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TRUCK ECO-DRIVING PROGRAMS
CURRENT STATUS IN LATIN AMERICA AND INTERNATIONAL BEST PRACTICES

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BACKGROUND AND INTRODUCTION

Trucking is the cornerstone of freight activity around the world. In markets like the United States, trucks account for about 72% of total tons transported (Bureau of Transportation Statistics, 2018). Trucking is also responsible for a large share of the total carbon dioxide (CO_2) and other harmful air pollutant emissions from on-road transportation, even though there are significantly fewer trucks than passenger vehicles (Kodjak, 2015). Globally, diesel vehicles account for more than 40% of on-road energy consumption, and 90% of it is from heavy-duty trucks (International Energy Agency, 2017a, 2017b).

Eco-driving programs achieve reductions in CO_2 and other emissions. The term eco-driving encompasses a range of driving techniques and practices that improve the overall fuel economy of vehicles. This can lead to a reduction of greenhouse gas (GHG) emissions, lower fuel and maintenance costs, and co-benefits such as a higher degree of professionalization of drivers and improved road safety.

This is also key because fuel accounts for between 30% and 40% of the operating costs of trucks in the United States (American Transportation Research Institute, 2018; U.S. Energy Information Administration, 2019) and most other regions around the world. Truck carriers in the United States saved about $41.8 billion in fuel costs from 2004 to 2020 by implementing energy efficiency technologies and strategies (U.S. Environmental Protection Agency, 2021). Clearly, the trucking sector has a strong motivation to cut fuel consumption. Doing so reduces the risk of fuel price volatility and offsets the rise of other costs.

ECO-DRIVING AS PART OF 'GREENING' FREIGHT

There is a growing interest especially in Latin America in the implementation and expansion of voluntary green freight programs that include eco-driving as a key component. One such program is SmartWay, implemented in the United States and Canada. In this paper, we review the status of eco-driving programs for the on-road freight industry in Argentina, Brazil, Chile, Costa Rica, Mexico, and Peru, where we recognize tangible opportunities for implementation or expansion. We identify the key stakeholders in each market, outline the current eco-driving policies and programs, and present stakeholders' perspectives and insights regarding the barriers to and opportunities for success.

The second part of this paper draws from the experience of eco-driving programs embedded in green freight initiatives in North America and around the world. Natural Resources Canada's (NRCan) *SmartDriver* e-learning course is a central resource for this work because it documents the evolution of an eco-driving program over 30 years within the context of SmartWay. We use it to present best practices for eco-driving programs while also considering the lessons learned from other pilot programs and studies around the world. Based on the best practices from North America and worldwide, current practices in Latin America, and interviews with stakeholders from the public and private sectors and academia, we identify the key components of a "gold standard" in designing and implementing an eco-driving program. These interviews were carried out in 2019 and 2020. The list of stakeholders interviewed is included at the end of the paper.

A successful eco-driving program has local contextualization; a robust curriculum; effective partnerships with private and public stakeholders; a pilot stage before it scales; flexibility in delivery methods; effective monitoring, evaluation, and feedback mechanisms; and plans for maintenance. It also takes into consideration enabling policies and incentives surrounding the program. These key lessons can serve as a starting point for regulators, fleet owners, and training institutions that plan to introduce permanent eco-driving training programs.

THE BENEFITS OF ECO-DRIVING

A report for the U.K. Department for Transport by the American multinational engineering company AECOM defines eco-driving as "a combination of safe, defensive, and anticipatory driving techniques … to increase fuel efficiency, improve road safety, and lower carbon emissions" (Department for Transport, 2016, p.14). In practice, eco-driving programs vary in terms of scope, delivery methods, curriculum on driving techniques, evaluation metrics and methods, and other supporting elements. As a result, there is no standard definition of an eco-driving program. We argue that such programs should be as comprehensive as possible to include a diversity of formats and methods that achieve sustained and long-term benefits. In this paper, the term eco-driving program refers to the driving techniques and the series of articulated policies and mechanisms needed to maximize the benefits of those techniques.

Eco-driving does not happen only during vehicle operation. It includes pre- and post-driving activities like route planning, vehicle inspection, and maintenance. These techniques allow drivers and fleet managers to understand what factors impact a truck's fuel consumption and provide them with recommendations on how to operate more efficiently. Other terms for eco-driving techniques are "soft driving," which usually refers to fuel-saving practices, and "smart driving," which incorporates not just fuel-efficient maneuvers but also safety behaviors like defensive driving.

Green freight, another term used frequently in the freight transportation sector, is an even broader concept that refers to attempts to improve efficiency, reduce emissions, or decarbonize a segment or the whole supply chain. Green freight programs are typically SmartWay-type programs and include things like fuel efficiency and fleet management information and tools; monitoring, reporting and verification systems; benchmarking; and recognition programs. They bring together shippers, carriers, logistics agents, technology providers, government agencies, and other associated stakeholders. Eco-driving is an important subset of best practices in the most successful green freight program, SmartWay.
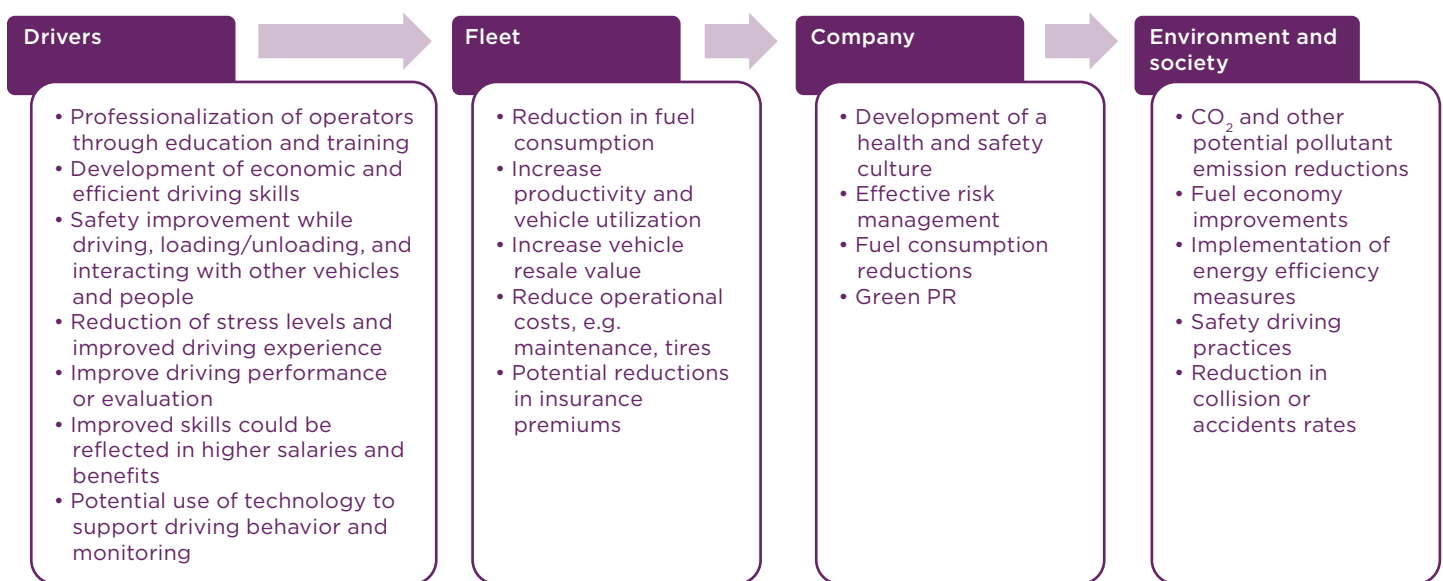
A literature review of eco-driving pilot programs and studies (Boriboonsomsin, 2015) found that fuel savings for truck fleets can range from 3.5% to 30% (Table 1). Our interviews with trucking sector practitioners that have implemented eco-driving pilot programs or training within the context of a green freight program reported similar results. This wide variance in results can be explained by differences in driver experiences and profiles, data collection, monitoring and reporting methods, choice of metrics and goals, time frame of studies, and baseline measurements. Some studies do not provide enough information about their methodology to contextualize and understand the conclusions. Although all of this means the fuel economy benefits of these studies and pilot programs are not directly comparable, we could nonetheless expect an average 5% reduction in fuel consumption from eco-driving based on our review of the data and interviews.

