

The workshop covered a wide set of topics from vehicle fuel economy and emissions labelling to vehicle testing, to "in-use" measurement, in light duty vehicles. The productive discussions held during the workshop helped shape the first steps in the development of a new GFEI-led Green NCAP strategy. The first stage is to set the boundaries of what would be included in this new effort to measure the environmental performance of light vehicles.

DEFINITION OF VEHICLE ENVIRONMENTAL PERFORMANCE

The workshop addressed what to include in a new measurement system and the boundaries of the considered vehicle environment performance:

- **Tailpipe emissions:** there was a broad consensus that CO₂ and homologated pollutants (HC, NO_x, PM, CO) should be included in the green score calculation methodology.
 - Non homologated pollutant (benzene, NO₂,...) are not included due to data availability.
- **Vehicle efficiency:** in order to simplify the issue of dual fuel vehicles and pure electric upstream CO₂ emissions, one proposal was to include the vehicle efficiency (in J/km) instead of CO₂ in the score calculation. For ICEs vehicles this can simply be calculated based on the energy content of the fuel; there might be some data availability issues with PHEVs / EVs.
 - With zero tailpipe emission vehicles, efficiency will be the main factor impacting the energy / environmental impact of vehicles during its use.
- **Fuel upstream emissions:** Some participants felt that to properly assess the different fuel alternatives, full "well-to-wheel" emissions should be considered; others felt. the label should focus on the vehicle itself, given uncertainties regarding data for upstream emissions factors and the risk of ending up with quite general average factors.
 - As part of the Global NCAP, upstream emissions will be left out for the first phase of the green NCAP label development.
- **Noise:** noise would be a nice feature to include in the score, though data availability and reliability might be an issue.
 - Noise will be included in the first phase as hopefully the data is available (the Belgian Eco-score is using it, so we can collaborate with them).

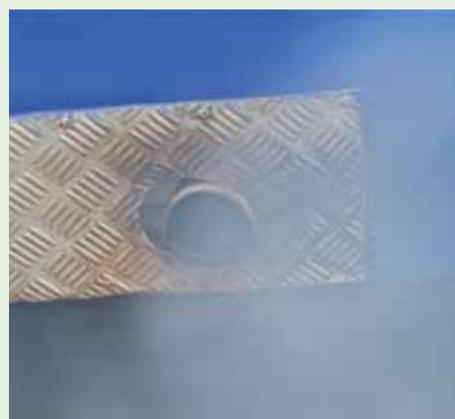


FIGURE 15 Matrix of four GGNCAP workstreams

	Demanding Green NCAP wscore	Read-to-be-used GFEI green score
Scoring working group	1. Long term score methodology definition	2. What can be delivered now for GFEI pilot countries as scoring methodology?
Labelling working group	3. On-line score visualization	4. Display sticker

There was a general consensus that it should be possible for regional users / local authorities wishing to use the work done here to do its properly weight of each of the factors (Pollutant / GHG / efficiency / noise) according to local priorities. So it is important to keep each criteria separated. The Green NCAP scores would then proposes its own weighting to be used as a reference.

PM and NOx seem to have the biggest impact on health and the higher external costs; it is suggested to reflect this in the pollutant weighting factors.

The workshop touched upon several issues that would need to be treated separately in the future.

The work to be provided covers both short- and long-term goals work items have been identified that would address both NCAP needs to have a demanding green score for light duty vehicles and the short term necessity to provide some ready-to-use tool for GFEI pilot countries. Those four work streams in Figure 15, and detailed in the following sections. Each work item would need to be treated separately.

Following the workshop, the next steps in the project are to work with the newly created Consultation Group to further develop a score calculation methodology. This effort will result in a report to GFEI partners and the public during 2014.

5.3 Relationship between fuel economy and pollutant emissions

GFEI maintains a focus on the relationship between fuel economy improvement and vehicle pollutant emissions – both in terms of how fuel economy can assist non-CO₂ emissions reduction, and in terms of how pollutant emissions reductions and improvements in fuel economy can affect fuel economy. The interactions are complex and dependent on specifics for each type of technology and fuel (e.g. gasoline v. diesel). This is an area where GFEI is interested to conduct more research. ICCT leads a range of studies that look at the relationship between fuel economy and pollutant emissions. Some general findings are summarized below.

