grütter consulting

FINAL REPORT

TA-7987 (REG)

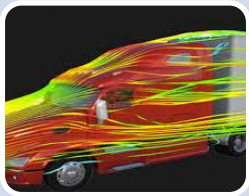
Core Environment Program and Biodiversity Conservation Corridors Initiative in the Greater Mekong Subregion, Phase 2 – Green Freight Project Implementation – Lao and Viet Nam

Report realized on behalf of ADB

Jürg M. Grütter, 01/09/2016

MODULES

The reports within the ADB Green Freight Project are divided into four modules being Green Freight Technologies (GFTs), Eco Drive, Logistics Measures and Monitoring of implemented options. Within each module reports include an upfront technology assessment, a report on the pilot phase as well as a report on the full implementation level. The FINAL REPORT corresponds to the Impact Monitoring report D2.



MODULE A

GREEN FREIGHT TECHNOLOGIES

Report 1: Potential of GFTs

Report 2: Pilot Implementation GFTs

Report 3: Financing Mechanism GFTs

Report 4: Full Implementation GFTs

MODULE B

ECO DRIVE

Report 1: Potential of Eco Drive

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Report 3: Curriculum Eco Drive

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MODULE C

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MODULE D

IMPACT MONITORING

Report 1: Monitoring Scheme GF Measures

Report 2: Impact Monitoring Report / FINAL REPORT

Abbreviations

AC	Air Conditioning
ADB	Asian Development Bank
ASIF	Avoid, Shift, Improve, Fuels
BAU	Business as Usual
BC	Black Carbon
CAI	Clean Air Asia
CAPEX	Capital Expenditures
CCAC	Climate and Clean Air Coalition
CDM	Clean Development Mechanism
COR	Coefficient of Resistance
CSS	cascade Sierra Solutions
CTF	Climate Technology Fund
DPF	Diesel Particle Filtre
EF	Emission Factor
EPA	Environmental Protection Agency
ESCO	Energy Service Company
IRR	Financial Internal Rate of Return
GCF	Green Climate Fund
GDP	Gross Domestic Product
GEF	Global Environment Facility
GF	Green Freight
GFA	Green Freight Asia
GFP	Green Freight Project
GFT	Green Freight Technology
GHG	Greenhouse Gas
GMS	Greater Mekong Subregion
GPO	Group Purchasing Organization
GPS	Global Positioning System
GVW	Gross Vehicle Weight
HDV	Heavy Duty Vehicle
HP	Horse Power
IEA	International Energy Agency
INDC	Intended Nationally Determined Contribution
IPCC	Intergovernmental Panel on Climate Change
LIFFA	Laos International Freight Forwarder Association
LRR	Low Rolling Resistance
MOT	Ministry of Transport
NAMA	Nationally Appropriate Mitigation Action
NCV	Net Calorific Value
OPEX	Operating Expenditures
PM	Particle Matter
QA	Quality Assurance
RRC	Rolling resistance Coefficient
SFC	Specific Fuel Consumption
SME	Small and Medium Sized Enterprise
TKM	ton-kilometre
TTW	Tank-to-Wheel
UNEP	United Nations Environment Program
UNFCCC	United Nations Framework Convention on Climate Change

VCS	Verified Carbon Standard
WACC	Weighted Average Capital Cost
WBCSD	World Business Council on Sustainable Development
WRI	World Resources Institute
WTW	Well-to-Wheel

Contents

Summary

1. The **Green Freight Program** was implemented by ADB in Viet Nam, Lao PDR and Thailand from 01/2015 to 08/2016. Implementation in Viet Nam and Lao PDR to which this report relates was realized by Grütter Consulting.

2. The overall **objective** of the program is to foster low carbon sustainable freight transport.

3. **GF instruments** implemented are Green Freight Technologies, Eco Drive and Logistics solutions.

Table 1: Summary of GF Implementation Actions

Activity	Viet Nam	Lao PDR
Aerodynamic equipment	11 trucks	11 trucks
Efficient Tires	15 trucks	12 trucks and 3 buses
Fuel Audit Tool	20 companies	20 companies
Eco Drive training instructors	15 instructors	15 instructors
Eco Drive training drivers	100 drivers	100 drivers
Workshops	2 workshops with 90 participants	2 workshops with 72 participants
Brochures	3 brochures	3 brochures
Reports	12 technical reports	

4. **Implementation results**:

- Efficient tires reduce fuel consumption by 4-6%;
- Aerodynamic devices reduce fuel consumption by 2-3%;
- 1 bar higher tire inflation reduces fuel consumption by 2%;
- Eco Drive reduces fuel consumption by 3-6% (lower impact over time);
- Combined measures reduce fuel consumption and GHG emissions by 10-13% representing per truck per annum 7-9 tCO_2 for Lao PDR and 11-15 tCO_2 for Viet Nam.

5. The **economics** are:

- Efficient tires require an incremental investment of 900 USD per truck with a payback time of 12-13 months;
- Aerodynamic devices require an investment of 900-1,000 USD per truck with a payback time of 2-3 years;
- Eco Drive requires an investment of around 150 USD and has a payback time of 3-6 months;
- Combined the measures require an additional investment of 2,000 USD, with a payback time of 1 year and a FIRR of >90%.

Measures are profitable but encounter barriers like lack of reliability and visibility of savings, additional investment, and drivers being paid a fixed amount for fuel and therefore lack of interest of the truck owner to invest in energy saving devices.

6. The proposed **steps forward** are:

- Include Eco Drive in the compulsory curricula for driver training.
- Establish national regulations concerning Coefficient of Resistance of tires, such as e.g. in the EU.

- For other GFTs such as aerodynamic devices, low-carbon trucks and fuels as well as other measures implement a GF climate finance fund coupled with technical assistance and dissemination of best practices.
- Other measures which could be explored include the usage of larger trucks, improving traffic fluidity and the establishment of fuel consumption standards for new trucks.

7. Main **project implementation experiences** include:

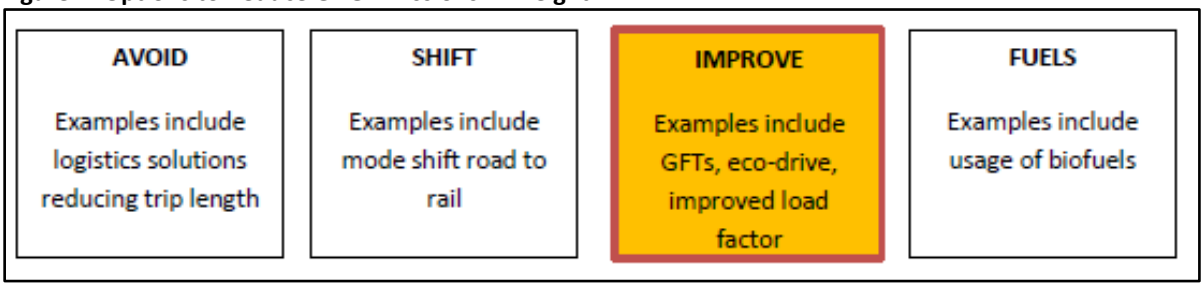
- Local driving circumstances are very important and experiences from other countries are only partially valid.
- Low technology availability can result in significant additional GFT costs.
- The majority model used for “fuel management” by trucking companies in both countries is to pay drivers a fixed allowance for fuel based on the trip realized. Therefore, companies are not very interested in fuel saving technologies.
- The program has produced impact data of value also for other GF interventions.
- The monitoring approach based on comparison before-after has proven to be the most reliable approach.

1. Introduction

The Green Freight Program is implemented by ADB in Viet Nam, Lao PDR and Thailand with start January 2015 and termination August 2016. The project management and implementation in Viet Nam and Lao PDR was realized by Grütter Consulting. The following report therefore only relates to the activities and results of Viet Nam and Lao PDR.

The objective of the Green Freight (GF) component of the ADB project is to reduce Greenhouse Gas (GHG) freight emissions. Therefore, the impact monitoring of measures follows this objective and provides information on GHG reduction of measures implemented. The project focus is on measures to reduce truck emissions i.e. with the framework of ASIF (Avoid, Shift, Improve and Fuels) the focus is on "Improve".

Figure 1: Options to Reduce GHG Emissions in Freight



Source: Grütter Consulting

The structure of this report includes the following parts:

- Chapter 2: Program objectives, activities, institutions involved and outputs
- Chapter 3: Green Freight Instruments;
- Chapter 4: Monitoring approach;
- Chapter 5: Implementation results;
- Chapter 6: Environmental, financial and economic impact;
- Chapter 7: Steps forward;
- Chapter 8: Implementation experience.

2. Program Brief

2.1. Background

The Green Freight Program (GFP) is part of Core Environment Program and Biodiversity Conservation Corridors Initiative administered by ADB and overseen by the environment ministries of the six countries which form the Working Group on Environment. The program aims to achieve an environmentally friendly and climate resilient Greater Mekong Subregion (GMS). Economic corridors are being developed across the GMS to improve transport connectivity, facilitate trade and economic development and boost regional cooperation. With initial road transport corridors almost complete, there is an increasing realization that the competitiveness of these corridors needs to be improved by increasing resource use efficiency and by reducing their impact on ecosystems and the environment. Increased traffic and development along these corridors is likely to result in increased greenhouse gas emissions and environmental changes. These need to be carefully managed to ensure environmental sustainability.

Fuel costs are one of the main factors defining high logistics costs in Viet Nam, Lao PDR and Thailand. The regional Green Freight Initiative consists of three national pilot projects in Lao PDR, Thailand and Viet Nam testing green freight / low carbon interventions for freight operators as a way of reducing fuel consumption and fuel costs.

The activities in Thailand are implemented by the Federation of Thai Industries whilst Grütter Consulting has been entrusted by ADB for the project implementation in Viet Nam and Lao PDR.

2.2. Objectives

The **overall objective** of the program is to reduce the carbon footprint of freight transport across the GMS Economic Corridors. Low carbon sustainable freight transport shall be fostered in Lao PDR and Viet Nam.

The **objective of the assignment** or the GFP is to test a decentralized model to deploy green freight interventions among SMEs engaged in road freight in Lao PDR and Viet Nam. Based on results of pilot interventions recommendations are provided how these could be scaled up.

Beyond the objective or target of the project itself this assignment shall also result in some common goods which allow green freight projects also in other countries and regions to prosper.

2.3. Tasks

The following table contrasts planned and realized outputs of the program.