Table 1. Eco-driving studies and fuel economy improvements (Boriboonsomsin, 2015)

Year	Location	Training method	Evaluation setting	Number of drivers	Fuel economy improvement
2005	United Kingdom	Driving simulator	Driving simulator	>600	3.5% immediately after training
2007	United States	Classes	Closed driving course	36	33.6% to 40.5% immediately after training
2009	Australia	Classes	Prescribed real-world route	12	27.3% immediately after training; 26.9% after 3 months
2010	European countries	Class followed by monthly feedback and regular refreshing class	Actual real-world routes	322	9.4% after an unknown period
2011	United States	Individualized coaching and in-vehicle real-time feedback system	Actual real-world routes	695	13.7% after 2 months
2013	Japan	Classes	No information available	~3,000	8.7% immediately after training
2014	United States	Individualized coaching and in-vehicle real-time feedback system (plus financial incentives)	Actual real-world routes	46	2.6% (5.4% with financial incentives) for sleeper cabs and 5.2% (9.9% with financial incentives) for day cabs after 2 months

Eco-driving has several co-benefits, including safety, health, and climate change mitigation. A study analyzing the differences between drivers who had been in a collision and those who had not found that, on average, drivers who had been in a collision consumed 7.5% more fuel than those who had not (SmartDrive, 2011, 2016). Eco-driving also improves drivers' skills and promotes professionalization. Although training does involve some level of cost ranging from training fees and truck operation expenses to opportunity costs for drivers' loss of income, the benefits that accrue over time significantly outweigh them.

Eco-driving benefits spill over to stakeholders in the entire freight value chain. Indirect benefits achieved are listed in Figure 1.

Drivers → **Fleet** → **Company** → **Environment and society**

Drivers
- Professionalization of operators through education and training
- Development of economic and efficient driving skills
- Safety improvement while driving, loading/unloading, and interacting with other vehicles and people
- Reduction of stress levels and improved driving experience
- Improve driving performance or evaluation
- Improved skills could be reflected in higher salaries and benefits
- Potential use of technology to support driving behavior and monitoring

Fleet
- Reduction in fuel consumption
- Increase productivity and vehicle utilization
- Increase vehicle resale value
- Reduce operational costs, e.g. maintenance, tires
- Potential reductions in insurance premiums

Company
- Development of a health and safety culture
- Effective risk management
- Fuel consumption reductions
- Green PR

Environment and society
- CO_2 and other potential pollutant emission reductions
- Fuel economy improvements
- Implementation of energy efficiency measures
- Safety driving practices
- Reduction in collision or accidents rates

Figure 1. Eco-driving benefits that accrue to different stakeholders. *Note:* Adapted from Department for Transport (2016).

ECO-DRIVING STATE OF PRACTICE

We identified ongoing eco-driving initiatives in Argentina, Brazil, Chile, Costa Rica, Mexico, and Peru. In those countries we also see tangible opportunities to implement or expand permanent eco-driving programs.

Elements of eco-driving training are mandatory in driver licensing in most countries. Each country's eco-driving program or programs build on collaboration between public and private stakeholders. Such training could also be offered by the private sector. Government bodies that lead the design and implementation of eco-driving programs are typically the ministries of energy, environment, and transport and their sub-branches that have the authority to issue driver's licenses, define training curriculum and materials for truck driver licensing, and certify training providers. Drivers' training and workshops often rely on freight carrier associations' wide-reaching memberships of drivers and fleet managers. Truck manufacturers in these markets also offer driving courses and telematics system solutions. Academic institutions and international organizations also play a role in lending technical support to national governments and private sector stakeholders.

Table 2 summarizes key information of each country's eco-driving state of practice: the existing eco-driving initiatives, green freight programs, and mandatory eco-driving training as part of receiving a driver's license; and key public, private, and other stakeholders within freight transport that are relevant to the implementation of eco-driving programs.

Table 2. Summary of eco-driving practices in select Latin American countries

	Argentina	Brazil	Chile	Costa Rica	Mexico	Peru
Truck eco-driving initiatives	Yes, through public and private green freight programs and truck manufacturer training	Yes, through private green freight programs and truck manufacturer training	Yes, through public and private green freight programs and truck manufacturer training	Yes, through private fleets	Yes, through public and private green freight programs and truck manufacturer training	Yes, through authorized training schools and truck manufacturer training
Green freight program	Programa Transporte Inteligente Rango Verde	Despoluir Programa de Logística Verde Brasil (PLVB)	Giro Limpio	No	Transporte Limpio	No
Mandatory eco-driving training in DL	Proposed HDV eco-driving in its Nationally Determined Contributions (NDC) submitted to the United Nations Framework Convention on Climate Change, but not yet implemented	No	No	No	No	Yes, included in NDC and implemented
Government agency in charge of mandatory eco-driving	Agencia Nacional de Seguridad Vial (ANSV)	Conselho Nacional de Trânsito, (CONTRAN)	Comisión Nacional de Seguridad de Tránsito (CONASET)	Ministerio de Obras y Transporte (MOPT)	Secretaría de Comunicaciones y Transportes (SCT)	Ministerio de Transportes y Comunicaciones (MTC)
Supporting government agencies	Ministerio de Transporte Secretaría de Energía Ministerio de Ambiente y Desarrollo Sostenible (MAyDS)	Ministério da Infraestrutura	Agencia de Sostenibilidad Energética (Agencia SE) Ministerio de Transportes y Telecomunicaciones (MTT)	Consejo de Seguridad Vial (COSEVI) Instituto Nacional de Aprendizaje (INA) Ministerio de Ambiente y Energía (MINAE)	Comisión Nacional para el Uso Eficiente de la Energía (CONUEE) Secretaría del Medio Ambiente y Recursos Naturales (SEMARNAT) Instituto Mexicano del Transporte (IMT)	Superintendencia de Transporte Terrestre de Personas, Carga y Mercancías (SUTRAN)
Industry actors	Federación de Entidades Empresarias del Autotransporte de Cargas (FADEEAC) Fundación Profesional para el Transporte (FPT) Confederación Argentina del Transporte Automotor de Cargas (CATAC)	Confederação Nacional do Transporte, CNT / Serviço Social do Transporte e Serviço Nacional de Aprendizagem do Transporte, (SEST SENAT)	Confederación Nacional de Dueños de Camiones de Chile (CNDC) Confederación Nacional de Transporte de Carga de Chile (CNTC) Chile Transporte – Asociación Chilena de la Industria del Transporte de Carga por Carretera	Cámara Nacional del Transporte de Carga (CANATRAC)	Cámara Nacional del Autotransporte de Carga (CANACAR) Confederación Nacional de Transportistas Mexicanos (CONATRAM) Asociación Nacional de Transporte Privado (ANTP)	Asociación Nacional de Transporte Terrestre de Carga (ANATEC) Unión Nacional de Transportistas Dueños de Camiones del Perú (UNETE PERÚ)
Think tanks/ NGOs	Automóvil Club Argentina	Not identified	Automóvil Club Chile	GIZ Costa Rica	Fundación Carlos Slim	GIZ Peru
Academic institutions	Not identified	Federal University of Rio de Janeiro	Universidad Andres Bello, Centro de Transporte (UNAB)	Not identified	Not identified	Not identified

ARGENTINA

Eco-driving for HDV was included in Argentina's Nationally Determined Contribution (NDC), adopted in November 2016, and in the 2017 National Mitigation Plan for the Transportation sector, which called for cumulative emission reductions of 5.5 Mt CO_2 by 2030.[1] (Ministerio de Ambiente y Desarrollo Sustentable, 2017; República de Argentina, 2016; Secretaría de Medio Ambiente y Desarrollo Sustentable, 2019).

The 2017 National Mitigation Plan recognized that an important barrier to implementing eco-driving programs is opposition from carriers or drivers because investing in training implies days of income loss. The plan also recognized the need to:

» Organize "train the trainers" programs to support the expansion and capacity-building of eco-driving programs.

» Incorporate simulators and training tracks to support classroom learning.

» Raise awareness of shippers about eco-driving benefits to create a demand for "green" services.