Pollutant emission control has had a major impact on diesel technology and efficiency. Because the diesel engine always runs lean, conventional three-way catalysts used for petrol engines do not work on diesels and NOx aftertreatment is much more difficult and less efficient. In addition, ignition occurs almost immediately after fuel is injected in a diesel, giving little time for the fuel to vaporize and creating large amounts of particulate matter (PM) emissions. Historically, diesels had high levels of both NOx and PM and strategies to decrease one in the combustion



chamber would increase the other. As the US, Japan, and Europe adopted more stringent emission standards, the only way for diesels to comply was to adopt additional technology. Direct fuel injection, high pressure common rail fuel injection, cooled EGR, turbocharging, and even variable valve timing have been adopted by modern diesels, to a large degree, in order to meet emission standards. This improved technology also makes diesels quieter, smoother, easier to start, and more efficient. It would be possible to design a diesel engine around a particulate filter and avoid using these engine technologies, but particulate filters aren't cheap and the efficiency penalty with this approach means that it is unlikely any engine manufacturer would do this.

A similar relationship between emission standards and engine efficiency does not exist for modern petrol engines. Petrol engine emission control is accomplished primarily with fast engine light-off, precise air/fuel control, and high-efficiency catalysts, plus an evaporative system. The catalysts and the evaporative system have nothing to do with fuel economy. Precise air/fuel control and fast engine light-off can be done extremely well with sequential port

injection, wide-range oxygen sensors, and an idle air control valve. These are all 10-15 year old technologies that have nothing to do with recent increases in petrol engine fuel economy. Variable valve timing helps with emissions, but isn't required as it just replaces an external EGR valve. The primary benefit of variable valve timing is achieving the same level of emission control with better efficiency than an EGR valve.

For developing countries that still have decades old technology on their engines, adoption of basic emission standards can be an important first step to improving efficiency, as it forces decent fuel injection systems, oxygen sensors, and computer controls to be adopted. These technologies offer efficiency advantages over older technology. But all emission standards can do for petrol engines is to push circa 2000 fuel economy technology into the fleet.

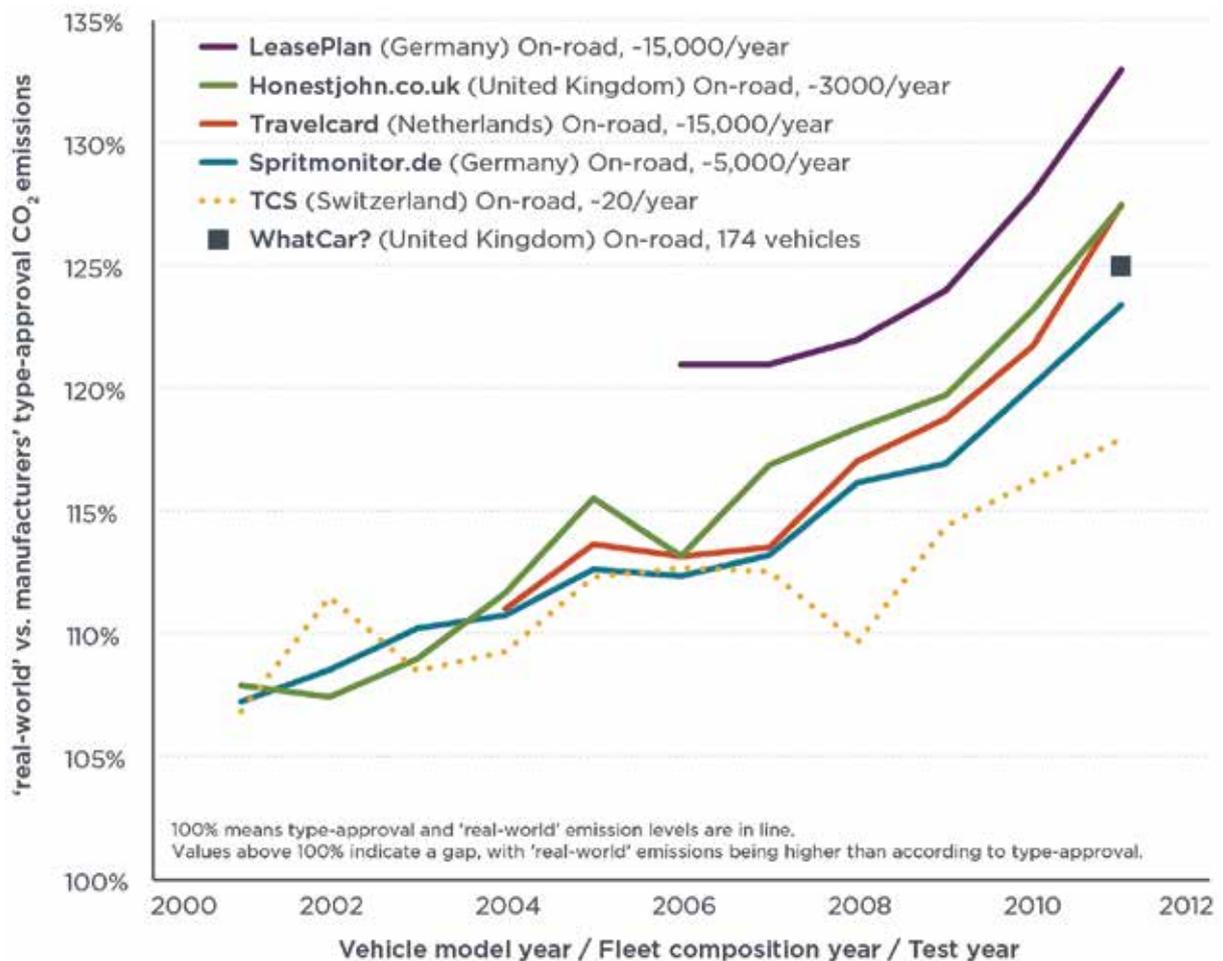
One interesting consequence is that much of the current diesel efficiency advantage over petrol engines is due to the much higher level of technology required for diesels to meet the emission standards. More stringent CAFE and GHG standards adopted in the US through 2025 and in Europe through 2020 will force