Table 2: Planned and Realized Outputs of GFP

Component	Planned Output[1]	Realized Output
1. Green Freight Technologies (GFT)	1.1. Report on GFTs with country list of potential GFTs	Report A1: Potential of GFTs
	1.2. Guidelines for monitoring GFT impact	Report D1: Monitoring Scheme GF Measures
	1.3. Report on GFTs incl. results of 3 pilot GFTs	Report A2: Pilot Implementation GFTs
	1.4. Report on Financing plan for GFTs	Report A3: Financing Mechanism GFTs
	1.5. Workshop report on green financing	Workshop report on GFTs and Finance
	1.6. Technical material on GFTs produced	Brochure GFTs
	1.7. Fuel conservation plan in 10 companies and GFTs implemented in 20 companies	Fuel conservation plan in 20 companies per country; GFTs implemented in 26 trucks/companies per country
	1.8. Report on impact of GFTs	Report A4: Full Implementation GFTs
2. Driver Training Eco Drive	2.1. Report on Eco Drive experience	Report B1: Potential of Eco Drive
	2.2. Guidelines for monitoring Eco Drive impact	Report D1: Monitoring Scheme GF Measures
	2.3. Pilot test Eco Drive in 3 companies	Report B2: Pilot Implementation Eco Drive
	2.4. Draft standard driver training program with training material for drivers and for trainers	Report B3: Curriculum Eco Drive
	2.5. Report on Driver Training seminars: Train 100 drivers and 10 trainers	Report B4: Full Implementation Eco Drive 15 instructors trained per country 100 drivers trained per country
	2.6. Report on potential integration of Eco Drive in national driving and licensing regulations	
	2.7. Guidelines for QA Eco Drive program	
	2.8. Report on impact of Eco Drive and dissemination strategy	
3. Logistics management incl. reduction of empty backhaul	3.1. Report on empty backhaul incl. identification of potential solutions	Report C1: Potential of Logistics Measures
	3.2. Guidelines for monitoring the impact of logistics management solutions	Report D1: Monitoring Scheme GF Measures
	3.3. Report on solutions to reduce empty backhaul incl. pilot test in 3 company's logistics solutions	Report C2: Pilot Implementation Logistics Measures
	3.4. Report on impact of logistics management solutions and dissemination strategy	

2.4. Timeline

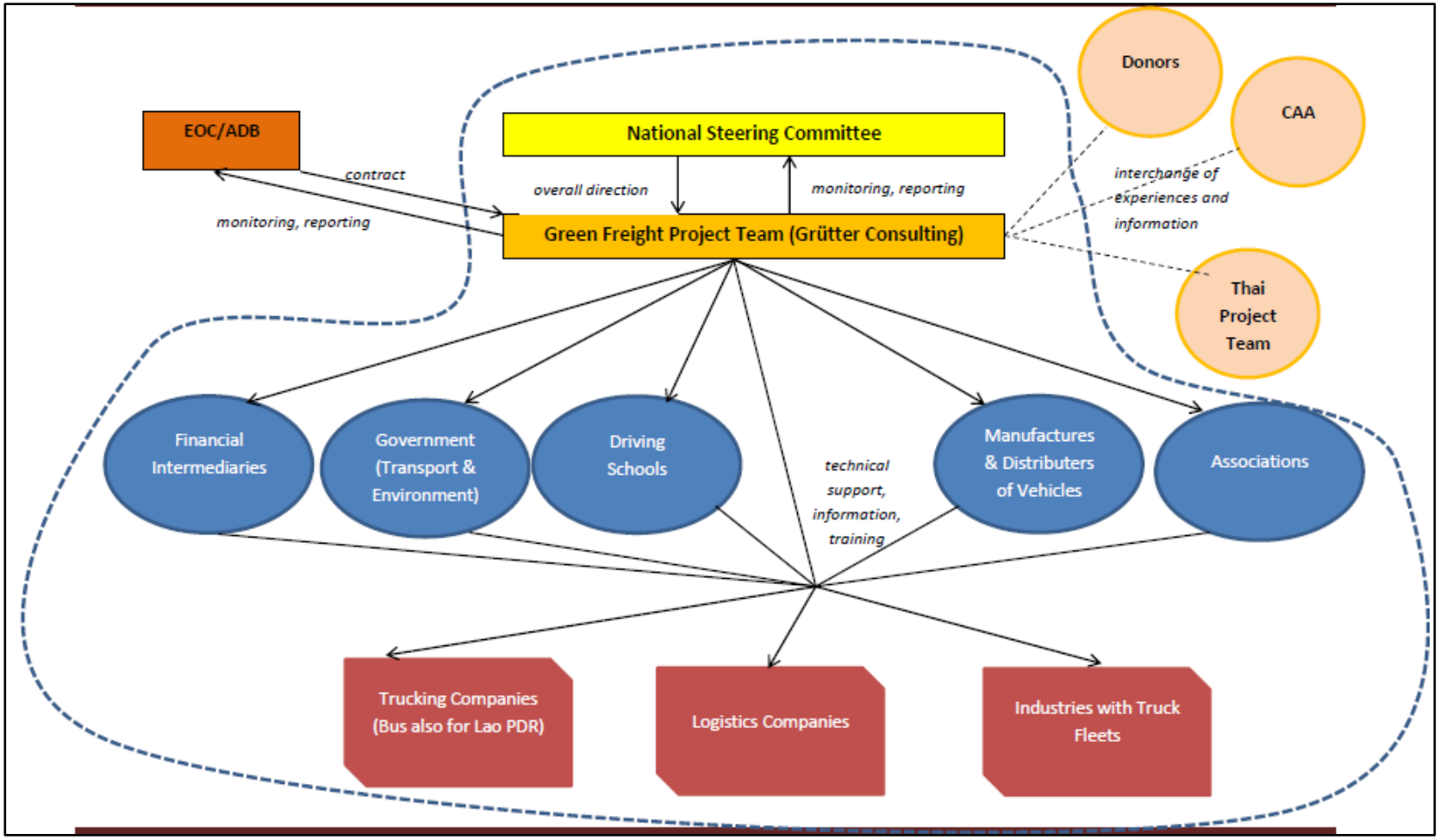
All activities should have been realized by July 2016. Implementations had been finished by 30.6.2016, however final reports were only produced until end of August 2016 due to awaiting monitoring results of technology implementations. Technology implementations had been behind schedule, especially in Lao PDR due to late disbursement of funds by ADB[2].

[1] Based on Inception Report Table 1

[2] Funding request was realized 12/2015 and funds where received by the consultant as of 05/2016

2.5. Organization

Figure 2: Institutional Set-Up



3. Green Freight Instruments

3.1. Introduction

The project focuses on road based freight transport. GHG reductions with mode shift, economic and fiscal instruments or industrial policies to change production and transport structures are therefore not part of this report. The focus is also on long-haul road transport which has some distinct features from short-haul transport e.g. technologies which can be used or logistics solutions.

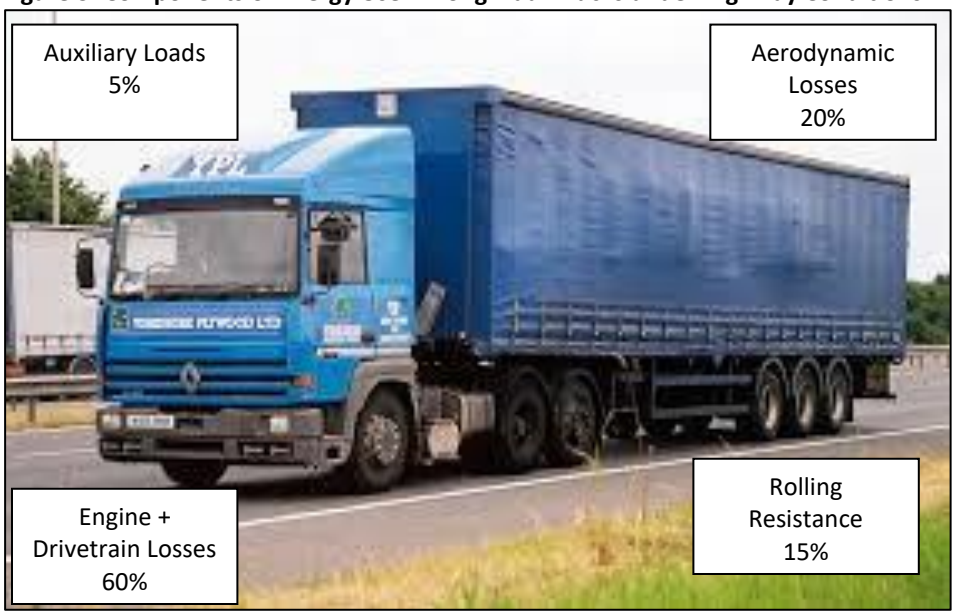
Green Freight (GF) instruments included in this report and applied by the project are Green Freight Technologies (GFTs), Eco Drive and Logistics solutions.

3.2. Green Freight Technologies

3.2.1. Introduction

Around 60% of the power produced by a truck is lost within the engine. The remaining 40% is used to move the vehicle down the road and to power auxiliary equipment like air-conditioning (AC). The figure below gives an indication of what this energy is used for based on a long-haul combination truck travelling on a flat road under highway conditions with an average speed of more than 80km/h.

Figure 3: Components of Energy Use in Long-Haul Trucks under Highway Conditions



Source: Grütter based on US DOE, 2006

The figure gives an indication of main energy loss areas which can be tackled with retrofit devices being:

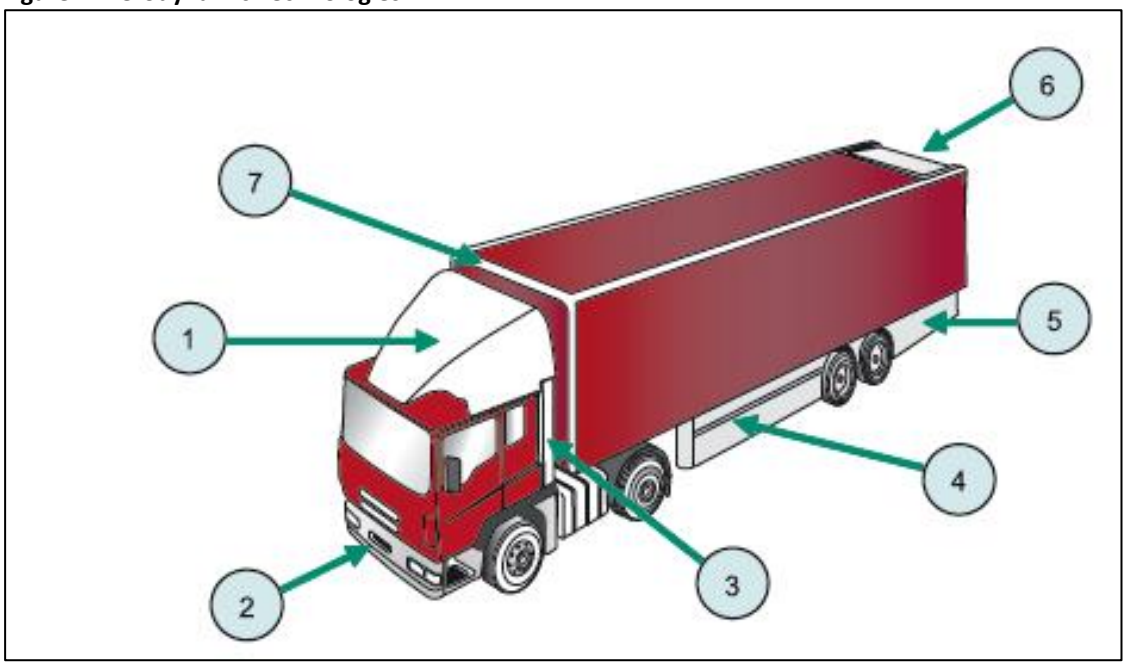
- Aerodynamics;
- Rolling resistance i.e. tires/wheels;
- Auxiliary loads;
- Engine losses.