In 2017, mandatory eco-driving for all driver's licenses was included in the proposal for a National Law for Energy Efficiency, but it was not approved by Congress (Ministerio de Energía y Minería, 2018a). Following this initiative eco-driving was included in the curriculum for driver's licenses in the city of Buenos Aires and in the courses delivered by the Argentinean Automotive Club. To date, eco-driving has not yet been fully implemented by the National Road Safety Agency (*Agencia Nacional de Seguridad Vial, ANSV*) which is part of the Ministry of Transport. Since January 2019, ANSV is the agency responsible for truck driver's license requirements, approval of training providers, and defining the scope of training coursework (Presidente de la Nación, 2019). Several materials, including guidelines on efficient management of freight road transport (Ministerio de Energía y Minería, 2018b), were already developed by the undersecretary of Renewable Energy and Energy Efficiency (Secretaría de Energía, 2019).

In October 2018, the government launched the Intelligent Transport Program *(Programa Transporte Inteligente, PTI)*, which is based on the structure of the U.S./ Canada SmartWay program and aims to reduce fuel consumption in the freight sector by as much as 30%. *Rango Verde*, an initiative of the Federation of on-road carrier companies (*Federación Argentina de Entidades Empresarias del Autotransporte de Cargas*, FADEEAC), is another relevant green freight program that encompasses the larger fleet carriers. Both programs incorporate eco-driving training. The ICCT interviewed women participating in a female-only eco-driving training offered by the training branch of FADEEAC. Argentina and Peru were the two cases found that focused on women truck drivers.

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1   In this document we refer to metric tons (1,000 kg) when referring to tons.

February 2021. Escobar, Argentina. Eco-driving training for women in collaboration with Scania. Photo credit: FPT.

As a result of major institutional changes at federal agencies following the 2019 elections, the implementation of eco-driving requirements did not materialize. PTI is looking to strengthen the driver training component through collaborations with local stakeholders like FADEEAC and other trucking associations, and with Chile's Sustainable Energy Agency (AgenciaSE).

During 2020, the Ministry of Transport resumed efforts toward implementing eco-driving and participated in a pilot with private companies and the Smart Freight Centre (SFC) to train more than 200 fleet managers in efficient strategies including eco-driving techniques. The Ministry of Transport has emphasized the importance of implementing a robust and periodic training for truck drivers to overcome the challenge one-time trainings, after which drivers might go back to previous practices. That is why partnering with transport chambers and associations and key stakeholders is important to highlight the environmental, energy, safety, and social benefits, and to persuade them to adopt sustained eco-driving techniques. Other relevant context is that 70% of trucks are owned by small operators who have fewer resources and access to trainings and top technologies; they also tend to have less well maintained trucks. Therefore, incentives targeted to small operators are imperative.

Other eco-driving training courses are offered by some truck manufacturers like Volvo, Scania, Mercedes, and Hino.

The implementation of mandatory eco-driving training for truck drivers in Argentina could build on existing initiatives including PTI, Rango Verde, and private driver training programs. Other carrier associations like the Argentine Confederation of Automotive Freight Transport (*Confederación Argentina del Transporte Automotor de Cargas, CATAC*) are important to broadening the scope of driver training programs,

especially to small operators and owner-operators, which might need incentives to participate in training and programs. Argentina's Automobile Club is another ally that could support truck driver training as it offers courses for passenger car drivers which consider eco-driving.

Driver's license process

All truck drivers are required to obtain a license as professional drivers. They need to complete knowledge and practical training according to the cargo they transport (hazardous or nonhazardous) and pass examinations and a medical exam. The frequency with which driver's licenses have to be renewed is based on the type of license and the age of the driver (Table 3). Driver training varies if the driver's license is being issued for the first time or renewed, but in both cases the knowledge and practical tests are required (Agencia Nacional de Seguridad Vial, 2019).

Table 3. Driver's licenses for trucks in Argentina (Agencia Nacional de Seguridad Vial, 2019)

Type of vehicle	Driver's license type	Description	Length of certification
Rigid trucks	C.1	≤ 12 tons GWV	2 years for drivers between 21 and 45 years old 1 year for drivers older than 46 years
	C.2	≤ 24 tons GWV	
	C.3	> 24 tons GWV	
Articulated trucks	E.1	tractor trailers	
	E.2	nonagricultural special machinery	

BRAZIL

Eco-driving training is not required for truck drivers in Brazil. We identified two green freight program initiatives that consider it, both from the private sector. One is *Despoluir*, which is offered by the National Confederation of Transport (*Confederação Nacional do Transporte, CNT*) and the Social Transport Service and the National Apprenticeship Service of Transport (*Serviço Social do Transporte e Serviço Nacional de Aprendizagem do Transporte, SEST SENAT*). The other is the *PLVB* program (*Programa de Logística Verde Brasil, PLVB*), a consortium of large shippers, carriers, logistics companies, and academia.

In 2019, CNT, SEST SENAT, the ICCT, and Natural Resources Canada (NRCan) extended their collaboration to share international experiences and adapt NRCan's *SmartDriver* and *FleetSmart* programs to the Brazilian context. This adaptation required a thorough analysis of the Brazilian context to adjust to it and accordingly create new content for videos and manuals. Additionally, CNT and SEST SENAT acquired 123 driving simulators to complement driver training, and an app was developed to support data collection and monitor fuel consumption, CO_2 emissions, and freight activity. Three courses were developed (truck driver, bus driver, and fuel management), and more than 11,000 people have participated from March 2018 to March 2021. Drivers have reported average fuel savings of 24%. In addition, the program developed an app to support the adoption of efficient practices and track fuel consumption. Drivers are also taught how to use this resource. For more information, see our report of the 2019 international workshop on green freight initiatives in Brasilia (Pineda, 2020).

November 2019. Brasil. SEST SENAT truck driver training facility simulator.

Driver's license process

Driver's licenses (*Carteira Nacional de Habilitação*, CNH) are issued by each state traffic agency under the national traffic law implemented by the National Traffic Council *(Conselho Nacional de Trânsito, CONTRAN)*. Truck drivers (license type C or E) are considered professional drivers and must follow the same rules that apply to the other license categories. All drivers have to pass knowledge, psychological, mental, physical, and practical tests by approved schools in each state or district. Topics evaluated include defensive driving, though not specifically eco-driving techniques. Some licenses require drivers to take some training related to road safety or transport of hazardous materials. In October 2020, some changes to the regulatory framework were published (Law 14.071/2020), including the extension of driver's license expiration dates:

» 10 years for drivers age younger than 50 years (before, it was 5 years for ages 65 and younger).

» 5 years for drivers between 50 and 70 years of age (before, 3 years for ages 65+).

» 3 years for drivers 70 and older.

In addition, professional drivers need to test negative on a toxicology test every 2.5 years, for drivers under the age of 70. Brazil also implements a points system under which drivers accrue points based on the number and severity of traffic violations. This will affect the requirements, expiration date, and mandatory training for obtaining a driver's license type for the first time or renewing one.

CHILE

Eco-driving is required in the training curriculum to obtain a driver's license in Chile, but in practice it is not fully developed, nor is it taught or evaluated. A coming initiative led by the Sustainable Energy Agency (*Agencia de Sostenibilidad Energética, AgenciaSE*), a public-private partnership, may help advance eco-driving in Chile.

In August 2018, the Ministry of Transport and Telecommunications (*Ministerio de Transportes y Telecomunicaciones, MTT*) and the Ministry of Energy along with the University Andrés Bello launched the SmartWay-based green freight program Giro Limpio, which is currently managed by AgenciaSE. Giro Limpio partners account for 5% of Chile's fleet of 240,000 trucks.

AgenciaSE has already developed some eco-driving guidelines and best practices documents for different vehicles but wants to establish certification to train truck drivers who are part of Giro Limpio in eco-driving. To achieve this, NRCan, the EPA's SmartWay, and the ICCT have partnered with AgenciaSE to support the Spanish adaptation of the SmartDriver e-learning platform on eco-driving. This collaboration will result in a Chilean Spanish version to be offered to Giro Limpio partners and will be used to certify truck drivers on eco-driving skills.

Other eco-driving training is offered by private-sector truck manufacturers and Chile's Automobile Club, which has courses for passenger car, bus, and truck drivers. The MTT and AgenciaSE have offered subsidy systems to absorb the cost of training in the past, but this support is dependent upon available resources and resources are not available for 2021.