petrol engines to install similar technologies to comply. Much of the efficiency advantage of the diesel will disappear as direct injection, cooled EGR, down-sized boosted engines, variable valve timing, and higher compression ratios are adopted by petrol engines to meet the CAFE/GHG standards. In fact, modeling by Ricardo for the U.S. EPA and for ICCT suggests that by 2025 light-duty diesel engines may not be any more efficient than advanced petrol engines.

No known emission control technologies have a penalty on gasoline vehicle fuel economy. In the early days of emission control there were some problems. For example, early EGR systems degraded both fuel economy and drivability. However, manufacturers have figured out that, when controlled properly, EGR actually can help improve

efficiency, as it reduces combustion temperatures and allows higher compression ratios and more spark advance. However diesels are different. For example, some types of particular filters require extra fuel to burn up the stored particulates. Lean-NOx traps are similar; they require periodic fuel enrichment cycles to remove the stored NOx and can reduce fuel economy by 3-5%. SCR systems do not cause a direct reduction in fuel economy but the added urea requires energy to produce that is currently not counted in fuel economy tests. Finally, control of diesel engine-out NOx requires compromises in fuel injection timing that also reduces fuel economy. This used to be a large impact, but it may be that modern high-pressure fuel injection with up to 8 injection events per combustion event and better combustion chamber design have reduced this effect.

FIGURE 16 Divergence, real-world vs. manufacturers' type-approval CO₂ emissions for various on-road data resources (ICCT, 2013)



5.4 Pilot Project on In-use Fuel Economy

ICCT has undertaken a pilot study to investigate approaches to better measure in-use fuel economy. Some key findings are presented here, that will be elaborated on in a future report. Vehicle fuel economy is determined via type-approval or certification process, which involves testing vehicles under laboratory conditions. For accurate fuel economy labeling and standards compliance, it is important to keep the driving conditions constant when comparing different vehicles' fuel economy. This is the purpose of testing vehicles using a prescribed driving cycle in a laboratory test, also known as chassis test. The driving cycle is designed to represent a snapshot of real-life driving conditions, mixing stop-and-go driving patterns from urban transit and medium and high speed driving patterns from rural roads and highway transit.

However, the FE information obtained via chassis testing under laboratory conditions is not capable of representing the wide range of real-world driving conditions that vehicles and drivers experience during the vehicle lifetime. In some cases, the laboratory conditions designed several decades ago are unable to represent current driving conditions and new vehicle technologies. Deviations of FE data from laboratory results can have a significant impact in estimating real-world fuel consumption and GHG emissions (see figure 16).

A technically precise definition of real-world driving conditions is elusive because of variations in vehicle design and in the ways that drivers drive. But by aggregating large sets of on-road driving data, clear trends can be observed. A recent report by the ICCT analyzed the real-world fuel consumption of several large datasets, for both private and company cars, from various European countries. It reveals an overarching trend: while the average discrepancy between type-approval and on-road CO₂ emissions was below 10 percent in 2001, by 2011 it had increased to around 25 percent.⁴

Comprehensive real-world information is needed to assess FE label adjustments, properly determine off-cycle credits for FE standards and estimate total real-world fuel consumption. On top of it, technologies have significantly evolved the last decade, new technologies

are entering the market (e.g. GDI, hybrids, plug-in hybrids) and fuel quality is changing in most countries to accommodate renewable fuel sources (E10-E15).