Engine losses are basically tackled with engine design and therefore with new trucks and not with retrofit technologies.

3.2.2. Aerodynamics

Aerodynamic drag or wind resistance is a retarding force on a vehicle. Basically the power or amount of energy required to overcome the aerodynamic drag is affected by the effective frontal surface of the vehicle, the shape of the vehicle and the vehicle traveling speed. The power required to overcome aerodynamic drag increases as a function of the cube of vehicle speed thus making speed a critical parameter for determination of potential improvements due to reduction of aerodynamic drag. Main retrofit technologies available to reduce aerodynamic drag available for trucks and trailers are shown in the following figure.

Figure 4: Aerodynamic Technologies



Source: Department for Transport UK, Freight Best Practice Case Study, 2010

① Cab roof fairings or deflectors: These components change the shape of the cab roof and direct the air flow smoothly over the top of the truck cab;

② Air dam: This is a downward extension of the trucks front bumper;

③ Cab extension: Side fairings and side extenders modify the shape of the side of the cabs;

④⑤ Trailer side skirts including rear quarter panel;

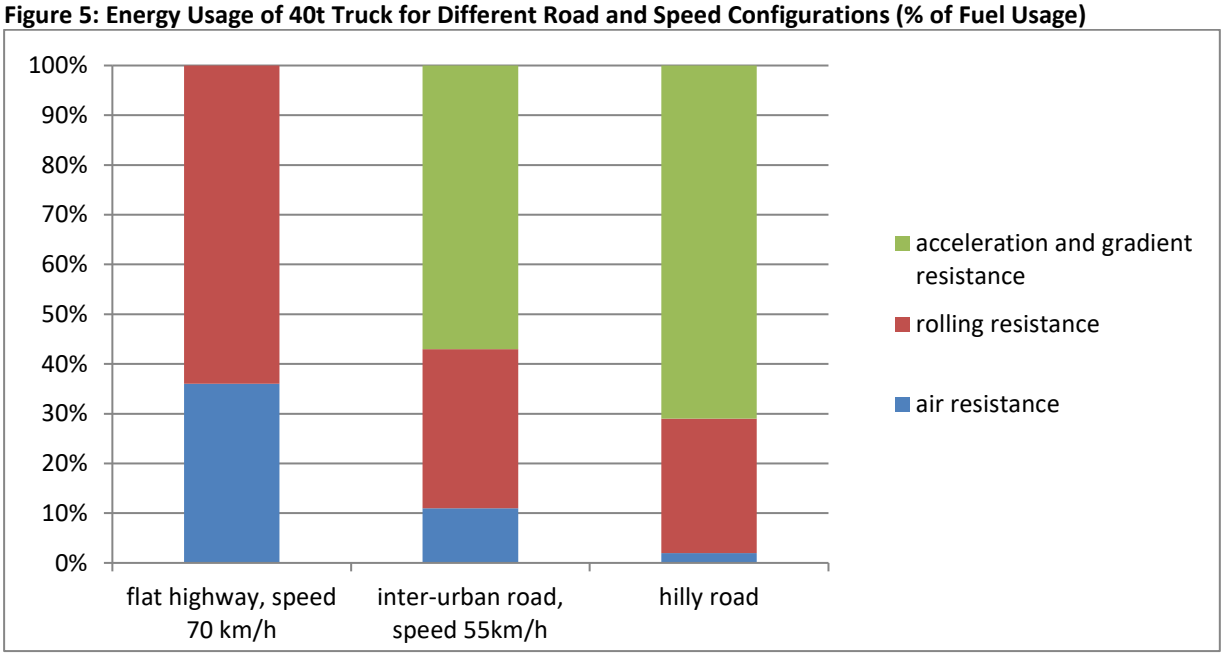
⑥ Roof tapering; this can include trailer boat tails;

⑦ Front fairings and nose cones for trailers;

The following figure shows the relation between the importance of aerodynamics relative to the trip profile and average speed clearly. The aerodynamic losses are basically important with flat roads and at speeds of 70 km/h and higher. With hilly roads at low speeds on the other hand aerodynamics

becomes irrelevant. At intermediate speeds of around 55 km/h the energy used for aerodynamic resistance is only around 10%.

Figure 5: Energy Usage of 40t Truck for Different Road and Speed Configurations (% of Fuel Usage)



Source: W. Appel, Nutzfahrzeugtechnik, 2013, Figure 2.2; see also comparable relations between speed and aerodynamic losses in National Research Council Canada, Technical Report Review of Aerodynamic Drag Reduction Devices for Heavy Trucks and Buses, 2012, Table 2

Following general conclusions concerning the potential application of aerodynamic devices are therefore drawn:

- Aerodynamic devices are useful for trucks operating under medium to high speed conditions with a minimum average speed of 55 km/h. Basic truck improvements including cab deflector and cab extensions are feasible at this speed.
- For trucks operating at a higher speed (average speed of 80 km/h and higher) a more integrated aerodynamic package can be made with truck and trailer improvements including side skirts, and trailer front fairings.

3.2.3. Tires

The rolling resistance is directly correlated with the Coefficient of Resistance (COR) of the tire and the vehicle mass. The rolling resistance related fuel efficiency per km is widely speed-independent. Tires for drive axles in general have a higher COR than steer and trailer tires due to higher grip requirements leading to a certain trade-off with reducing resistance.

Following main technologies exist to reduce rolling resistance:

- Low rolling resistance tires;
- Wide based tires;
- Optimum tire pressure.

Low rolling resistance (LRR) tires use different tire blends (e.g. adding silica to rubber materials) and modify the tire body. They have a COR or Rolling Resistance Coefficient (RRC) which is around 10% lower than a conventional tire. LRR tires are installed basically on the non-steering wheels of the tractor and trailer. Within the EU regulations exist which specify minimum requirements for COR. The current requirements are a maximum of 8.0 kg/t for tires sold after 1.11.2016 and maximum 6.5 kg/t for new type approvals of tires (for tires sold this value will be enforced from 1.11.2020 onwards). The EU also introduced a standardised tire label including energy efficiency based on the COR, wet grip and noise, effective as from the year 2012.

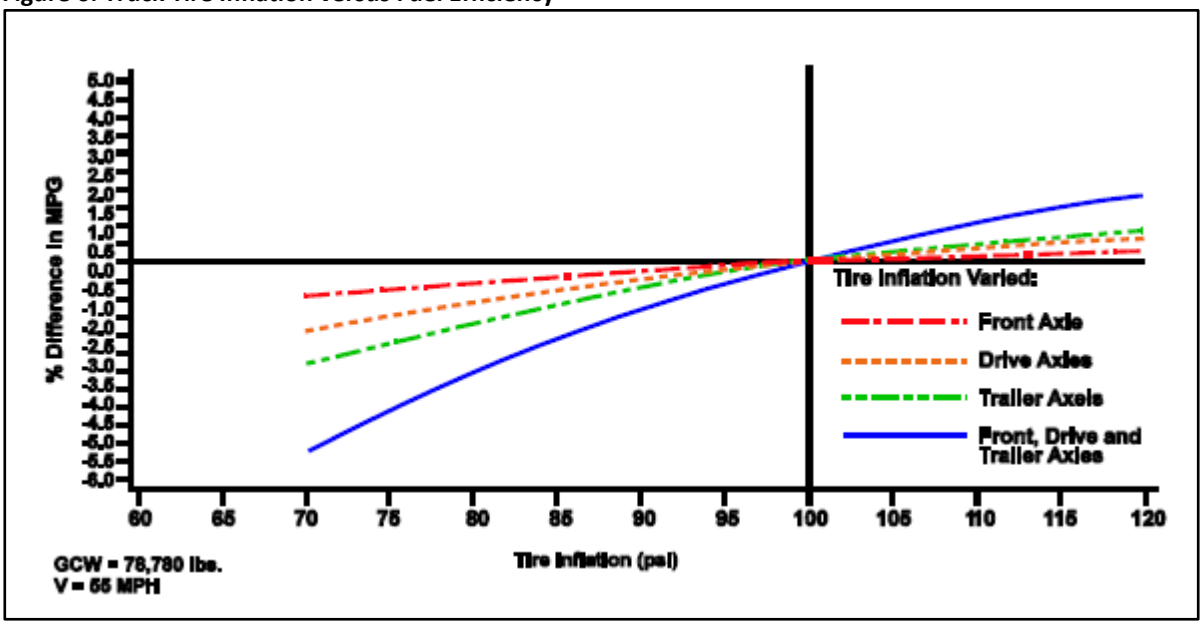
Single wide-based tires can be used on non-steering truck and trailer axles, albeit being more common on trailer axles. Wide-based tires have less sidewalls whose deformation is a large contributor to rolling resistance. Single wide based tires not only have less rolling resistance but also weight around 80 kg less per axle than dual tires i.e. this can result in a weight reduction of around ¼ t for a truck. A problem is that trucks cannot continue to drive if a wide-based tire blows out whilst they can continue driving a short distance with a dual tire. Also replacement of single wide-based tires during trips might cause 2 types of difficulties:

- The heavy weight and the size of wide-sized tires requires 2 persons for tire changing. Trucks driven by single persons could have difficulties in this context.
- Repair shops, especially in Developing Countries, will lack wide tires in their offer and might not even have the equipment to repair such. Thus as minimum 2 spare wide tires need to be taken along.

Additionally, single wide-based tires require an investment in new wheels and vehicle adaptation.

Tire pressure influences fuel usage. Every 10 psi of under-inflation represents approximately 1% penalty in fuel economy with the largest difference on trailer axles (see figure below)[3].

Figure 6: Truck Tire Inflation versus Fuel Efficiency



Source: Cummins MPG Guide based on Goodyear

[3] Cummins MPG Guide

3.2.4. Other Technologies

Idling reduction technologies are an important aspect especially in long-haul sleeper trucks with cabins equipped with multiple equipment as used e.g. in North America. Idling occurs when delivering goods but to a large extent is related to equipment used in cabs including heating, AC and electricity for a variety of applications such as TV, microwave, laptop etc. Options to reduce fuel usage include advanced truck stop electrification, auxiliary power units and automatic shut-down/start up systems. Long-haul trucks without sophisticated sleeper cabs including heating/AC and multiple electric devices will only profit marginally from anti-idling devices.

Synthetic base lubricants exhibit less thickening at low temperatures. Thickening oil increases fuel consumption. This makes synthetic oils more fuel efficient at lower ambient temperatures. The fuel efficiency gain is thereby in the order of 1% but less in long-haul operations which operate at constant high temperatures.