Driver's license process

Truck drivers are required to obtain professional driver's licenses type A4 (trucks) and A5 (rigid trucks and articulated vehicles) and complete a minimum of 150 hours of training for knowledge and 134 hours of practical training (Comisión Nacional de Seguridad de Tránsito, 2018). Both license types require drivers to pass a knowledge and a practical test given at either a training school or a provider approved by a regional office of the MTT (Ministerio de Transportes y Telecomunicaciones, 1999).

The National Traffic Safety Commission (*Comisión Nacional de Seguridad de Tránsito, CONASET*) is responsible for developing traffic regulations. It recently updated the guidance document for professional drivers to include eco-driving techniques (Comisión Nacional de Seguridad de Tránsito, 2018). Driver training is offered by certified schools, many of which offer practical training with driving simulators. Although eco-driving techniques are part of the guidance document, the curriculum is not comprehensive enough, and training schools have the flexibility to adapt the coursework as long as they meet the overall requirements for driver's licenses, which do not prioritize eco-driving. Consequently, there is a need for standardization of training materials and enforcement mechanisms to ensure that eco-driving is implemented.

COSTA RICA

The National Energy Plan (*Plan Nacional de Energía 2015–2030, PNE*) and the National Freight Logistics Plan (*Plan Nacional en Logística de Cargas 2014–2024, PNLog*) identified eco-driving for truck drivers as a mitigation policy that could deliver not only energy efficiency gains and emission reductions but also support the professionalization of the trucking sector.

Currently the Road Safety Council (*Consejo de Seguridad Vial, COSEVI*), a unit of the Ministry of Public Works and Transport (*Ministerio de Obras Públicas y Transporte, MOPT*), is in charge of issuing driver's licenses. MOPT is leading the efforts to update the manuals for driving passenger cars and motorcycles and will expand the content on eco-driving. MOPT and COSEVI are collaborating to continue with truck and bus manuals and has partnered with the ICCT and the German Corporation for International

Cooperation (GIZ) to carry out a pilot program with company fleets that participate in the road safety program, *Empresa Segura.* There is no green freight program in Costa Rica, but the results of this pilot program will provide relevant information to develop a green freight or eco-driving program.

Costa Rica plans to leverage the work and materials already developed in other countries such as Peru and a previous eco-driving training for truck drivers offered a few years ago by the National Learning Institute (*Instituto Nacional de Aprendizaje, INA*) that is not offered now.

In 2019, the ICCT undertook a freight assessment study in Costa Rica that included workshops with key stakeholders to discuss some policy and program recommendations. Based on these discussions, eco-driving for truck drivers is well accepted by carrier associations, public fleets, and government agencies. They all agreed that there were few barriers for its implementation and direct short-term benefits for fleets, drivers, the environment, and society. It was mentioned that previous training courses have not had sufficient participants since many companies were not able to allocate the time that truck drivers would "lose" and trucks could not operate during the duration of the course. Furthermore, it was mentioned that formal training in a classroom had caused certain skepticism by experienced drivers in a sector where informal training by relatives has been the standard for decades.

Driver's license process

Driver's licenses for trucks (B-2, B-3, and B-4) require drivers to pass knowledge and practical tests. When issued for the first time, the driver's license is valid for three years. Within this time frame, drivers are subject to a points system (as in Brazil) that will affect the expiration date of the driver's license. For every traffic violation, drivers accumulate points (0–12) that will determine the expiration period of the renewal (3–6 years). If drivers accrue five or more points, they need to take a training on a given topic based on the severity of the violations—driving education, drug addiction and anger management, or psychological support. Another course or a cross-cutting topic could very well be eco-driving.

MEXICO

Although some eco-driving techniques are included in the official curriculum for mandatory driver training, as in many other countries, it is not comprehensive. Mexico has a long history of eco-driving programs or initiatives, though, and it is interesting that there are several collaborations between the public and private sectors and that several initiatives coexist without any effort to integrate them into a single, more robust program.

The National Commission for the Efficient Use of Energy (*Comisión Nacional para el Uso Eficiente de la Energía, CONUEE*) has been a pioneer in eco-driving training since the early 2000s with the Efficient Carrier, or *Transportista Eficiente*, program in the past. CONUEE provides eco-driving training to drivers of vehicles in government fleets. This training is mandatory, and the fleets are required by law to implement energy efficiency measures. There are 250 government agencies and about 40,000 vehicles subject to this obligation. CONUEE also provides training to private fleets or other stakeholders by request and has even trained country delegations in Central America, which shows the need to establish more eco-driving programs in the region. CONUEE has found fuel consumption savings of as much as 30%.

The Secretary of Environment (*Secretaría del Medio Ambiente y Recursos Naturales, SEMARNAT*) manages the green freight program, Clean Transport (*Transporte Limpio*), with support from CONUEE and the Secretariat of Communications and Transport (*Secretaría de Comunicaciones y Transportes, SCT*). *Transporte Limpio* is a recognition program based on SmartWay. Partner companies and operators that adopt energy efficiency measures, including eco-driving, report their fuel savings every year. *Transporte Limpio* does not offer training but provides information to fleets and operators about best practices. SEMARNAT directs companies or fleets interested in eco-driving training to other partners like CONUEE or independent consultants.

The National Chamber of Freight Transport (*Cámara Nacional del Autotransporte de Carga, CANACAR*), started eco-driving training in 2003 in collaboration with CONUEE. In 2015, CANACAR created "Distintivo CANACAR" as a recognition program for companies that completed some training on supply chains and logistics, regulatory frameworks, incentives programs, and eco-driving. The training is online. Distintivo CANACAR recognizes companies, not individual operators, and only federal fleets can receive the certification. Other fleets can take the training without obtaining the certification.

The Carlos Slim Foundation has an e-learning platform that offers multiple free training sessions, including one for efficient fleet operation that was developed with the support of CONUEE, CANACAR, and the Mexican Institute of Transport (*Instituto Mexicano del Transporte, IMT*).

Other eco-driving resources, such as videos and manuals, and pilot programs have been funded by GIZ to support eco-driving initiatives by *Transporte Limpio* and CONUEE. These have reported fuel savings in the range of 5% to 30% (Fernández, 2014; Martínez, 2015).

Driver's license process

All truck drivers are required to complete and pass specific knowledge and practical training programs based on their driver's license type and operation (*Licencia Federal de Conductor*). Licenses "B" and "C" for trucks and "E" for tractor-trailers are required for freight truck operation. The first two must be renewed every four years and license "E" every two years (Dirección General de Autotransporte Federal de la Secretaría de Comunicaciones y Transportes, 2016). Driver's licenses are issued by the General Department of Federal on-road Transportation (*Dirección General de Autotransporte Federeal, DGAF)* of the SCT. The agency determines the curriculum of each training program. Training centers must have equipped classrooms and driving facilities with trucks or driving simulators. Some of the training programs, in particular for tractor-trailers, include a module on eco-driving.

PERU

Peru included eco-driving training for truck drivers in its NDC with a cumulative reduction of 4.5 Mt CO_2 in 2030 (Gobierno del Perú, 2018; Ministerio de Comunicaciones y Transportes, 2018; Espinoza, 2020). The working group assessing this mitigation measure also identified a road map and specific actions needed to fully implement eco-driving as a mandatory requirement for a driver's license. Several regulatory changes were made by mid-2020 to include eco-driving in the training curriculum, develop supporting materials on eco-driving that schools could use, and standardize the driving test to evaluate eco-driving techniques (República del Peru, 2020a, 2020b). The Ministry of Transport and Communications, (*Ministerio de*

Transportes y Comunicaciones, MTC) has also developed a new guidance manual for instructors on eco-driving and a manual for truck drivers. Peru does not have a green freight program.

MTC and the Ministry of Environment *(Ministerio del Ambiente, MINAM*) organized workshops with key stakeholders to discuss the road map for eco-driving in Peru, understand different carriers' business models and challenges, and identify opportunities for financial support, incentives, and to use other regulatory tools. Ultimately, MTC in partnership with GIZ and Volvo carried out a pilot training program during the second half of 2019. It also assessed the impact of eco-driving driver training using driving simulators and on real-world routes. The findings showed fuel savings of as much as 17% and average savings of 7%. Some of the key lessons were:

» Eco-driving should be added to the curriculum in addition to the current training for truck drivers.

» MTC should work with authorized training schools to train the trainers and support capacity-building throughout the country.

» Incentive programs are important, so as a reward or recognition for their good performance.

» Eco-driving techniques should be reinforced periodically when drivers renew their licenses.

