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FACILITATION OF TRANSPORT AND TRADE IN LATIN AMERICA AND THE CARIBBEAN

Freight transport by road: tools and strategies for energy efficiency and sustainability

Introduction

In a globalized world, the key actors in different industries constantly have to set off the benefits of innovating to improve products and services against the short-, medium- and long-term effects of their activity on the environment.

The transport sector is a major energy consumer, accounting for 19% of final global energy consumption in 2013. The sector is expected to account for 97% of the increase in global oil consumption between 2013 and 2030. The implications for energy consumption and greenhouse gas emissions of a transport sector dominated by oil suggest that reducing fuel use in the sector should and must be one of the highest priorities for all countries.

Moreover, transport is responsible for a quarter of all energy-related greenhouse gas emissions. Without radical measures to curb them, transport emissions can be expected to rise from 7.7 gigatons (Gt) to about 15 Gt by 2050.

The problem is global: transport is the largest source of energy-related greenhouse gas emissions in 45% of countries and the second-largest in all the rest. Consequently, transport must be a key element in any effective solution.

At the same time, freight transport by road (FTR) is the transport type that moves the largest quantity of products within the region's countries and the second largest internationally in Latin America and the Caribbean.

The 2030 Agenda for Sustainable Development approved by the United Nations in 2015 proposed the Sustainable Development Goals (SDGs) for global development up to 2030.[1] The Agenda puts forward medium- and long-term goals and targets with the focus on all-round development, highlighting the importance of having investment plans or road maps with a long-term dimension that can address today's infrastructure gaps, making use of all the advantages of the region's countries and preparing them to tackle future challenges and opportunities.

[1] See http://www.un.org/sustainabledevelopment/.

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This *FAL Bulletin* presents challenges and success stories in the implementation of energy efficiency strategies in freight transport by road.

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Reducing fossil fuel consumption and discussing alternatives are issues of global debate and priority. The search for affordable clean energy is one of the 17 SDGs. This goal calls for expanded infrastructure and improved technology to provide modern, sustainable energy services for all in developing countries, particularly the least developed, small island developing States and landlocked developing countries, in accordance with their respective support programmes.

As regards efficiency, energy security, greenhouse gas emissions and emissions of local impact (particulate matter, NOx and SOx, among others), there is a clear need to reduce fossil fuel consumption in general. As a place to start, FTR is one of the most strategic sectors, with considerable potential for improvement at the local, national and global levels.

There is a good understanding of the direct effects that this sector of the economy, and FTR in particular, has on the productivity and competitiveness of firms and countries, as well as of its social and environmental impacts, the intensity of countries' energy consumption, and emissions of particulate matter and greenhouse gases. However, many developing countries have not yet implemented strong initiatives to raise sustainability standards in freight transport or programmes capable of bringing about positive change in transport and the logistics chains in which these organizations participate.

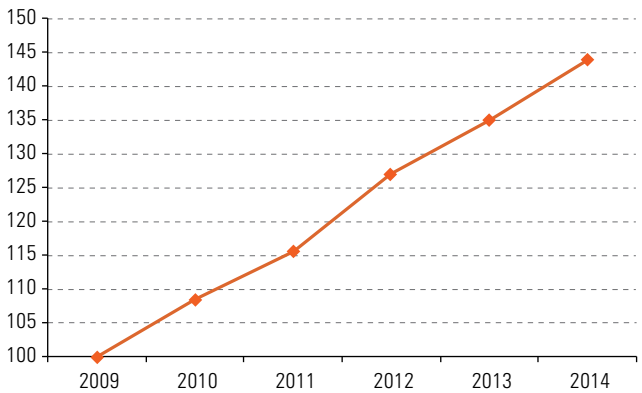
This bulletin aims to show that there are both organizations and programmes around the world that have been working for years to improve the economic performance and reduce the social and environmental impacts of FTR, with a view to identifying the factors that have brought success and singling out the best practices these programmes have developed, so that this knowledge can be absorbed and such programmes adopted in the Latin American context.[2]

I. Transport efficiency: the public sector and the private sector

The FTR sector is one of the most dynamic in society, and its operations have underpinned part of the current economic development model, allowing certain human needs to be met in a highly demanding globalized framework. Figure 1 shows growth in the FTR fleet, which has been highly dynamic, with an increase of nearly 50% in a period of five years, taking the truck fleet in the countries of South and Central America to over 32 million vehicles.[3]

The challenge of zero carbon emissions and zero energy consumption in buildings also applies to transport. **The aspiration of sustainable mobility is a transport model that meets the social, economic and environmental needs of society without harming the environment**.