Predictive cruise control, on-board telematics and the usage of GPS can help to identify the shortest and most convenient routes thus reducing distance and avoiding congestion. Predictive cruise control also identifies upcoming gradients and informs the driver of optimum gear change and acceleration / braking. On-board telematics support drivers and enhance driver-follow-up.

3.2.5. Previous Experience with GFTs in Viet Nam and Lao PDR

Viet Nam

Lane separated highways are not common in Viet Nam resulting in multiple intersections and constantly changing speeds. However various highways are currently under construction, e.g. Hanoi to Haiphong. Maximum permitted speed for trucks is currently 60 km/h and driving conditions do not allow for significantly higher speeds. The low driving speeds result in limited effects of aerodynamic devices. A random visual counting survey conducted on the route Hanoi-Haiphong revealed that around 70% of all large trucks already had basic truck aerodynamic equipment installed (cab roof fairing plus cab extension). In medium sized trucks (3-4 axles with a GVW of 24-32 t) however only around 30% had such equipment installed. The widespread usage of aerodynamic truck devices is due to acquiring basically used US trucks and new Chinese trucks, both of which have such equipment already installed. Aerodynamic equipment on trailers including nose cones and side skirts are non-existent. Aerodynamic equipment can be bought in the Vietnamese market based on domestic production or importing original equipment from China or Thailand.

Low rolling resistance tires only have a marginal market share in Viet Nam and are only sold by very few tire dealers. The main market for LRR tires has been for long-distance buses whilst in trucks they are only used in singular cases and on some axles (truck but not trailer wheels). Wide-based tires are currently not allowed in Viet Nam. Automatic tire inflation systems or tire pressure indication systems are not used in Viet Nam and also no such equipment is currently available in the Vietnamese market.

Long-haul trucks are not equipped with many electronic devices like US trucks making idling reduction technologies of little sense.

Lao PDR

In Lao PDR road conditions on main arteries are in general paved roads which are however suffering severe deterioration. Curvy roads in mountainous conditions are common. The maximum allowed speed limit for trucks and buses is 90 km/h. Drive speeds however tend to be lower due to road conditions. Most long haul trucks are equipped with basic aerodynamic equipment (cab deflector). Trailer aerodynamic equipment is not observed. 2nd hand aerodynamic equipment can be bought in the country adapted to the individual truck.

Concerning tires the situation in Lao PDR is comparable to Viet Nam: usage of tube tires is common; different tire brands, tire wear and patterns on the same truck; non-usage of low-rolling resistance tires and non-usage of wide-tires which would also require a permit as they are currently not allowed. The mining company Phu Bia (PanAust company) has made trial runs with wide-based tires of Michelin. However, the company has rejected using such tires in the future due basically to the issue that with a blow-up the truck must be stopped and cannot continue to drive.

3.2.6. GFTs Implemented

GFTs implemented and tested in both countries within the GFP are:

- Cab roof deflector as aerodynamic device;
- LRR on all wheels:
- Manual tire-inflation.

10-15 trucks were equipped in each country with aerodynamic devices and another 10-15 trucks with full sets of LRRs.

Photo 1: Aerodynamic Devices Installed

Due to low average driving speeds in both countries more advanced aerodynamic equipment does not make sense. The table below shows that the average driving speed for both countries was in the range of 40km/h for long-haul trucks i.e. the impact of aerodynamic devices is limited.

Table 3: Average Circulating Speed Long-Haul Trucks, 2016

	Viet Nam	Lao PDR
Average speed in km/h	37	40
Lower and upper 95% confidence interval	36 / 38	36 / 44

Source: Measurement based on GPS with over 2,000 data points over a period of 6 months, multiple routes and trucks; Grütter Consulting

LRRs used were Michelin and Bridgestone US-SmartWay certified LRRs. For tire inflation manual procedures were used inflating tires 1bar higher than usual. Automatic tire inflation equipment is costly and not available in both countries. Idling devices as well as other GFTs were not used due to limited applicability and potential in Viet Nam and Laos.

Photo 2: LRR Tires Installed

3.3. Eco Drive

3.3.1. Concept of Eco Drive

Eco Drive refers to a smarter and more fuel-efficient driving style adopting driving techniques that get the most out of modern vehicles and engines. Eco Drive tactics include accelerating slowly, cruising at more moderate speeds, avoiding sudden braking, idling less, as well as selecting routes that allow more of this sort of driving. Eco Drive is not only an easy and cost-efficient way to reduce fuel consumption but is also an attitude and respect for society as a whole. Eco Drive has been promoted since various decades in many countries worldwide with the goal of reducing fuel consumption with a safe driving style. Eco Drive as a government policy is in place in various countries of Europe, the US, Japan and Korea. International organizations such as the International Energy Agency (IEA) or The United Nations Environmental Program (UNEP) today also promote Eco Drive which has become a global effort.

The major **benefits** identified for applying Eco Drive are:

- Environmental impact (reduced GHG emissions and local pollutants);
- Economic benefits due to reduced fuel consumption and lower maintenance costs;
- Lower accident rate and less stressful driving;
- Eco Drive as an instrument to demonstrate the social and environmental responsibility of a company.

Important factors to ensure a sustainable impact of Eco Drive include fuel consumption monitoring, regular repetition of core messages and updating of information (e.g. for new vehicle technologies).

Major **obstacles** identified for widespread application of Eco Drive include:

- Eco Drive has the image of driving slowly;
- The benefits of Eco Drive are not recognized by all stakeholders i.e. low awareness as well as low motivation and interest resulting in low demand for training courses;
- Influencing drive-styles and habits is difficult;

Despite its popularity, there is poor and inconsistent research evidence regarding the effects of Eco Drive on both fuel consumption and emissions. Wahlberg states for example: "*The claims regarding the Eco-drive benefits were mainly made by educators and bureaucrats, and lack scientific backing*". Eco Drive is difficult to turn into a driving habit as it is dependent on the driving situation such as traffic, environment and personal motivations. The impact of Eco Drive is potentially dependent on the driving circumstance (urban, highway), driver background (professional or amateur drivers) and on the vehicle category (bus, truck, taxi, passenger cars, motorcycles). Mostly data has been reported for passenger cars.

3.3.2. Previous Experience with Eco Drive in Viet Nam and Lao PDR

Viet Nam

Various and regular trainings for Eco Drive in passenger cars, taxis and light duty vehicles have been realized e.g. through the University of Transport Technology of the Ministry of Transport (MOT). Swisscontact, in cooperation with Clean Air Asia (CAI), organized some years ago Eco Drive trainings for around 100 garbage truck drivers in Hanoi measuring the impact however only during the training course itself. Nippon Japan as well as Hino have also realized Eco Drive training with a focus on light duty truck drivers without ex-post impact measurement.

Lao PDR

Some companies have been trained on Eco Drive e.g. the Vientiane Capital State Bus Enterprise trained drivers on Eco Drive under a Japanese program and Phu Bia mining has realized training internally for their truck drivers with an Australian instructor. Phu Bia has a truck simulator for trainings. No reports are available on monitoring of impacts of driver training.

3.3.3. Eco Drive Curriculum

Based on experience with an initial Eco Drive course for truck drivers a Curriculum for Eco Drive was developed[4] and discussed in workshops in Viet Nam and Lao PDR. Thereafter, the curriculum was applied in various training courses in both countries with around 100 truck drivers being trained in Eco Drive[5].

The curriculum includes a theoretical and a practical part:

[4] See for details Report 3
[5] In Lao PDR also long-haul bus drivers were trained

- **Theoretical part:** This includes motivating the driver, explaining reasons why Eco Drive is good, explaining what needs to be done and why, and demonstrating the results of changing the driving style.
- **Practical experience:** This includes test-driving either on a simulator or with actual trucks. The instructor thereby gives the driver tips on how to improve his Eco Drive skills. Ideal is if a first test-drive can be realized prior the theoretical course and another test-drive after the course.

The 4 golden rules of Eco Drive are promoted:

1. Check your vehicle prior driving; The most relevant checks for low fuel consumption prior driving are tire pressure, cargo and aerodynamics;
2. Up-shift as early as you can and use high gears;
3. Drive defensively running at constant speed;
4. Effectively utilize the engine brake and retarders.

3.3.4. Activities and Trainings Realized

Basically two types of trainings were realized:

- Capacity building of trainers of driving schools on Eco Drive on the curriculum developed. This was realized in 2015 through a training workshop realized with 15 trainers in each country.
- Training of 100 truck drivers in Viet Nam and 100 truck and bus drivers in Lao PDR in various courses during 2015 and 2016 using the developed curriculum. In all trainings all drivers performed trips on a standardized route prior course with precise fuel consumption measurement and just after the course measuring again the performance. The run after the course included feedback and recommendations of the instructor whilst the run prior course the driver had to drive as usual without assistance.

Photo 3: Training Courses Lao PDR and Vietnam

3.4. Logistics Improvements

3.4.1. Overview of International Experiences with Logistics Measures

Logistics measures in the context of the GFP are such which reduce GHG emissions, even if this is not the primary objective. Such measures avoid trips, reduce trip distances or increase trip efficiency. A core indicator is thereby the increase of the average load factor[6]. The trend towards just-in-time production and narrower delivery time windows have resulted in shipping of smaller quantities of goods and lower load factors. Also demands on speed and guaranteed delivery times make shipping aggregation problematic resulting in reduced load factors. Figures in Europe for example show average load factors of loaded vehicles in the year 2012 of only 56% and a ratio of empty trips of 24% resulting in an average overall load factor of around 43%[7]. In the US the National Private Truck Council estimates an empty load percentage of 28% i.e. a similar figure as in Europe. Reasons to under-loading next to a focus on speed and delivery times are specialized logistical requirements of freight consignments (e.g. refrigeration requirement, fuels etc.), inherent asymmetries in distributional networks (e.g. round wood transporting from forests to sawmills), and changes in production and consumption patterns such as reduced stock warehousing.

Potential logistics solutions include[8]:

- Drop-and-Hook: “Drop” refers to delivering a trailer and dropping it at the customer or destination site while “hook” refers to immediately hooking up a loaded trailer to the next destination. This approach shall reduce empty trips. The core motivation for “drop-and-hook” is however on reducing time in which the driver and the truck is not used thus being able to potentially reduce logistics costs[9]. Drop and hook itself will not provide for more matching

[6] Important is in this context that the average load factor should not be trip but tkm based e.g. a 40t truck driving 500km with 50% of load is another truck of 40t with 70% of load driving a 50km trip result in a 60% average load factor of trips but only 52% load factor based on tkm
[7] See A. Leshchynskyy, Under-utilisation of road freight vehicle capacity, 2013
[8] See also CAI, design of Green Freight China Program: Review of Freight Logistics Solutions, 2011
[9] The reduced driver and truck cost has to be compared with the increased cost for trailers.

loads. Its chance to work will be much higher if tractor and trailer owner for small companies (one truck one driver) are separate and if a high degree of standardization exists.