» Use of driving simulators is encouraged as it would standardize training, allow for training under various scenarios and weather conditions, improve road safety by training drivers before going out on the road, and eliminate the need for a truck and its associated operating costs.

» Practical training on the road is also needed to reinforce eco-driving knowledge and techniques. Drivers learn better from experience on real routes.

» Additional pilot programs should be considered to incorporate other route and traffic conditions.

Other training is offered by truck manufacturers including Volvo, Scania, and Hino. Additionally, Volvo has a training program called "Iron Woman" focusing on female drivers. Peru stood out from the other countries in emphasizing the incorporation of a gender perspective in the design of policies, and several women participated in the pilot program. Recently, MTC has been working with municipalities to implement campaigns to train transit bus drivers to reduce fuel consumption and traffic accidents.

The ICCT's Leticia Pineda, using a simulator at the Volvo Training Academy in Peru. May 2019.

Driver's license issuing process

Truck drivers have to enroll in a training program and complete a certain number of hours to receive a certificate as professional drivers (*Constancia de Finalización del Programa de Formación de Conductores, COFIPRO*). This is needed to obtain a driver's license, or *Brevete*. The *Brevete* has to be renewed every three years (Ministerio de Comunicaciones y Transportes, 2016). The license types applicable to freight are A-IIB (light trucks, pickups, and rigid trucks), A-IIIB (open trucks), and A-IIIC (all vehicle types).

MTC is the agency responsible for approving the requirements and design of the training courses. Training providers have to be accredited by the MTC. Each driver's performance, results, and driving history are logged into the Driver's National System online platform (*Sistema Nacional de Conductores*).

ECO-DRIVING BEST PRACTICES

DEFINING ECO-DRIVING ELEMENTS

Having reviewed the state of practice of eco-driving in a number of Latin American countries where eco-driving programs are starting, this section details best practices from more mature markets like Canada and the United States.

Recall that eco-driving programs vary in terms of scope, delivery methods, curriculum on driving techniques, evaluation metrics and methods, and other supporting elements. As a result, there is no standard definition of eco-driving. We argue that a definition should be as comprehensive as possible to include a diversity of formats and methods.

With this in mind, we considered the key design and implementation successes of *SmartDriver* under the SmartWay program and other noteworthy lessons from having closely followed a few eco-driving pilot programs in Peru, Argentina, and Costa Rica, and recommendations from practitioners knowledgeable about leading programs worldwide. We conclude that seven components are key to making eco-driving programs successful.

Such a gold standard combination is especially relevant for countries that are planning an eco-driving program or are in the early stage of implementing one. The elements are:

» **Contextualizing a program** to a specific country or fleet, ensuring it meets local needs.

» **A robust curriculum** that ensures a sound understanding of eco-driving techniques.

» **Partnerships** with public and private stakeholders to help eco-driving programs reach a larger audience with greater effect, including **pilot testing** before scaling them up.

» **Flexible delivery** methods, allowing drivers to fit training into their schedules.

» **Monitoring and feedback** systems to support program evaluation and improve driver performance.

» **Maintenance best practices,** ensuring that vehicles are in the best driving condition.

» **Enabling policies and incentives** to support the program implementation over the long term.
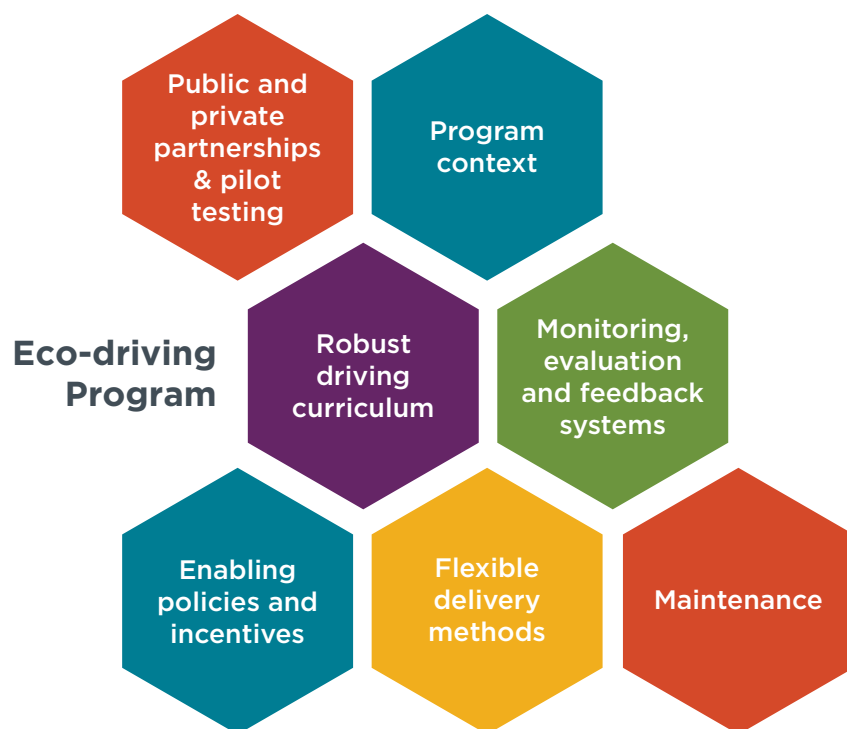
Figure 2. Components of a gold standard eco-driving program

PROGRAM CONTEXTUALIZATION

Accounting for the particular context and regulatory environment for an eco-driving program requires having an understanding of the fleet characteristics, truck technologies and operations, intended audience, and regulations affecting the trucking sector in a particular market (Sharpe, 2017). These are important for being able to fine-tune the content of training. This does not, however, imply that a completely different program needs to be developed every time. That is not necessary because there are shared common practices across trucking applications. But program contextualization does help to better meet the needs of a fleet and will appear more relevant to truck drivers in a given context. This component is fundamental to the design and implementation of an eco-driving program (Table 4).

Understanding fleet operations is relevant to eco-driving program design because trucks carry a great variety of cargo types and travel various terrains in wide-ranging climates and under logistics profiles that differ from country to country. Different truck technologies and fuels are another factor. A good eco-driving program would also make the distinction between different types of drivers based on level of education and experience and provide comprehensive material for both new and experienced drivers.

Finally, each market has idiosyncratic laws and regulations, some of which enable unique eco-driving programs and initiatives. In the United Kingdom and Jakarta, Indonesia, eco-driving training is integrated into commercial driver's licensing courses, thanks to partnerships with relevant authorities.

Table 4. Contextual elements for eco-driving program design

Factors to consider	Examples
Fleet operations	• Distance traveled: short- vs. long-haul. • Type of cargo: liquids, bulk, dry, refrigerated, hazardous, containerized. • Routes: urban, suburban, mixed. • Terrain: paved, unpaved, flat, hilly, number of lanes in the road. • Weather conditions: rain, snow, wind, temperature. • Fuels: fuel quality and availability along the route, fuel prices. • Logistics profile: hub-and-spoke, point-to-point.
Fleet characterization	• Type of truck: rigid, articulated, container chassis, flatbed, specialty, light commercial, refuse, recycling, tank. • Fuels or drivetrain: diesel, gasoline, CNG, LNG, LPG, battery electric, fuel cell. • Type and size of trucking fleets: owner-operators, shippers, third-party logistics companies. • Truck technologies and age: telematics, electronic logging devices (ELDs), aerodynamic components, on-board diagnostic systems (OBD).
Regulatory environment	• Driver's license requirements. • Road regulations: speed and weight limits. • Vehicle restrictions: size, hours of operation, traffic restrictions to specific areas at specific times (e.g., low-emission zones, air quality regulations). • Vehicle regulations: inspection and maintenance programs, anti-idling, truck loads and size.

ROBUST CURRICULUM ON DRIVING TECHNIQUES

Large companies usually have fleet managers who carry out fuel management strategies and assess the environmental impact of truck operations. This is not the case for owner-operators, who consequently require more training and information on these subjects. Therefore, the training curriculum should cater to needs of audiences that have different levels of knowledge, requirements, and capacities, while providing the basic elements of eco-driving techniques for all. This structure also allows for more flexibility for drivers and fleet owners to accomplish training modules one by one.

Periodic training is another important element as it ensures that drivers are constantly reaffirming and updating their skills. It is recommended that fleet managers and other staff understand the concepts of eco-driving and the impacts of the truck driver and vehicle technology on the performance of the vehicle. Keeping the curriculum and content up to date to reflect the latest truck technologies (e.g. electric trucks) and best practices is essential.