ICCT has thus identified the need to determine the characteristics of instantaneous fuel economy tendencies of vehicles in today's U.S. and European fleet of light-duty vehicles. ICCT recognized that before a major nationwide instrumentation study of fuel economy characteristics could be undertaken, a pilot study addressing logistic and technical issues was required. ICCT contracted Eastern Research Group in the US and TÜV NORD Mobilität in Germany to conduct each a pilot study to identify areas of concern and possible alternative solutions in four areas: vehicle sample structure and size, vehicle recruitment methodology, datalogger evaluations, and estimated project cost. This report summarizes the results of both the US and EU pilot studies.

Vehicle Recruitment

The recruitment methodology for the full-scale study aims to select a representative sample of the fleet that covers a range of vehicle technologies, operating environments, and driving conditions. Both the US and EU pilot studies explored methodologies to find and recruit drivers and vehicles, as well as mechanisms to keep communication from beginning to end of the data collection process, and alternatives for motivating participation and keeping drivers actively engaged during the study.

In the US, ERG concluded that an on-going household travel survey approach is the most attractive option to recruit drivers and vehicles. In Europe, TNM concluded that vehicle clubs, more specifically, some club members of the Fédération Internationale de l'Automobile (FIA) are interested in the project. Another option to reach vehicles/drivers in both regions is close collaboration with motor vehicle registration offices in specific regions, which increases the pool of potential participants but reduces the geographic coverage of the study.

In addition to identifying vehicle recruitment sources, the pilot rendered an idea on the size of the sample pool to extract the recruitment sample. A survey conducted by TNM at 5 service centers across Germany show that around 50% of interviewed people are aware of deviations with respect to the CO₂ label. About 25% of the people who filled the survey were interested in participating in the OBD field investigation.

Sample Size

The pilots served to identify the sampling approach and the two main criteria to establish the sample size: the field-study main objective and the level of OBD data available on each vehicle.

Both pilots coincided in that stratified sample is the proper approach to determine the vehicle sample size. The stratification is based on known characteristics of vehicles, such as powertrain technology and FE/GHG label values. The resulting sample size can vary significantly, depending on the main goals of the investigation,

- a smaller sample size in the range of 200 vehicles allows for example analyzing certain influences of the real vehicle fuel consumption in general for the vehicle fleet;
- a size in the range of 500 vehicles allows a more detailed analysis of the deviation of the real fuel consumption from the type approval values, for example to prove the model year curve from the Spritmonitor.de analysis performed by the ICCT; and;
- a large sample size in the range of 1,000 vehicles or above might be suitable if a detailed investigation with analyzing the FC behavior for the different popular vehicle models is intended.

The analysis concluded that a sample no smaller than 200 vehicles should be used for the nationwide study.

Datalogger Technology

The OBD standard specifies a large set of parameter identifiers to request sensor data from the vehicle ECUs connected to the diagnosis system. The investigation showed that common vehicles support only a small set of data as Standard PID signals. There are other non-translated signals that can be accessed but that require support for proper signal interpretation from manufacturers; these are called enhanced-PID signals. While Standard PIDs are free, enhanced-PIDs require paying for the ability to read and translate those signals.

Information on current datalogger costs varies between US\$200 and \$1000. We expect that a datalogger covering our project specific needs should retail for no more than US\$500. Current dataloggers can transmit via cellular networks and/or store the data required during 1 year.



How much is a full-scale study going to cost?

This depends on sample size, defined by project objective, and datalogger technology. Estimated per-vehicle costs are: a 200-vehicle scenario ranges between \$US3000 and \$US8000 per vehicle, while a 800-vehicle scenario ranges between US\$2,000 and US\$5,000 per vehicle. These costs may come down after the first program, and could be lower in developing countries, but the extent of potential reductions is unclear. One big cost is the dataloggers, which are roughly \$1,000 each. One area of potential cost reduction is to recycle data loggers in multiple studies, perhaps via a loan or sharing program.

Designing software to download data, match it to GIS data, calculate FE, etc. is likely to be hundreds of thousands of dollars for the first program, but hopefully much of this can be used for subsequent programs for significant cost reduction.

Smaller sample sizes are also possible but with loss of information and greater uncertainty in results. The current analysis indicates that the standard deviation of arbitrary distributions of values of fuel economy influencing coefficients can be known with an uncertainty of about $\pm 11\%$ with a 200 vehicle sample or with an uncertainty of about $\pm 8\%$ with a 400 vehicle sample. A small sample could be designed to understand general relationships and trends in the vehicle fleet, while a larger sample would be needed to study the effects of specific technologies.(e.g the real world driving effect of 8-9 gears on FE compared to 5-6 gears).