- Online freight marketplaces: Online freight marketplaces include spot market logistics platforms and freight exchange platforms. Basically logistics platforms attempt to match carrier availability with loads. Such platforms are today basically internet-based and often offer other services next to match-making such as vehicle positioning or cargo tagging.
- Freight Consolidation Centres: These are distribution centres, situated generally close to a town centre, shopping mall or construction sites, at which part loads are consolidated and from which a lower number of consolidated loads are delivered to the target area. A consolidation centre often tends to have multiple objectives, but the most common aims are associated with reducing congestion, traffic disruption and vehicle emissions within the primary urban area that the consolidation centre serves. Some monitored experience of freight consolidation centres however also shows the limitations especially concerning financial sustainability as well as their GHG impact[10]. Consolidation centres are basically an instrument of reducing urban freight transport issues. Experience with such centres has been mixed and financial sustainability is problematic. Their incidence in long-haul transport is marginal and total emission reductions are limited.
- Freight company consortia's: This is an association between usually small and medium carriers or distributors to pool their resources and strengths in order to win and manage larger and more lucrative logistics contracts. Main features of such consortia's include integrated fleet management (truck and load tracking), information sharing, facilities sharing and profit sharing. Collaborative efforts can be "vertical" or "horizontal". Vertical alliances are between trading partners at different levels within a single supply chain. Horizontal collaboration occurs between separate supply chains in an attempt to share risks and rewards thus leading to a greater competitive advantage and business performance than would be achieved by the involved actors individually. Consortia's have the potential of increasing load factors and thus reducing emissions. Overall such collaborative efforts will require considerable levels of mutual trust between involved partners. The role of a 3rd party or government in promoting such consortia's seems to be limited.

3.4.2. Logistics in Viet Nam and Lao PDR

Viet Nam

In transport, the road sector is the dominant mode in terms of freight transportation in Viet Nam. Viet Nam has about 600 and 800 logistics service providers with a number around 1,000 just for freight forwarders[11]. A large number are small enterprises with limited staff (15 to 30). Many of the freight forwarders limit their activities to customs clearing and simple shipment orders. There is intense competition between these small operations as they are capable of only getting a small share of the market (20%). The big share of the market goes to larger firms, which are either joint ventures with global logistics players or Vietnamese agents of international firms.

[10] See Scott Wilson, Freight Consolidation Centre Study, 2010 and M. Panero et.al., Urban Distribution Centers, 2011

[11] See VITRANSS 2, 2010

To get an updated picture of actual load factors of long-haul trucks a roadside survey was realized December 2015 on the Phap Van toll-booth located on the national highway connecting the North and South provinces of Viet Nam. Trucks with a Gross Vehicle Weight (GVW) of more than 10 tons were surveyed randomly in both directions. The following table shows the main results of the load factor study.

Table 4: Results Load Factor Study Viet Nam 2015

Parameter	South-North	North-South	Average
Median trip distance[12]	121 km	111 km	116 km
Median GVW	32 tons	32 tons	32 tons
Average load factor unweighted[13]	59%	54%	56%
Average load factor based on tkm[14]	71%	67%	69%
Average empty backhaul unweighted	36%	34%	35%
Average empty backhaul based on tkm	27%	25%	26%

Source: Grütter Consulting

To estimate a realistic improvement potential of load factor changes the following table gives an indication of share of tkm and the determinant empty load factor as well as average tkm weighted load factor per good.

Table 5: Baseline Load Factor and Improvement Potential per Good, Viet Nam 2015

Parameter	Relevant empty backhaul factor[15]	Relevant average tkm weighted load factor[16]	Improvement potential
Container transport	18%	78%	Empty backhaul is relatively low and the load factor is high. Therefore, the improvement potential is considered as marginal.
Miscellaneous goods	32%	60%	The empty backhaul and the average load factor are at a moderate level. A moderate improvement potential is thus identified.
Cement / building material	37%	51%	The empty backhaul is relatively high and the average load factor low. The improvement potential is high but the commodity only represents a small fraction of total tkm.

The commodities which represent a large fraction of tkm (container and miscellaneous goods) have only a limited improvement potential as trucks are in fact already well loaded and with a low empty backhaul rate. In the area of cement and building material the improvement potential is higher but this only represents a relatively small fraction of the tkm driven for long –haul truck transport. The improvement potential for match-making platforms is therefore considered as limited. This coincides also with an assessment made in the UK after analysing disaggregated data in a specific sector[17].

[12] the median is taken as very long trips influence average trip distances
[13] not weighted according to trip distance or tkm
[14] load factor weighted based on tkm
[15] in case of asymmetric goods flows i.e. asymmetric load factors N-S and S-N the lower empty backhaul value is taken as this value can be improved realistically whilst the value in the other direction is influenced basically through the asymmetric goods flow.
[16] idem to empty backhaul; the higher of the average load factors is taken as the improvement potential is determined through the path/direction where goods primarily flow.
[17] A. McKinnon, The potential for reducing empty running by trucks: a retrospective analysis, 2006

Internet-based logistics platforms in general have the problem that shippers have the added burden of trusting cargo to a carrier or broker they are often not familiar with. Risks include non-compliance of delivery times, damaged or stolen products, loss of products and non-compliance with other contractual obligations as demanded by the shipper. For truckers on the other hand the risk is of default on the side of the shipper e.g. not paying for the services rendered or not paying timely or other contractual defaults. Many businesses therefore share trepidation about using these services and their caution is well-founded because pitfalls do exist. Most of these pitfalls can be overcome by financial services including insurance coverage as well as third party retaining of fees. These instruments are however hardly if at all developed in Viet Nam thus making usage of platforms a matter of trust for both Parties. Many trading platforms therefore use ratings (for both sides of the deal) to eliminate fraudulent or low-quality participants and to allow parties to make an informed choice with whom to engage in business. However, such systems require time and large brokerage volumes to arrive at sound and reliable rating levels, making start-ups complicated. The non-existence of instruments to reduce the risk of platforms in Viet Nam make Internet-based logistics platforms at the current stage little attractive compared to traditional brokerage services of 3L logistics companies. This combined with the relatively low improvement potential concerning load factors results in the conclusion that it is currently not worthwhile to invest resources in such a platform. Also at least 3 platforms already exist in Viet Nam which offer these services[18] – however they do not seem to be widely used.

Lao PDR

Based on the Ministry of Public Work and Transport total nearly 4 million tons of goods or 330 million tkm are transported in Laos PDR. The modal split of transport goods in Laos PDR is road and inland waterway as no rail transport exists. Based on a GMS transport study realized by ADB (2006) and confirmed by JICA based on the Lao Statistical Yearbook (2008) the road sector is dominant in terms of tkm with around 2/3rd against 1/3rd inland waterway.

Logistics companies in Vientiane are mostly private forwarding and trucking companies whilst in the provinces logistics companies are basically owner-drivers. The Lao International Freight Forwarder Association (LIFFA) is the largest umbrella organization of logistics companies in the country.

To get an updated indication of actual load factors of long-haul trucks a roadside survey was realized December 2015 on the national highway road No. 13 at km 85. This highway connects the Provinces from the Northwest with other Provinces in Laos PDR. Trucks with a GVW of more than 10 tons were surveyed randomly in both directions. Peak hours of truck movement was between 5 and 8 am and 5-7 pm. The following table shows the main results of the load factor study.

[18] www.vietnamtrucking.vn/trang-chu/10/san-van-tai/, www.vitransportal.com/trang-chu/, www.vinatrucking.com

Table 6: Results Load Factor Study Laos PDR 2015

Parameter	South-North	North-South	Average
Median trip distance[19]	560 km	440 km	520 km
Median GVW	48 tons	36 tons	42 tons
Average load factor unweighted[20]	59%	50%	55%
Average load factor based on tkm[21]	65%	45%	55%
Average empty backhaul unweighted	29%	44%	37%
Average empty backhaul based on tkm	25%	50%	38%

Source: Grütter Consulting

The following table gives an indication of the realistic potential of load factor improvements.

Table 7: Baseline Load Factor and Improvement Potential per Commodity, Laos PDR 2015

Parameter	Relevant empty backhaul factor[22]	Relevant average tkm weighted load factor[23]	Improvement potential
Mining products	53%	72%	This represents around 30% of tkm transported. Empty backhaul is high but related to the commodity. It is not considered as feasible to receive significant loads for the same origin-destinations using mining trucks. Therefore, the improvement potential is considered as marginal
Miscellaneous goods	19%	56%	This represents around 20% of tkm transported. The empty backhaul is at a low level. The average load factor is at a moderate level with a significant level of partial loads. A low to moderate improvement potential is thus identified.
Cement / building material	30%	46%	This represents around 25% of tkm transported. The empty backhaul is moderate S-N and very high N-S due to asymmetric good flows. Also some partial loads are being realized S-N. A moderate improvement potential exists, however the issue in this commodity is basically of asymmetric flows.
Liquids	11%	88%	This represents around 10% of tkm transported. The empty backhaul is very low and the load factor is very high. No improvement potential is identified.

For around 50% of goods transported no or only a marginal improvement potential is identified due to the commodities transported (minerals, liquids) and asymmetric goods flows. For around 50% of goods a low to moderate potential has been identified.

Therefore, similar to Viet Nam the potential for a match-making platform are deemed to be limited.

[19] the median is taken as very long trips influence average trip distances
[20] not weighted according to trip distance or tkm
[21] load factor weighted based on tkm
[22] in case of asymmetric goods flows i.e. asymmetric load factors N-S and S-N the lower empty backhaul value is taken as this value can be improved realistically whilst the value in the other direction is influenced basically through the asymmetric goods flow.
[23] idem to empty backhaul; the higher of the average load factors is taken as the improvement potential is determined through the path/direction where goods primarily flow.

3.4.3. Green Freight Label

A GF label is considered as interesting instrument to promote low-carbon freight due to the following:

- GF labels require appropriate monitoring of company performance including fuel usage. This results in good quality data of actual performance levels and allows companies to track improvements.
- GF labels require companies to implement GF technologies or improvements such as Eco Drive courses for their drivers. This ensures that companies actually invest in and implement GF measures.
- GF labels are attractive for companies as they improve their competitive position allowing to increase their market share, get a larger customer base or increase prices. This again allows to invest in GF technologies.

The label used by the GFP is the Green Freight Label given by Green Freight Asia (GFA)[24] which values the environmental performance of the company. The label can be taken as proxy for a reliable company with internal controls and with a good environmental performance.

GFA is an industry led program incorporated in Singapore as a non-profit organization. It is a member driven organization, mainly of shippers and carriers and provides for a clear and simple definition and recognition of Green Road Freight Transport. The GFA label comprises four distinct tiers of recognition and has as participating companies e.g. Heineken, HP, IKEA, DHL, UPS, Lenovo etc.