SmartDriver is an eco-driving learning platform developed and maintained by NRCan in consultation with the trucking industry. There are several courses targeting different truck and bus operations: highway trucking, forestry, transit, school buses, and driving in the city. The highway trucking course is the only one fully implemented in an e-learning environment, open to anyone and free of charge. It offers three training versions for truck driving fundamentals, fleet drivers, and owner-operators. It is available in English and French. There are efforts to develop a Spanish and Chilean Spanish version for the *Giro Limpio* program in Chile.

The Smart Freight Centre (SFC), a global non-profit organization based in the Netherlands is also an important stakeholder and implements a Smart Transport Manager Training program that has five main modules: fuel management, drivers and staff skills, vehicles and maintenance, performance monitoring, and information technology. These types of programs not only provide training to managers but also serve as an enabling context to adopt eco-driving programs. The center has trained more than 200 managers and offers in-person and online training in English and Spanish. The most recent training took place in Argentina in collaboration with the Ministry of Transport at the end of 2020 and it was 100% online. SFC has delivered similar trainings in Brazil and Uruguay in recent years.

The key concepts of a robust eco-driving curriculum can be divided into three main groups: fuel efficiency fundamentals, driving techniques, and vehicle inspection and maintenance.

Fuel efficiency fundamentals

Teaching fuel efficiency fundamentals means providing an overview of the importance of reducing fuel consumption and the basic ways of achieving it. This includes information about how energy is transformed, used, and lost during truck operation, exhaust emissions and their environmental and health impacts, fuel and vehicle technologies, load characteristics, typical truck operation and cost breakdown, eco-driving benefits, and how the driver can influence the fuel consumption of a truck. Some concepts introduced here are rolling resistance, aerodynamic drag, and how terrain characteristics, road grade, weather, and vehicle speed affect fuel consumption. The driver should also gain a high-level understanding of both local and global emissions from the transportation sector.

Driving techniques

Good eco-driving curriculums agree on a set of driving techniques that are beneficial for reducing the fuel consumption of commercial vehicles. These are related to things like engine start, idling, acceleration, cruising, braking, and refueling. Table 5 describes some key eco-driving techniques.

Table 5. Common eco-driving techniques

	Vehicle starting does not require warming up the engine for an excessive amount of time or using the gas pedal. Doing either of these only increases the fuel consumption by injecting more fuel to the engine without the vehicle performing any work.
	Anti-idling may be required by law[2] in some regions because idling not only wastes fuel but also has impacts on local air quality. Some truck components may require independent power auxiliaries to run certain systems that provide cabin comfort, such as air conditioning, or to keep an adequate environment for the cargo, such as refrigerated goods.
	Drivers should operate the vehicle in the **engine's optimal range**. Each engine has a "sweet spot" where it is most efficient as a result of the relationship between torque and engine speed.
	Using **constant speed or cruise control** whenever possible—especially for long distances—saves fuel by eliminating abrupt accelerations that increase consumption or unnecessary decelerations that waste extra energy. Aggressive driving should be avoided not just as a fuel-efficiency measure but also to improve road safety.
	Trip planning is recommended to select the most fuel efficient route and anticipate road conditions like traffic, street design, parking, truck stops, etc.
	Weather conditions and hazards. Extreme temperatures can affect combustion; winds can affect truck speed and stability; rain and snow will impact road safety; and all of them will alter the performance of the vehicle. These should be accounted for through the use of adequate tires, load securement and height, preventive maintenance, and more.
	Braking. Avoiding speeding, maintaining proper following distance, cruising, and exhaust braking are all a better use of the truck's momentum and reduce the wear on tires.
	Load securement. Distributing the load and weight in the cargo area of a truck provides greater truck stability, reduces air drag, and improves overall safety.

Vehicle inspection and maintenance

Proper maintenance and inspection of vehicles goes hand in hand with good driving practices to save fuel. This is applicable to drivers and fleet managers alike. For drivers, this means following user manual instructions, reading maintenance monitors onboard vehicles, ensuring proper tire inflation and wear, and communicating issues and problems to servicing staff in time, just to name a few. Drivers should also perform vehicle inspections before, during, and after trips, document any irregular situations, and assess the risks associated with continuing trips after an incident.

PARTNERSHIPS WITH KEY STAKEHOLDERS AND PILOT TESTING

The success of eco-driving programs depends on effective partnerships with public and private institutions. Apart from drivers, fleet managers, carrier associations, and

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2   A compendium of idling regulations in the U.S. by ATRI can be accesed here; https://truckingresearch. org/2020/03/16/idling-regulations-compendium/

those in the trucking industry who directly participate in eco-driving training, other stakeholders include vehicle manufacturers, maintenance and service providers, training providers, telematics and accessories providers, and government agencies.

One of the most important activities when partnering with stakeholders is to conduct a pilot program. The experts we interviewed emphasized this element, which was part of most of the eco-driving programs and initiatives analyzed. After understanding the local context of the freight sector, it is always a good idea to test the program on a smaller scale to make sure it is representative. Discuss the pilot program design with stakeholders and carry it out to validate, adjust, and expand the eco-driving program design. Partner with other stakeholders to share resources, reduce costs, learn from particular expertise, consolidate support, and then ultimately arrive at a final design. Once implemented, evaluate the program regularly and adjust accordingly.

The role of partnerships is especially pertinent in developing markets where regulators might not have the necessary human resources or technical capacity to design, implement, and evaluate eco-driving programs. Clean Air Asia finished pilot testing an eco-driving campaign in Jakarta, Indonesia, that began in 2016. The pilot campaign received support from key public institutions and private sector groups: the University of Indonesia; the Committee on Phase Out Lead (KPBB), an Indonesian environmental nonprofit group; and vehicle manufacturer Toyota. Equally important was buy-in and endorsement from government agencies and regulators at multiple levels, including the National Traffic Police Corps, the Ministry of Environment and Forestry, the Ministry of Transportation, the Ministry of Education, the National Development Planning Board, and the Transportation Agency of the Special Capital Region of Jakarta.

Private and public partnerships have also laid the foundation for eco-driving programs in Peru. Since 2018, the MTC has worked with GIZ and Volvo to develop the training curriculum and materials. The MTC has also worked through workshops with the Ministry of Environment to understand the trucking sector's business models and identify opportunities for support. Additionally, in Mexico, several eco-driving initiatives and pilot programs have been developed and coexist as a joint effort between the private and public sectors.

These partnerships grow out of the first element of the eco-driving gold standard, the contextual assessment of the sector and identification of relevant stakeholders. This has to be accompanied by an outreach and communications strategy to engage with key stakeholders in the design stage.

FLEXIBLE DELIVERY METHODS

One of the most common barriers facing drivers is the difficulty of attending eco-driving training due to schedule conflicts. The Canadian Trucking Human Resources Council reported that the most common barriers for licensed truck drivers are lack of time outside of working hours, lack of funding, no financial support from the employer, training programs not offered in the region, and concerns about the quality of training. In response, NRCan developed its SmartDriver course for highway trucking. It is fully online and available in English and French, with Spanish coming soon. The course has all the functionalities of an e-learning platform, giving drivers more flexibility to complete the course at their own pace and allowing them to navigate across lessons to review the content. It also has a library section with supporting materials, presentations, and other resources. It is structured in three versions according to the level of detail required based on the audience: (1) fundamentals, which can be

completed in 30 minutes to an hour and is recommended for all audiences, (2) fleet drivers (1–2 hours), and (3) owner-operators (1–2 hours). The owner-operator course is the most complete version. All versions include evaluations that monitor the trainee's progress. At the end of each complete version there is a final evaluation; if a driver answers at least 80% of the questions correctly, the driver will receive a certificate for successfully completing the training.

Flexibility in delivery methods is fundamental for improving the scope and success of eco-driving programs. Multiple and customized delivery methods also support different learning styles and suit different audiences. Successful training curriculums offer flexibility on the environment or setting where the training is offered, whether in classrooms, on roads, online (live, recorded, or interactive), or in driving simulators. They also provide flexibility on design of modules, course duration, training evaluation metrics, and types of course materials.