Figure 1
GROWTH IN THE TRUCK FLEET, 2009-2014
(Index: 2009 = 100)



Source: USI and Economic Commission for Latin America and the Caribbean (ECLAC), on the basis of information from 15 countries of South and Central America.

A diagnostic of the current situation must involve identifying the niches with the biggest challenges and opportunities for improvement. At this stage it is vital to have an appreciation of international history and experience, and likewise of policies and experiences in this area in local contexts and the roles of the different actors.

It would be unwise to assume that the goal of reducing fuel consumption in FTR operations was an unequivocal one shared by the private sector (transport operators and their principals) and the public sector. Although both sides will acknowledge that moving towards transport efficiency is desirable and necessary, the circumstances and modes of proceeding towards this goal differ substantially in the two cases.

The private sector: haulage firms and the supply chains they serve. In speaking of efficiency in FTR operations, the operators and freight customers whose businesses rely on this strategic service are fundamentally concerned with reducing costs, increasing productivity and developing more and better services. The private sector in this case comprises transport operators, freight customers, distribution channels, logistics operators, transfer hubs and consumers (who determine the standards and features required of these services). The priority is to improve financial results and service quality for customers, and they achieve this by professionalizing their organizations and applying "best practices".

[2] This *FAL Bulletin* follows the definition of sustainable development proposed by the United Nations in *Our Common Future* (the Brundtland Report) of 1987, which defines it as development that "meets the needs of the present without compromising the ability of future generations to meet their own needs".
[3] This chart is based on information from 15 countries of South and Central America.

The public sector: what the public sector means by efficiency in FTR operations is essentially achieving market transparency, providing the necessary infrastructure, improving the competitiveness of the economy and reducing the sector's environmental and social impacts. The public sector comprises ministries, municipalities, departments, committees, commissions and citizens (who are becoming increasingly demanding and intolerant of the impact of any economic activity on their quality of life). The public sector understands that its contribution to the goal of efficiency in transport operations is to be made in the sphere of regulation, oversight and development support.

II. Best energy efficiency practices in FTR

A. The international context: energy efficiency programmes for FTR

The transport industry, and land transport in particular, creates social, environmental and economic impacts that are manifested at both local and global levels in the medium and long run. It is thus important to identify the actual impact that the industry produces so that steps can be taken to mitigate it. Trucks in India, for example (Green Freight Asia, 2010):

- represent 5% of the country's vehicles;
- consume 46% of fuel;
- produce 63% of carbon dioxide (CO_2) emissions; and
- produce 59% of particulate matter emissions.

This state of affairs, far from discouraging the key stakeholders, should be an incentive to understanding how the FTR industry operates in each country, what effects it has and thus how these impacts can be reversed in the quest for a future of sustainability and development. Globally, medium and heavy trucks are projected to consume 1.24 trillion litres of fuel by 2050, a 138% increase over the level presented by the industry in 2000 (Green Freight Asia, 2010).

In developing countries, the use of fuels with a high sulphur content accounts for a large percentage of total emissions of black carbon, greenhouse gases and other pollutants, making it important to understand this effect and create comprehensive programmes that can help achieve efficient fuel use so that trade movements can develop properly and the environmental effects can be mitigated.

This analysis demonstrates the need for energy efficiency programmes for the transport industry. International evidence shows some positive impacts from the implementation of programmes of this type (see diagram 1) (SmartWay, 2014).