Appendix 1

References

- 1 Stabilizing GHG Emissions from Road Transport Through Doubling of Global Vehicle Fuel Economy: Regional Implementation of the Global Fuel Economy Initiative (GFEI) <http://www.thegef.org/gef/node/9972>
- 2 Based on work by ACEEE: <http://www.theicct.org/events/international-alignment-fuel-efficiency-standards-heavy-duty-vehicles>
- 3 Charts reprinted with permission from Transitions to Alternative Vehicles and Fuels, 2013, by the National Research Council of the National Academies. Courtesy National Academies Press, Washington DC.
- 4 ICCT, 2013. From Laboratory to Road, A Comparison of Official and 'Real-World' Fuel Consumption and CO₂ Values for Cars in Europe and the United States. Washington DC.

Links to key reports and to online information

HDV efficiency: Aligning standards internationally

<http://www.theicct.org/events/hdv-efficiency-aligning-standards-internationally>

International comparison of light-duty vehicle fuel economy: An update using 2010 and 2011 new registration data (page 16)

http://www.globalfueleconomy.org/Documents/Publications/wp8_international_comparison.pdf

Fuel economy policies could spare Commonwealth governments from an impending transport fuels disaster (page 39)

<http://events.sas.ac.uk/icws/publications/971>

Global Fuel Economy Initiative Working Papers

<http://www.globalfueleconomy.org/publications/Pages/WorkingPapers.aspx>

Stabilizing GHG Emissions from Road Transport Through Doubling of Global Vehicle Fuel Economy: Regional Implementation of the Global Fuel Economy Initiative (GFEI)

<http://www.thegef.org/gef/node/9972>

Appendix 2

The GFEI Partners

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The FIA Foundation is an independent UK registered charity which supports an international programme of activities promoting road safety, the environment and sustainable mobility, as well as funding motor sport safety research.

Our objects are to promote public safety and public health, the protection and preservation of human life and the conservation, protection and improvement of the physical and natural environment through: promoting research, disseminating the results of research and providing information in any matters of public interest which include road safety, automobile technology, the protection and preservation of human life and public health, transport and public mobility and the protection of the environment; and promoting improvement in the safety of motor sport, and of drivers, passengers, pedestrians and other road users.

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The IEA has been an active partner of GFEI since 2009. The IEA is an international organisation which main activity is to ensure reliable, affordable clean energy for its 28 members countries. The IEA four main areas of work are: energy security, economic development, environmental awareness and engagement worldwide.

The IEA involvement in GFEI over the years comprises areas such as data development and analysis of fuel economy potentials by country and regions. Support for national and regional policy making efforts. Outreach and awareness raising to stakeholders especially the EU and vehicle manufacturers.

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The International Transport Forum at the OECD is an intergovernmental organisation with 54 member countries. It acts as a strategic think tank for transport policy and organises an Annual Summit of ministers.

The ITF goal is to help shape the transport policy agenda on a global level, and ensure that it contributes to economic growth, environmental protection, social inclusion and the preservation of human life and well-being.

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The International Council on Clean Transportation is an independent nonprofit organization founded to provide first-rate, unbiased research and technical and scientific analysis to environmental regulators. Our mission is to improve the environmental performance and energy efficiency of road, marine, and air transportation, in order to benefit public health and mitigate climate change.

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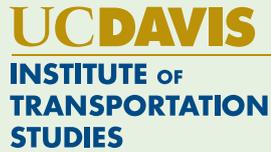
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The Institute of Transportation Studies at UC Davis (ITS-Davis) is the leading university center in the world on sustainable transportation. It is home to more than 60 affiliated faculty and researchers, 120 graduate students, and has roughly \$15 million in funding. While our principal focus is research, we also emphasize education and outreach.

The Institute is unique in hosting a graduate program in transportation, matching interdisciplinary research with interdisciplinary education. Our Transportation Technology and Policy (TTP) graduate curriculum draws from 34 different academic disciplines. Our more than 225 alumni are becoming leaders in government and industry.

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The United Nations Environment Programme was established to provide leadership and encourage partnership in caring for the environment by inspiring, informing, and enabling nations and peoples to improve their quality of life without compromising that of future generations.

The Transport Policy and Work Programme of UNEP was established to address externalities from road transport by setting up 3 fold strategies to avoid shift improve approach, these are: The Partnership for Clean Fuels and Vehicles (PCFV), the Global Fuel Economy Initiative (GFEI) and Share the Road all in partnership with the FIA Foundation and other partners.

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