Common training delivery methods and their benefits and challenges are summarized in Table 6. Eco-driving programs sometimes adopt a mixture of methods and formats of delivery to reach the widest audience. We were not able to find specific comparative analyses that assess the differences in delivery methods and their effectiveness, but we can conclude from the pilot programs, best practices, and experiences in Latin America that there is a need for various delivery methods to accommodate truck drivers' differing availability and levels of expertise. The Peru pilot program evaluated the results of two groups of drivers, one trained on simulators and the other on the road. The results are not perfectly comparable because of differences in the design of the two training courses and the availability of participants for completing the training. But the report concludes that a combination of methods is highly recommended. Simulators are a great learning resource, especially for new drivers, and practical training is much needed to validate and correct the driving skills of drivers under real conditions.

Table 6. Eco-driving training delivery methods

Setting	Benefits	Barriers
Classroom	Face-to-face training allows for better interaction and feedback between the instructor and the driver. Drivers can benefit from each other's experience and questions.	Requires drivers to take time off to attend the training, which implies financial costs.
On-road training	Drivers benefit from coaching while driving in real conditions; this improves and enhances the learned driving techniques. On-road training is always desirable to improve the results of the eco-driving program. In most countries, on-road training is required to obtain a truck driver's license, and eco-driving techniques could leverage that. The newest OBD technologies provide the driver with real-time information about fuel and other truck performance, which enhances the training.	May require drivers to take time off. Not all drivers own a truck, though the company or training school could provide trucks. If the driver uses his/her own truck, operational costs like fuel and wear are absorbed by the driver.
Online	Formats include pre-recorded, livestreamed, and interactive sessions. Online resources allow drivers to accommodate the training to their schedules and advance at their own pace. Drivers can review the content multiple times.	Requires drivers to be in a conducive setting to avoid distractions. Also requires a computer or device with an internet connection.
Driving simulator	Reduces the risks of on-road training. Simulator software and hardware could be adapted to different driving environments and provide the driver with real-time performance indicators.	Not all companies or schools own or can afford a simulator. Simulators should be as close to real driving conditions as possible, from the software to the dashboard and prompts. On-road training and testing are still highly recommended.

Offering flexibility does not necessarily mean compromising on the quality of training. Having flexibility in curriculum design and delivery style can reduce the resource and capacity burden on developing new eco-driving programs so that there is a starting point for future improvements to build on. For example, when driving simulators are not available, pre-recorded videos and instruction manuals are viable training options. For drivers, the ability to choose training schedules and evaluation metrics that best suit their needs creates positive reinforcement and encourages the adoption of eco-driving techniques. For example, FADEEAC in Argentina collects the truck data of *Rango Verde* with telematics to evaluate the performance of drivers and correct driving techniques with personalized training in simulators.

MONITORING, EVALUATION, AND FEEDBACK SYSTEMS

No matter the format and style of training, pre-training and post-training monitoring, evaluation, and feedback systems need to be in place to validate the positive results of eco-driving programs and improve performance. An evaluation framework is crucial for a gold standard eco-driving program. It involves several stages, from data collection and methods to setting a baseline and goals, selecting key performance indicators, benchmarking, and structuring feedback systems to inform the driver and apply corrective measures to improve performance.

Data collection methods

The collection of vehicle performance and fuel consumption data will depend on the technologies available. In North America and Europe, information technologies like telematics systems and electronic logging devices (ELDs) integrated onto modern trucks enable remote and real-time collection of operating data. Telematics systems and ELDs are connected to vehicles' OBD systems and continuously obtain data on the

vehicle's performance, including engine, emissions aftertreatment, transmission and driveline, and other systems on the chassis and body (Sharpe, 2019). Data stored on ELDs can then be transferred via a USB disk while telematics systems communicate the data wirelessly via cellular network.

Use of telematics systems, the best practice in data collection for truck operations, is growing rapidly in different markets, including Latin America. For fleet managers and eco-driving program administrators, telematics systems allow real-time monitoring of drivers' performance. Telematics systems dramatically improve data quality, eliminate human logging errors, and reduce the burden of data collection. Payloads, weights, and capacity utilization by volume and weight still need to be registered by drivers and operators. Another benefit of telematics is that the systems allow for a more robust assessment of the impact of eco-driving training over time.

The mandatory use of these technologies in markets like Europe and North America has supported the implementation of more advanced evaluation methods and frameworks for eco-driving programs. The use of information technologies will become even more prevalent with the introduction of regulations that mandate the use of ELDs in the United States as of 2020 and Canada by 2022. For more information on how advanced data collection and reporting methods work and how they are being integrated into green freight programs like SmartWay, see Sharpe (2019).

Key performance indicators (KPIs)
With monitoring and reporting mechanisms in place, a baseline should be set to measure the effects of eco-driving programs. A few things should be held constant or accounted for: the driver, type of truck, type of payloads, and route. Some common KPIs are engine idling time, speeding, instances of abrupt braking and acceleration, and fuel consumption. When possible, focusing on specific actions of the driver rather than what is happening to the vehicle—such as driver application of acceleration pedal versus vehicle speed—will better reveal changes in driving practices and behaviors that drivers need to make (Kurani, Sanguinetti, & Park, 2015). Many telematics companies offer monitoring of these and other KPIs.

Benchmarking is another common practice to compare results among different drivers accounting for differences in years of experience, route conditions, and truck characteristics. This will help to identify who the top performing drivers are, analyze their driving practices, and identify any other element of improvement that can be shared with other operators. This will also help improve the performance of fleet operators— even more so if there is an incentive or recognition program for top performers.

Feedback systems
Feedback systems communicate key performance indicators to the driver and help reinforce the desired behavior. Kurani, Sanguinetti, and Park (2015) provide a comprehensive analysis of best practices for feedback systems. We use some of their recommendations here. Indicators that combine multiple behaviors can inform about average performance, but they will not convey specific information about what actions have to be modified. On the other hand, when feedback is specific about a certain behavior and occurs immediately, it has greater impact. Fuel economy is a common indicator, but without a point of reference or range to compare it with, it provides limited information to the driver. Visual indicators work better and take the form of colored lights or images rather than numbers or other things that divert the driver's

attention and reduce overall safety. Other successful mechanisms include sensorial or haptic forms of communication such as alarms or vibrations.

The use of telematics enables the implementation of feedback systems that are calibrated to specific driving rules or operating thresholds. For example, a company might limit the maximum speed of a truck. If the vehicle surpassed such a threshold, a sound could alert the driver. But special attention needs to be paid to devising these alerts so that the driver becomes familiar with them and will not be distracted.

MAINTENANCE BEST PRACTICES

General preventive and regularly scheduled maintenance, along with vehicle inspection before, during, and after each trip, will result in the best performance of the vehicle and will reduce safety risks. Here are several tips from the *SmartDriver* program that are conducive to reducing fuel consumption:

» Regularly inspect truck components to determine whether they need to be replaced and how much lifetime they have left under current driving conditions. Make sure these components are operating adequately and follow up on any dashboard maintenance warning lights.

» Refer to the vehicle's manual to ensure that it is being operated under the conditions the manufacturer recommends and that fluids meet the advised levels.

» Pre-trip, on-route, and post-trip inspections should become routine. These are more important when different road conditions are expected. Drivers should plan accordingly. Important things to check include brakes, cargo security, fluid levels, and engine cooling system.

» Maintaining the tires on trucks and trailers is important for both fuel economy and safety. Adequate tire pressure will avoid increasing tire friction with the road surface, leading to heightened fuel consumption, regardless of whether a tire is old, new, or low-rolling resistance. It is also important to monitor tire wear. When replacing tires, use the kind recommended by the manufacturer and those that fit the expected driving conditions or terrain.

ENABLING POLICIES AND INCENTIVES

Based on interviews with drivers, fleet managers, training providers, program managers and regulators, and our literature review, we identified common barriers and challenges that hinder the effectiveness of eco-driving programs and prevent wider adoption. Some barriers go beyond eco-driving programs to the trucking industry in general:

» **Lack of awareness of eco-driving techniques**. Especially in countries that are proposing eco-driving measures for the first time, fleets, owner-operators, and companies may not be familiar with the concept or may not fully understand the benefits. If these are not addressed, training programs may not reach all intended audiences, and the industrywide fuel saving effect may be diminished.