Diagram 1
SOME CONTENTS OF ENERGY EFFICIENCY PROGRAMMES FOR IMPACT REDUCTION IN THE TRANSPORT SECTOR

Environmental and energy impacts	Social and economic impacts
• Reduce the public health impact of diesel emissions • Decrease impacts on vulnerable populations • Reduce black carbon and greenhouse gas emissions that contribute to climate change • Improve energy security by reducing oil dependency	• Reduce transport fuel costs by improving operating efficiency and decreasing fuel consumption • Mitigate infrastructure and congestion problems by making empty trips more efficient and planning routes • Improve road safety by reducing the number of vehicles on the roads • Boost technological innovation • Develop the local economy

Source: Prepared by the authors.

B. The main global organizations and working groups

Energy efficiency in general and that of the FTR industry in particular has been the subject of intensive work by different organizations, both private and public. These have now arrived at positive results from which it is possible to extract best practices that can be adapted to the FTR industry in Latin America and the Caribbean.

The following organizations have produced a number of studies and data compilations with a view to presenting recommendations and lines of action that are applicable to different situations.

Among the international organizations focused on the issue of achieving sustainable economies are the United Nations Economic Commission for Europe (UNECE), the International Organization for Standardization (ISO) and the Organization for Economic Cooperation and Development (OECD), in particular two of its agencies: the International Energy Agency (IEA) and the International Transport Forum (ITF), specializing in energy efficiency and transport.

UNECE heads the World Forum for Harmonization of Vehicle Regulations (WP.29). WP.29 is dedicated to providing technical regulations for the automotive industry relating to the safety and environmental performance of vehicles, engines and specific parts. The Working Party on Pollution

and Energy (GRPE) of this forum prepares proposals for pollution and energy efficiency regulations, based on research and analysis. An example of an FTR regulation from this group is UN Regulation No. 49, containing the technical provisions for pollutant emissions standards up to EURO VI for trucks and buses.[4]

The ISO 50001:2011 standard defines the requirements to be met by energy management systems with a view to organizations making continuous, systematic improvements in energy performance. Third party certification of an energy management system ensures systematic oversight and follow-up of the different aspects while contributing to the most efficient and sustainable energy use, creating trust in the management system.[5]

Energy management system certification is intended for organizations wishing to demonstrate that they have adopted an energy management system, are making greater use of renewable or surplus energy and/or have systematized their energy processes, seeking to ensure they are consistent with organization-wide energy policy. In general, the standard is supposed to:

- Assist organizations in making better use of their existing energy-consuming assets;
- Create transparency and facilitate communication on the management of energy resources;
- Promote energy management best practices and reinforce good energy management behaviours;
- Assist facilities in evaluating and prioritizing the implementation of new energy-efficient technologies;
- Provide a framework for promoting energy efficiency throughout the supply chain;
- Facilitate energy management improvements for greenhouse gas emission reduction projects;
- Allow integration with other organizational management systems such as environmental, and health and safety.

The ISO 50001:2011 standard for energy management systems is applicable to all sectors, including land transport. Nazar in Chile is an example of a firm that has implemented this standard in the region.[6]

IEA is an independent agency that was set up in November 1974. Its mission is twofold: to promote energy security among its member countries through a collective response to physical interruptions in the oil supply, and to generate research, analysis, statistics and recommendations in key areas such as energy security, economic development, global awareness and commitment to the environment (International Energy Agency, 2012). The institution works with 28 member countries in addition to supporting others that are not members. In 2008, the agency published "25 Energy Efficiency Policy Recommendations", of which four applying to the world of transport may be highlighted:

(i) Mandatory vehicle fuel efficiency standards;
(ii) Measures to improve vehicle fuel efficiency;
(iii) Fuel-efficient non-engine components, such as tyres and air conditioning;
(iv) Improving vehicle operational efficiency through eco-driving.

ITF works with 58 member countries (including Chile and Mexico in the region) with the aim of helping to shape the global transport policy agenda and ensuring that this contributes to economic growth, environmental protection, social inclusion and the preservation and well-being of human life (International Transport Forum, 2012).