Figure 7: GFA Label Tiers

The criteria to get the label is basically, next to being member and paying a membership fee a sound data management which takes account of the number of trucks, fuel type, and emission standard as minimum (tier 1) plus fuel consumption, distance driven and freight volume for tier 2. Tier 3 asks for GHG tracking and tier 4 for a public GHG commitment. The environmental commitment for tier 1 is that all trucks are included in a regular maintenance program. For the following tiers there are basically the criteria on usage of fuel saving technologies (e.g. Low Rolling Resistance Tires) and of drivers trained in Eco Drive asking for an ever increasing amount of technologies and trained drivers when moving from tier 2 to tier 4.

2 companies in Viet Nam and 1 company in Lao PDR were supported by the project to get the label (those in Viet Nam a 2-leaf label and the company in Lao PDR a 1 leaf label).

[24] website http://www.greenfreightasia.org/

3.5. Summary Implementations

The following table summarizes implementation actions realized in the two countries.

Table 8: Summary of GF Implementation Actions

Activity	Viet Nam	Lao PDR
Aerodynamic equipment	11 trucks	11 trucks
LRRs	15 trucks	12 trucks and 3 buses
Fuel Audit Tool	20 companies	20 companies
Eco Drive training instructors	15 instructors	15 instructors
Eco Drive training drivers	100 drivers	100 drivers
Workshops	2 workshops with 90 participants	2 workshops with 72 participants
Brochures	3 brochures	3 brochures
Reports	12 technical reports	

4. Monitoring Approach

GFTs and Eco Drive have potential impacts on the efficiency of trucks whilst improved load factors have an impact on the efficiency of moving goods. The monitoring is therefore not a general monitoring of freight efficiency (as this would also include mode switch measures) nor does it monitor avoidance or reduction of freight trips. This clarification is important due to its implications on parameters to be used.

The monitoring focuses on direct emissions sources and not on indirect or leakage[25] emissions. However, the emission factor for diesel will be presented with and without leakage emissions which are in this case upstream emissions (well-to-tank emissions caused by the extraction, transport and refinery of petroleum products). The fuel upstream emissions are explicitly stated as latter represent an important source of emissions. Also Black Carbon (BC) emissions are estimated based on the average Euro standard of trucks used per country.

The GHG included in monitoring is CO_2. CH_4 emissions are marginal in liquid fuel combustion of vehicles and gaseous trucks are not used in a significant share for long-haul heavy-duty operations. N_2O emissions are marginal for vehicular emissions[26]. BC is transformed to GHG equivalent for GWP100.

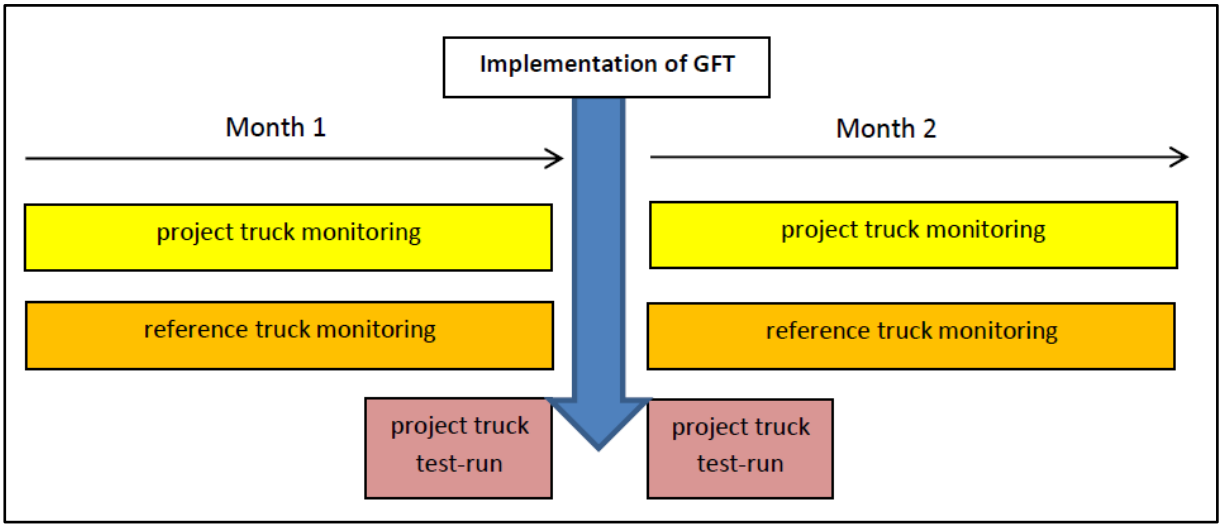
The three identified methodological approaches (see Report "Impact Monitoring") for GFTs are:

1. Before-after comparison where the fuel efficiency of the truck prior technology installation is compared with the fuel consumption after technology installation.
2. Control-group approach where the fuel efficiency of the project truck is compared to the fuel efficiency of a comparable reference truck.
3. Controlled test-run where the fuel efficiency before and after equipment installation is measured based on a realizing a controlled test-run.

All three methods were applied. In each country for each technology a pilot test run was performed based on a controlled test-run with controlled conditions. Already in the pilot phase all involved project trucks have been monitored 1-6 months prior implementation. Each truck installed with a GFT was driven under controlled circumstances with and without GFT. For more than 20 trucks per country a before-after comparison was made with data of minimum 1 month before and 1 month after installing the GFT and for 6 trucks measurements were made 6 months prior and 6 months after GFT installation.

[25] Leakage is defined as impacts not under direct control of the project but which can be attributed to the projects activities.
[26] See e.g. CDM approved methodology ACM0016

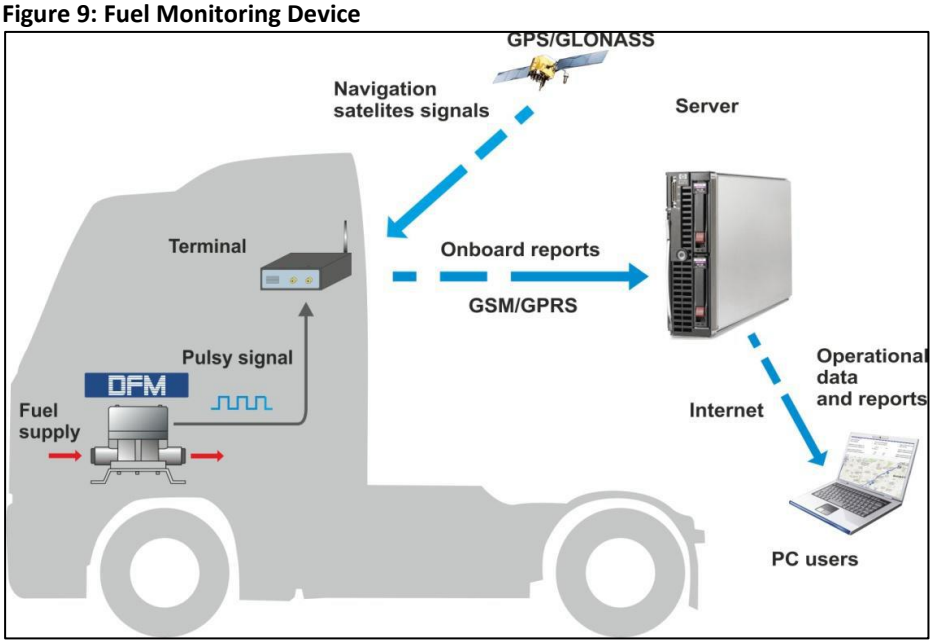
Figure 8: Monitoring Approach



Source: Grütter Consulting

Core parameters monitored are fuel consumption and distance driven. Weight measurement was made to ensure that average loads were comparable prior/after (calculation based on tkm). Speed measurements were also made to ensure comparable speeds prior and after installing GFTs and compared to reference trucks. Reference trucks were identical trucks in terms of GVW, brand and make, year, Euro standard and operating company. Fuel consumption was measured with fuel-flow measurement equipment and fuel station invoices. The parameter distance driven and driving speed was based on GPS whilst freight tonnage was based on loading papers.

Figure 9: Fuel Monitoring Device

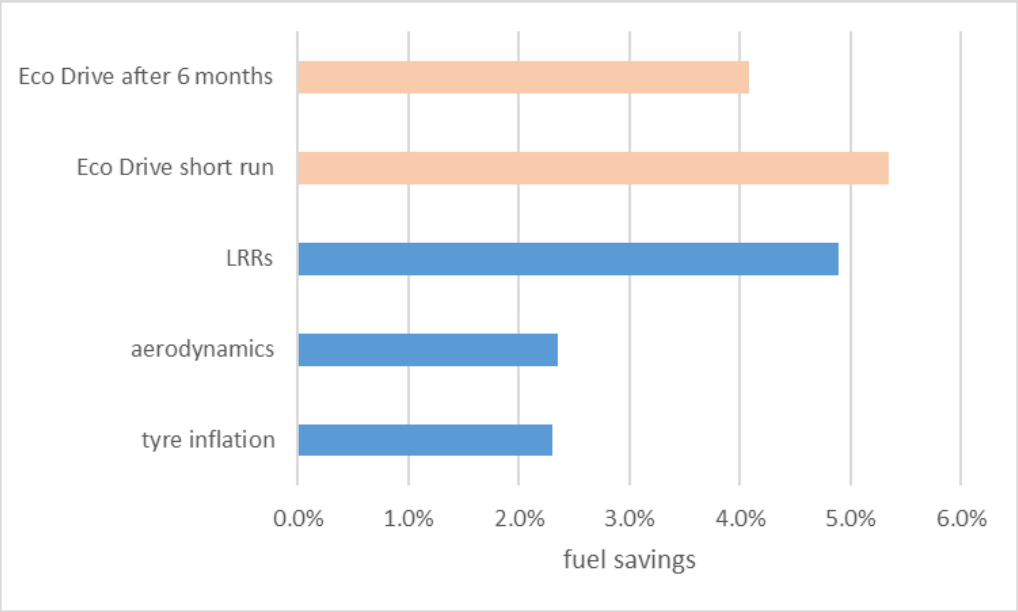


5. Implementation Results

Implementation results are shown for the GFTs applied (aerodynamics, LRRs, increased tire pressure) as well as for Eco Drive. Workshops, reports and implementation of the Green Freight Label are basically enabling measures and therefore not included. GHG reductions are proportional to fuel savings and are quantified in the next chapter which looks at the financial and economic impact.

The following figure shows the overall average fuel savings for both countries whilst the table shows detailed results.

Figure 10: Fuel Savings of Green Freight Activities
(average Viet Nam and Lao PDR in % of reduced fuel consumption per km)



Source: Grütter Consulting

Eco Drive and LRRs result in around 4-5% fuel savings whilst aerodynamic devices and tire inflation achieve around 2% savings. Combined an improvement of 13% is possible.