» **Lack of monitoring and reporting capacity**. An inability to analyze or even record data undermines an important early step of any eco-driving program—understanding current operations and establishing baseline performance. Effective ways to track fuel consumption and truck performance are needed. Drivers sometimes use rudimentary manual entries that are tedious and error-prone, especially in smaller fleets or companies. Insufficient or unreliable data also makes it hard to identify opportunities for improvement and fuel-saving. Telematics systems can support this, but they may not be fully available or widespread in emerging economies.

» **Costs**. While the overall benefits of eco-driving far outweigh the costs, financial, human resources, and opportunity costs are considerable for individual fleets, owner-operators, and smaller regulatory agencies. Even when there is flexibility in the delivery methods, drivers need to invest time and sometimes money to participate in eco-driving training. This means forgone income in a highly competitive sector with razor-thin margins. That is why incentive programs can support those fleets and drivers in disadvantageous conditions.

» **Sustaining and tracking eco-driving benefits over time**. Many pilot tests and programs provide a one-time evaluation immediately after the eco-driving training, but information on the long-term results of interventions is often scarce. There are a few exceptions, including a few pilot programs run as experiments for journal articles, and those that belong to a broader green freight program. In other cases, training courses are offered as a one-off pilot program with little to no further training to reinforce the lessons and messages. Such reinforcement is key when designing eco-driving programs.

The adoption of enabling policies and incentives will help overcome the barriers. Below are common policy tools adopted in successful eco-driving programs worldwide.

INSTITUTIONALIZATION OF ECO-DRIVING TRAINING

To expand the scope and ensure implementation, eco-driving training and evaluation should be included as a part of the requirements to obtain a driver's license. This is already the case in Argentina, Peru, and Jakarta. The goal of Clean Air Asia's Jakarta eco-driving campaign is to incorporate eco-driving as a necessary step for acquiring a driver's license for all vehicles in Jakarta.

Argentina and Peru included eco-driving in their NDCs submitted to the United Nations Framework Convention on Climate Change after the 2015 Paris Agreement. A country or region publicly committing to adopt sustainable practices in the transportation sector is a first step. Eventually the high-level commitment to eco-driving should translate into concrete actions, such as a prerequisite for driver licensing. This should include regular mandatory training for license renewal to reinforce eco-driving knowledge and techniques.

Certifying training programs, schools, and trainers

To ensure that minimum requirements of eco-driving curriculum are met, it is recommended that programs' training curriculum, eligible schools, and trainers first be recognized and certified by relevant government authorities. In many countries, there is already a network of training schools that meet governmental requirements and are approved for providing regular driving courses. Eco-driving training can tap onto these networks and complement the existing training curriculum's contents and evaluations to also include eco-driving techniques.

Improve data collection

Telematics and other mobile applications support the monitoring and feedback of driver performance and represent the best practice in data collection. SmartWay fleets are integrating advanced data collection methods and technologies to report their KPIs. In the future, such state-of-the-art data collection will be the international standard. Even in places without a nationwide, centralized data reporting system, voluntary data collection mechanisms are a good first step. These can help build a fuel consumption database for fleets that have incorporated eco-driving techniques.

It is important to recognize that extra equipment and compliance are added expenses for operators. Even in a mature market like North America, trucking industry participants in the SmartWay green freight program are unmotivated to incur extra costs (Sharpe, 2019). In developing markets, data reporting and monitoring products and services may be too expensive or altogether unavailable currently, but telematics services are expected to expand globally.

Financial and nonmonetary incentives

Financial incentives like subsidies to reduce the cost of eco-driving training or publicly funded courses can benefit those who otherwise could not afford the time or money to attend training. In the case of fleets, companies could reward drivers with monetary or nonmonetary incentives for top performers based on the adopted KPIs. Other incentives for eco-driving training fall within green freight programs where shippers, fleets, and carriers benefit from improving the sustainability of their operations and thus increase the demand for professionally trained drivers. In some markets, insurance companies provide better rates to those drivers that have fewer traffic incidents or accidents, and thus highlighting the road safety benefits of eco-driving will open the opportunity for more incentives.

Governments can also recognize eco-driving training completion certificates as labor competencies, which would improve the job market prospects for drivers who participate in eco-driving training. In Mexico, Distintivo CANACAR, led by the main truck carrier association, is recognized by the Secretary of Labor (CANACAR, 2019). In Chile, AgenciaSE is proposing to add a recognition seal or label to the driver's license of those who undertake eco-driving training through Giro Limpio.

Greater gender inclusiveness

Although most truck drivers are male—fewer than 5% of drivers in the United States are women—there is an opportunity to recruit and train more women in the trucking industry (Bureau of Labor Statistics, 2019). Volvo's "Iron Woman" program in Peru specifically addresses women—representing represent 0.3% of truck drivers—who want to become drivers of vehicles of more than 12 tons (Volvo, 2017). Targeting a wider audience increases the pool of trained and available drivers and can contribute to alleviating shortages in some markets.

Raise awareness

Awareness of eco-driving and its benefits is lower when the techniques are not mandatory or required in the driver's license training or where green freight programs have not been established. Thus, it is important to develop a strategy for disseminating the benefits of the program and share success stories so that fleets may be willing to invest time and money in training. Eco-driving training should be seen as a tool that provides benefits in terms of fuel efficiency, emission reductions, and safety.

Green freight programs

In markets including the United States, Canada, and Mexico, green freight programs have enabled the implementation of eco-driving programs as a voluntary practice. One is SmartWay, and its components involve fuel efficiency and fleet management information and tools, monitoring, reporting and verification systems, benchmarking, and recognition programs (NRCan, 2020).

CONCLUSIONS

This paper draws from the experience of established and emerging eco-driving programs to propose a gold standard for implementing and strengthening them. We paid particular attention to Latin America as there is a growing interest in the region in implementing energy efficiency measures in the freight sector. But eco-driving programs offer more than that. They support the efforts for professionalization of the trucking sector and its drivers and deliver fuel savings, emission reductions, and improved road safety. Given this, they should become a common practice, especially in a highly competitive sector such as trucking. Current and future trends like online shopping and challenges in decarbonizing freight transport highlight the importance of adopting eco-driving programs.

Collaboration among stakeholders and establishing long-lasting partnerships is fundamental in the implementation of best freight practices. Green freight programs help establish such an environment as companies can share best practices without compromising sensitive data and create a demand for green services and sustainable practices. Shippers play a key role in the adoption and implementation of such practices because they can set some of the rules and requirements for other stakeholders in the supply chain. Future research can look at the long-term effect of eco-driving training and the effectiveness of various delivery methods and incentives. As new vehicle technologies become available, eco-driving training for electric trucks needs to be incorporated.

ADDITIONAL RESOURCES

Here are some relevant eco-driving resources used in this paper:

» NRCan's SmartDriver for highway trucking (e-learning platform)

» Brasil SEST SENAT courses, app.

» Peru materials on eco-driving

  » Manual for instructors

  » Manual for truck and bus drivers

» Argentina

  » Guidelines for energy efficiency management in the freight trucking sector

» Chile

  » Guideline for efficient driving: freight vehicles

» Smart Freight Centre

  » Smart Transport Manager Training

LIST OF EXPERTS INTERVIEWED

Name	Institution	Country
Buddy Polovick	EPA SmartWay	United States
Bonne Goedhart	Smart Freight Center	Netherlands
Louis Brzozowski **Andreij Pozdniakov** **Mathieu Larivière** **Luke Bond**	Natural Resources Canada	Canada
Fernando Lía **María Inés Hidalgo**	Secretary of Energy	Argentina
Julio Velázquez **Alejandro Robson** **Guido Heras**	FADEEAC / FPT	Argentina
Miguel Martín	DriveUp	Argentina
Gustavo Rinaldi **Alejandra Pereyra** **Juan Manuel Escudero**	Ministry of Transport	Argentina
Javier García **Pascual Romo**	CONUEE	Mexico
Judith Trujillo	SEMARNAT	Mexico
Óscar Sánchez	CANACAR	Mexico
Luis Adrián Fernández	Consultor	Mexico
Helliot Levano	GIZ	Peru
Pablo Chirinos **Omar Rodríguez** **Yamira Pena** **Cristian Meza**	Volvo	Peru
Orlando Dávila **Jorge Espinoza**	Ministerio de Comunicaciones y Transportes	Peru
Julio Villalobos	Universidad Nacional Andrés Bello	Chile
Damiana Serafini	Consultora	Argentina
Erica Vieira	CNT	Brazil
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