The ITF document "Moving Freight with Better Trucks: Improving Safety, Productivity and Sustainability" describes innovations in truck engines and technology with a view to increasing fuel efficiency and reducing CO_2 emissions. Innovations and developments undertaken to improve fuel use and reduce CO_2 emissions will now be described.

Energy sources

Although substantial efforts are already being made to diversify energy sources for cars, this is harder in the case of trucks. Nevertheless, some progress has been made. For example, there are now some heavy trucks with hybrid propulsion. The challenge is for vehicles using compressed natural gas to improve their market share in environmentally sensitive areas over the medium term and for electric vehicles to do the same in private operations, such as at ports.

Engines

Today's long haul trucks carrying 40-44 tons have engines producing between 260 kW and 360 kW. However, a 40-ton truck and trailer unit only needs about 120 kW, at constant drive at 85 km/h on a flat highway, to overcome tractive resistances. The additional power is only required for accelerating and climbing hills.

Fuel consumption for an average truck has decreased over the past 30 years from about 50 litres per 100 km to 30-35 litres per 100 km, while engine power has doubled from about 180 kW to 360 kW. The engines of today's trucks have high thermodynamic efficiency, but it is possible to decrease

[4] For more details of the work, see http://www.unece.org/trans/main/wp29/presentation_wp29.html.
[5] See http://www.iso.org/iso/iso_50001_energy.pdf for details of the standard.
[6] See http://guiaiso50001.cl/caso-exito-nazar/ for details.

fuel consumption further to about 25 litres per 100 km, for example by downsizing the engine, reducing aerodynamic drag, reducing rolling resistance and improving the efficiency of auxiliary systems.

Tractive resistances

When driving a truck at a constant speed on a flat, level road, about 40% of the fuel consumed is used to overcome air resistance (drag) and 45% to overcome rolling resistance. The rest (15%) is consumed by powertrain losses and auxiliaries. Each of these elements will now be explained in more detail:

- **Aerodynamics**. The drag coefficient of trucks can be improved by using elements that improve their aerodynamics. Examples of initiatives that improve drag coefficient and its impact are:
  - side panels with wheel coverings, with an expected impact of 6%;
  - rear spoiler (speed-dependent inflatable), with an expected impact of 5%;
  - optimized semitrailer floor with rear diffusor, with an expected impact of 3%;
  - optimized air flow under the tractor, with an expected impact of 2%;
  - lower side panels on the tractor, with an expected impact of 2%;
  - roof spoiler on tractor, with an expected impact of 2%;
  - side spoilers on tractor, with an expected impact of 1.5%.
- **Tyre rolling resistance**. Rolling resistance changes with load and inflation pressure and marginally with speed. The smaller the tyre diameter, the higher the rolling resistance coefficient. Drive axle tyres have higher rolling resistance coefficients than steering axle tyres.

Total rolling resistance depends on the number of tyres on the vehicle and the wheel loads. A reduction of 20% to 25% in rolling resistance would bring a fuel saving of approximately 10%. In theory, an average rolling resistance reduction of 2.2% for all tyres would yield a fuel saving of 1% (0.022 x 0.45 = 0.01).

Alternative fuels

Biodiesel can be used as a replacement for oil, diesel and petrol. Made from vegetable oils, reclaimed kitchen oils or animal fats, it offers a potential 20% reduction in CO_2 emissions. It can be used in unmodified combustion engines and does not require substantial changes in distribution infrastructure. Notwithstanding this, the net CO_2 reduction from biodiesel use can vary significantly from the theoretical potential, depending on the manufacturing process and the indirect effects on land use.

In the United States, a tax credit has been a key driver of the biodiesel market. The State provides petroleum and biodiesel handlers with a credit for each gallon of biodiesel blended with diesel fuel. In Europe, volumetric production and blending targets have driven development of the biodiesel market. Technology will play a major role in lowering biodiesel production costs and in finding better alternative uses for the primary by-product, which is glycerine.