Table 9: Implementation Results in % of Fuel Savings

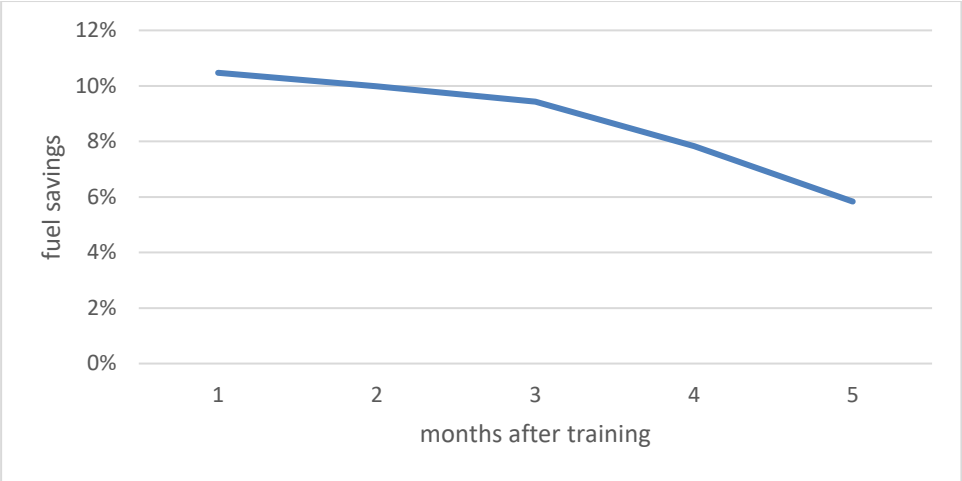
Measure	Viet Nam	Lao PDR
Tire inflation	Average: 3.1%	Average: 1.5%
Efficient tires (LRRs)	Average: 5.6% STDEV: 0.03 Upper and lower boundary 95% Confidence Interval: 2.4% to 8.9%	Average: 4.2% STDEV: 0.04 Upper and lower boundary 95% Confidence Interval: 1.6% to 6.7%
Aerodynamic devices	Average: 1.5% STDEV: 0.01 Upper and lower boundary 95% Confidence Interval: 0.4% to 2.7%	Average: 3.2% STDEV: 0.03 Upper and lower boundary 95% Confidence Interval: 0.9% to 5.4%
Eco Drive short run	Average: 7.6% STDEV: 0.06 Upper and lower boundary 95% Confidence Interval: 4.8% to 10.4%	Average: 3.1% STDEV: 0.03 Upper and lower boundary 95% Confidence Interval: 1.6% to 4.6%
Eco Drive long run	Average: 5.8%	Average: n.a.

Source: Grütter Consulting

Differences in results between the two countries exist, albeit not of large scale.

In the case of Eco Drive improvements change considerably over time as can be seen from the following figure showing results with average improvement 1 to 6 months after the course. This indicates the need of refresher courses as well as of constant incentives and supervision e.g. through telemetric equipment.

Figure 11: Eco Drive Results Over Time



Source: Grütter Consulting

6. GHG and Economic Impact

6.1. GHG Impact

The GHG impact is determined at two levels:

- Tank-to-Wheel (TTW) emissions based on fuel consumption, the Net Calorific Value (NCV) and the CO_2 Emission factor (EF_{CO2}) of the fuel used following IPCC procedures. The following table shows the key parameters used for this calculation.

Table 10: Parameters to Determine TTW GHG Emissions (Long-Haul HDVs)

Parameter	Value Viet Nam	Value Lao PDR	Data Source
Specific fuel consumption	37 l/100km	48 l/100km	Monitoring of >50 trucks during various months
NCV of diesel	43 MJ/kg		IPCC, 2006, table 1.2
EF_{CO2} of diesel	74.1 gCO_2/MJ		IPCC, 2006, table 1.4
Average GVW	44 tons	35 tons	Monitoring of >50 trucks during various months
Average net tons	22 tons	14 tons	Viet Nam: 12t truck weight; 69% average tkm weighted load factor Lao PDR: 9t truck weight; 55% average tkm weighted load factor
Annual mileage	90,000km	50,000km	Records companies

- Well-to-Wheel (WTW) emissions including the GHG impact of Black Carbon (BC) based on the key parameters as included in the following table.

Table 11: Parameters to determine WTW and BC Emissions (based on Euro III HDVs > 32t GVW)

Parameter	Value Viet Nam and Lao PDR	Data Source
PM2.5 emissions	0.151 g/km	EEA, COPERT, 2014, Table 3-21 (Tier 2 method)
BC carbon fraction of PM2.5	70%	EEA, COPERT, 2014, Table A.4.02 (Tier 3 method)
GWP BC	900	Bond, 2014 and World Bank, 2014
Upstream factor diesel	25%	JRC-Study 22%, CEC 23%, US DOE GREET 25%, NRC GHGenius 29%; average value taken

GHG emissions are expressed in gCO_2/km, gCO_2/tkm and tCO_2 per annum per truck based on average mileage per country. The following table shows calculated values.

Table 12: GHG Emissions Long-Haul Trucks Viet Nam and Lao PDR

Parameter	Viet Nam	Lao PDR
Emissions in gCO_2/km TTW	995 gCO_2/km	1,291 gCO_2/km
Emissions in gCO_2/km WTW incl. BC	1,339 gCO_2/km	1,709 gCO_2/km
Emissions in gCO_2/tkm TTW	45 gCO_2/tkm	92 gCO_2/tkm
Emissions in gCO_2/tkm WTW incl. BC	61 gCO_2/tkm	122 gCO_2/tkm
Emissions per truck per annum TTW	90 tCO_2	65 tCO_2
Emissions per truck per annum WTW incl. BC	121 tCO_2	85 tCO_2

Fuel usage is in absolute and even more per ton far higher in Lao PDR than in Viet Nam due to roads and driving conditions (many hilly roads). GHG emissions per truck in absolute terms are however higher in Viet Nam due to significantly higher annual mileage of trucks in Viet Nam.

The following table shows the GHG impact per annum per country per measure.

Table 13: GHG Impact per Truck per Annum

Parameter	Viet Nam		Lao PDR	
	TTW	WTW incl. BC	TTW	WTW incl. BC
Aerodynamic equipment	1.3 tCO_2	1.8 tCO_2	2.1 tCO_2	2.7 tCO_2
Efficient Tires (LRRs)	5.0 tCO_2	6.7 tCO_2	2.7 tCO_2	3.6 tCO_2
Tire Inflation (+1 Bar)	2.8 tCO_2	3.7 tCO_2	1.0 tCO_2	1.3 tCO_2
Eco Drive	2.8 tCO_2	3.7 tCO_2	1.0 tCO_2	1.3 tCO_2
Combined	**11.4 tCO_2**	**15.3 tCO_2**	**6.5 tCO_2**	**8.6 tCO_2**

Source: Grütter Consulting

Combined each truck can save in Viet Nam 11 to 15 tCO_{2e} (TTW or WTW incl. BC approach) and in Lao PDR 7 to 9 tCO_{2e} representing 10-13% of GHG emissions of long-haul trucks.

6.2. Financial Impact and GHG Abatement Costs

6.2.1. Introduction

The financial impact of GF measures is calculated and the marginal abatement costs per tCO_2 are calculated. The profitability of measures at company level is thereby determined.

6.2.2. Cost Structure Viet Nam

The following table shows core parameters for a long-haul trucking company based on data collected from various companies based on input market prices and performance reports of trucks.

Table 14: Core Parameters Trucking Costs Viet Nam, 2016

ID	Parameter	Value
1	Investment cost of new truck (Chinese)	1.8 Billion VND
2	Lifespan new Chinese truck	15 years
3	Investment cost used truck (US, 6-year old)	1 Billion VND
4	Remaining life-span used US truck	12 years
5	Fuel cost	12,000 VND/l
6	Maintenance cost per month	10 M VND/m
7	Annual repair cost	50 M VND/a
8	Annual vehicle tax	20 M VND/a
9	Other taxes and informal facilitation payments per month	7 M VND/m
10	Road toll fee per km for national highways[27]	3,500 VND/km
11	Truck insurance cost per annum	20 M VND/a
12	Driver salary incl. social benefits per month	15 M VND/m
13	Auxiliary driver salary incl. social benefits per month	6 M VND/m
14	Weighted Average Capital Cost WACC[28]	8.5%
15	Exchange rate USD-VND (Interbank rate)	1:22,000

Source: compiled by Grütter Consulting

[27] average rate for various routes

[28] Based on 15.6% cost of equity (UNFCCC, EB 85 Annex 12, CDM Methodological Tool Investment Analysis Version 6.0, 2015; rate for transport sector Vietnam); 6.5% cost of debt (SBV rate valid as of 01/2016; see http://www.tradingeconomics.com/vietnam/interest-rate); 22% tax rate (Deloitte, 2015); 30% equity and 70% debt finance

The following table shows the operational cost structure of trucking companies in Viet Nam excluding overhead and profits.

Table 15: Operational Cost Components of Trucking in Viet Nam (excl. toll fees), 2016

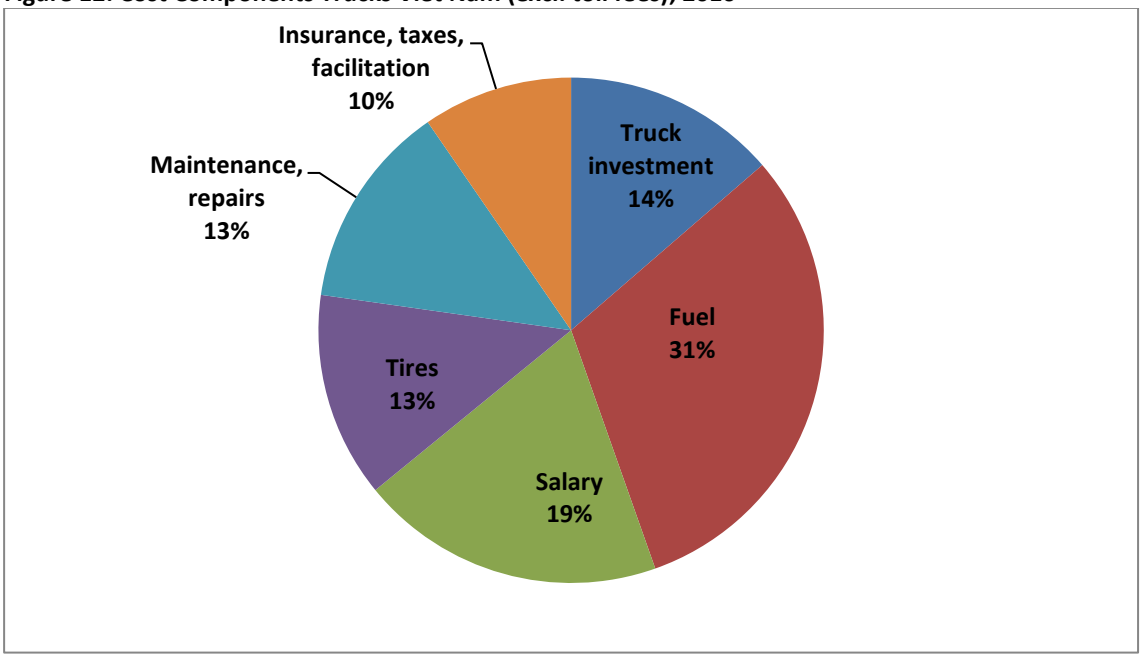
Parameter	in VND/km	in USD/km
Truck Investment (annualized, average of new/used truck)	1,961	0.09
Fuel	4,440	0.20
Salary Drivers	2,800	0.13
Tires	1,886	0.09
Maintenance & Repair	1,889	0.09
Insurance, Tax	1,378	0.06
Total cost per km	14,353	0.65
Total cost per net-tkm	652	0.03

Source: calculation by Grütter Consulting

The total cost per km and net-tkm does not include toll fees charged on highways. If using purely highways these amount to another 3,500 VND/km (0.16 USD/km) equivalent to another 250 VND per net-tkm (0.01 USD/net-tkm).