Fischer-Tropsch fuel is another alternative for heavy duty vehicles. It is synthesized from coal gas, natural gas, biomass or any other carbonaceous material and can replace petroleum diesel fuel without any modification to a conventional diesel engine. It biodegrades more easily than conventional diesel fuel and can be used to run conventional diesel engines at cold temperatures. It reduces emissions, although production and supply line emissions must not be neglected. For the moment, production costs remain too high to make it widely available on the open market.

Another international organization focused on the development of road transport is the International Road Transport Union (IRU). Founded in Geneva on 23 March 1948, its mission is to represent the interests of bus and truck operators vis-à-vis public and private organizations and the media, concentrating on sustainable growth in the sector. It had 180 members in 74 countries in 2011 (International Road Transport Union, 2011). As part of its approach, IRU developed a strategy call the 3 "I's" which focuses on three key points that must be considered if road transport is to be sustainable while remaining profitable for the industry (see diagram 2).

Diagram 2
THE 3 "I's"

Innovation
Always develop and implement "at source" technical measures that are more effective and practical in their operation to reduce the environmental impact of road transport.
Incentives
Encourage rapid implementation among transport operators of best practices and technologies available on the market.
Infrastructure
Invest adequately in infrastructure to eliminate bottlenecks while making better and greater use of existing infrastructure.

Source: International Road Transport Union (IRU).

This strategy was endorsed by the United Nations Environment Programme (UNEP) in 2002 and has been used as the standard for transport emissions reduction commitments around the world.

The mission of the **Environmental Protection Agency** (EPA) of the United States is to protect human health and the environment. It has been working since 1970 for a cleaner and healthier environment for the people of the United States, and it oversees the country's environmental sciences, together with research, education and evaluation efforts.

Diagram 3
EFFICIENCY STRATEGIES FOR THE FTR SECTOR

Low-friction lubricants
The use of low-viscosity lubricants is estimated to reduce transmission and engine friction to the extent of yielding fuel savings of 0.5% in summer and 2% in winter.
Less engine idling time
It is estimated that engines are left idling for approximately 1,000 to 5,000 hours per year, mainly in order to heat or cool the cabin. Using the engine for this purpose is extremely inefficient , as an idling truck engine is estimated to consume an average of 2.3 litres per hour, or 3.8 litres per hour with the air conditioning on.
Lower speeds
Most trucks can improve fuel economy by reducing road speeds. Carriers can adopt a top speed policy for their drivers as a way to save on fuel costs. Speed reduction can be implemented through engine speed regulators, driver training and electronic engine monitoring.
Driver training and programme follow-up
Good driving practices can have a big impact on fuel economy, irrespective of any technological improvements that may be applied. They include the way drivers accelerate, driving techniques, choice of routes, number of stops and the use of accessories.
Improved aerodynamics
It is estimated that improving truck aerodynamics can dramatically boost fuel efficiency at highway speeds. Technological advances in aerodynamics brought down the friction coefficient for a typical truck from 0.8 in 1970 to about 0.6 in 2000. However, using all aerodynamic options on the market could reduce it further to 0.45.
Wide-base tyres
Replacing double tyres with wide-base tyres improves rolling resistance and reduces truck weight and thence fuel consumption.
Tyre inflation
Maintaining proper tyre pressure reduces rolling resistance and fuel consumption caused by low pressure. An automatic inflation system can maintain optimal tyre pressure.
Tare reduction
Vehicle weight can be reduced by replacing some truck and trailer components with lighter materials or simply eliminating them.

Source: Prepared by the authors.

EPA provides financial assistance for research and graduate scholarships, supports environmental education projects that promote public awareness, knowledge and skills so that informed decisions affecting environmental quality can be taken, and provides the states, local government and small businesses with information on financing for environmental projects and services. EPA studies on land transport and its impact on sustainability yield eight key strategies to improve hauliers' efficiency (see diagram 3) (SmartWay, 2016).

III. Four dimensions for energy efficiency in FTR operations

When we speak of reducing costs, optimizing profitability, cutting energy consumption and minimizing the environmental impact of FTR, what we are essentially talking about is reducing fuel consumption per kilometre travelled and unit of freight transported. This is achieved through initiatives aimed at operational excellence in freight services. In transport, sustainability is synonymous with overall efficiency, and specifically with operational excellence.

Energy efficiency can refer to two concepts: (i) the efficiency of energy conversion, which describes the transformation of energy from its natural form into one that can be used by humans. The efficiency of a machine depends on the quality of the energy consumed, among other factors. For example, a diesel engine has an energy efficiency of 45% (Kuberczyk and others, 2009), while electric engines may have an energy conversion efficiency of up to 96% (Nozawa, 2009); and (ii) energy efficiency per unit of production, which measures how much energy is used in the production of one unit (Horta, 2010).

Synthesizing international evidence together with best management practices for FTR operations yields a fourfold structure for the strategic dimensions to be acted on. The aim is to improve energy consumption and sustainability standards in FTR operations. Each dimension entails a strategic aspect in the management of transport organizations and requires a comprehensive effort involving people, processes, technologies and infrastructure. Additionally, there is a fundamental role in each dimension for the public sector to drive the necessary changes and ensure the development of the transport sector is consistent with countries' all-round development. The four strategic dimensions for energy efficiency in FTR are:

1. Fleet configuration. This is the use of efficient vehicles, components and auxiliary equipment. It is estimated that advances in latest-generation engines, the development of light equipment, aerodynamic improvements, better tyres, latest-generation lubricants, etc., will mean that equipment may be up to 30% or 40% more efficient by 2030. Countries' ability to adopt these technologies is heavily determined by income level, and the results obtained from them by operators' ability to incorporate them properly. The challenges are to improve information and knowledge and to quicken the speed at which clean and efficient technologies can be incorporated into transport operations.

- Private sector: Transport organizations and the chains they serve must enhance their ability to learn about and select the appropriate technologies for their operations (vehicles, auxiliary items, inputs, etc.), strengthen their performance evaluation and monitoring capabilities and improve their processes for adapting innovative technologies and implementing them in their operations.
- Public sector: The authority must use the regulatory instruments available to raise countries' standards with regard to the nature of the fleet operating in their communities. Heavy vehicles emissions regulations, vehicle fuel efficiency standards, labelling systems, technology certification systems, permitted fuel standards, scrappage programmes and specific incentives or taxes, among other things, are the tools whereby the public sector acts in this area.

2. Fleet management. This concerns the day-to-day operating and efficiency standards achieved by transport organizations with each delivery. Maintenance strategies and policies, operating itineraries and all-round management of key transport processes (commercialization, service allocation, pick-up, route, delivery, etc.) are crucial to the efficiency of a correctly configured fleet.

- Private sector: Transport companies and the chains they

on driving time, fleet age, operating hours and zones and rest areas are some of the spheres in which the authority contributes to or constrains the potential development and efficiency of FTR operators in their day-to-day activities.

3. Safe and efficient driving. Alert, well-trained and motivated drivers are involved in fewer accidents, use less fuel, keep down maintenance costs, help care for vehicles and make them last, and are more reliably customer-oriented. Efficient driving or "eco-driving" is a driving style whereby the vehicle is operated within a band of revolutions that is within the engine's so-called "sweet spot", with less acceleration and a predictive approach to traffic. The fuel saving effects of driver behaviour and reduced demands on the engine are considerable.

- Private sector: Training in eco-driving is a key aspect of any energy efficiency programme and should be pursued systematically and consistently by fleet managers. A performance gap of 30% to 35% has been detected between the best and worst drivers. In Latin America, highway cargo transport firms that have taken up this challenge have usually had to make substantial internal training efforts, as outside training to the level required is not available to any significant extent. These efforts do not ensure driver retention, so there is the risk of their being wasted because of the high turnover of this human resource. Eco-driving training courses yield fuel savings of between 5% and 10%. A 10% reduction is generally achieved right after the first course, albeit only for a short time, as drivers tend eventually to regress in part to their earlier driving style, which reduces these benefits. On this point, it is essential for transport organizations to be able to develop a culture of efficiency that can consolidate driving habits and forestall changes. In any event, average long-run savings of 8% to 10% from driver management are achievable. Daily, weekly or monthly incentive and daily