The following figure shows the cost share per component.

Figure 12: Cost Components Trucks Viet Nam (excl. toll fees), 2016



Source: calculation by Grütter Consulting

The largest cost component is fuel with around 1/3rd of total costs. This is followed by salaries with 19% and truck investment, maintenance & repairs, tires, insurance & taxes which all have a comparable share.

6.2.3. Cost Structure Lao PDR

The following table shows core parameters for a long-haul trucking company in Lao PDR based on data collected from various companies and performance reports of trucks.

Table 16: Core Parameters Trucking Costs Lao PDR, 2016

ID	Parameter	Value
1	Investment cost of new truck (Chinese)	570 Million KIP
2	Lifespan new Chinese truck	15 years
3	Investment cost used truck (Japanese, 5-year old)	340 Million KIP
4	Remaining life-span used truck	10 years
5	Annual distance driven	50,000 km
6	Gross vehicle weight (GVW)	35 tons
7	Average load factor (freight tons)[29]	14 tons
8	Number of tires (8 axles)	22 tires
9	Lifespan of tire (Chinese tire)[30]	70,000 km
10	Cost per tire (Chinese tire)	2.2 M KIP
11	Specific fuel consumption	48 l/100km
12	Fuel cost	6,600 KIP/l
13	Maintenance cost per month	4 M KIP/m
14	Annual repair cost	48 M KIP/a
15	Annual vehicle tax	30 M KIP/a
16	Truck insurance cost per annum	4 M KIP/a
17	Driver salary incl. social benefits per month	2 M KIP/m
18	Auxiliary driver salary incl. social benefits p.m.	0.8 M KIP/m
19	WACC[31]	8.5%
20	Exchange rate USD: KIP (Interbank rate)	1:8,000

Source: compiled by Grütter Consulting

The following table shows the operational cost structure of trucking companies in Lao PDR excluding overheads and profits.

Table 17: Operational Cost Components of Trucking in Lao PDR, 2016

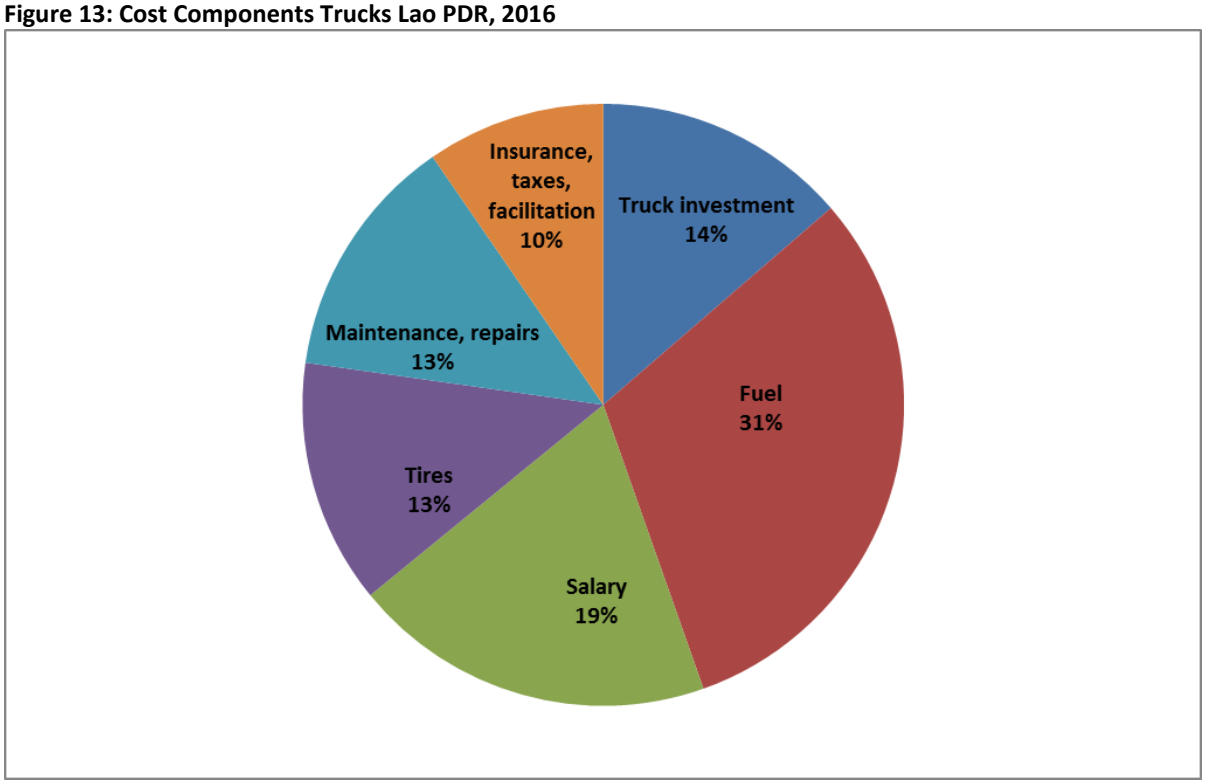
Parameter	in KIP/km	in USD/km
Truck investment (annualized, average of new/used truck)	1,205	0.15
Fuel	3,168	0.40
Salary drivers	672	0.08
Tires	691	0.09
Maintenance, repairs	1,920	0.24
Insurance, taxes	680	0.09
Total cost per km	8,336	1.04
Total cost per net-tkm	595	0.07

Source: calculation by Grütter Consulting

The following figure shows the cost share per component.

[29] 37t net payload; 50% empty load factor
[30] largest market share
[31] Assumed same as for Viet Nam

Figure 13: Cost Components Trucks Lao PDR, 2016



Source: calculation by Grütter Consulting

The largest cost component is fuel with around 1/3rd of total costs. This is followed by salaries with 19% and truck investment, maintenance & repairs, tires, insurance & taxes which all have a comparable share.

6.2.4. Financial Impact of GF Measures

The cost-benefit of the following GF measures is assessed for long-haul trucks:

- Installation of a cab-roof deflector (aerodynamic device);
- Usage of Low-Rolling Resistance Tires (LRRs);
- Driver training on Eco Drive;
- Package of measures including also increased tire inflation.

Table 18: Profitability of GF Measures[32]

Measure / Parameter	Viet Nam	Lao PDR
Aerodynamic Device		
1. Incremental CAPEX per truck	USD 1,000	USD 900
2. Savings OPEX per truck	USD 1,360	USD 3,170
3. Payback time	3.5 years	1.5 years
4. FIRR	35%	245%
LRRs		
1. Incremental CAPEX per truck	USD 880.-	USD 880
2. Annual Savings OPEX per truck	USD 1,130	USD 1,660
3. Payback time	10 months	13 months
4. FIRR	28%	89%

[32] Based on cost structures and impact as recorded per country

Eco Drive		
1. Incremental CAPEX[33] per annum per truck	USD 150	USD 150
2. Annual Savings OPEX per truck	USD 560	USD 297
3. Payback time	3 months	6 months
4. FIRR[34]	275%	98%
Combined Measures		
1. Incremental CAPEX per truck	USD 2,030	USD 1,930
2. Annual Savings OPEX per truck	USD 2,300	USD 1,990
3. Payback time	1 year	1 year
4. FIRR	98%	90%

Each individual measure has a high FIRR and a short payback time. However, companies have to realize additional incremental investments and fuel savings are not visible, especially if no high-quality monitoring is in place. Therefore, companies are reluctant to invest in these technologies.

6.2.5. CO_2 Marginal Abatement Costs

The marginal abatement cost (MAC) for each measure as well as for the full package is negative as all measures have a profitable FIRR which is significantly above the WACC. The MAC in Viet Nam combined is -400 USD per tCO_2 avoided and in Lao PDR -600 USD per tCO_2 avoided[35]. This is not surprising considering the high FIRR of investments.

However various barriers apply which also form the reasons why the measures have not proliferated (in absence of pre-installed cab roof deflectors):

- GFTs have performance risks which result in financial risks making them potentially non-profitable. These performance risks are basically the actual fuel savings and the life-span or durability of LRRs.
- Availability of low-cost efficient tires is in general not given. Only high quality brands such as Michelin or Bridgestone offer LRRs. These are however high price brands. The majority of truck tires used are however low cost brands or re-treaded tires. The absolute price difference between a commonly used tire and a LRR is therefore significant (around double) due primarily to brand differences (the average difference between same brand LRR and conventional tire is only 40-50 USD per tire). This limits the application of LRRs due to limited market availability. Also in many countries truckers still use tube tires whilst LRR tires are basically for tubeless tires requiring an additional investment in rims. Tube tires are preferred by many truckers as they are cheaper and allow for overloading with less potential of blow-outs.
- The majority model used for "fuel management" by trucking companies in both countries is to pay drivers a fixed allowance for fuel based on the trip realized[36]. This avoids fuel stealing or haggling with drivers. The down-point is that reliable fuel consumption data lacks and that companies are not very interested in fuel saving technologies as they have to pay the additional investment but the savings are pocketed by the driver. This creates a significant

[33] Cost of course and day lost for work
[34] Impact of course estimated at 12 months
[35] Based on TTW GHG avoided using NPV with a WACC of 8.5%
[36] In various trucks the driver dismantled the installed equipment for fuel measurement indicating that it hindered truck performance. The equipment has no incidence on truck performance but obviously the driver feared that knowledge over actual fuel consumption would result in reducing his payment for fuel.

barrier for monitoring GF programs and for creating interest for implementing measures. This situation might change in the future with more telematics included in trucks and with electronic fuel payment. However, as of today, it constitutes a significant barrier towards adoption of GFTs, especially of smaller and less organized companies.

6.3. Financial Structuring Possibilities

6.3.1. ESCO

Traditional Energy Service Company (ESCO) structures are deemed as not applicable for GFTs. The majority of ESCOs follow the "Energy Performance Contracting" model where the ESCO guarantees a specific level of energy savings and amounts in excess are shared with the ESCO. Terms, including the split, are agreed at project start, based on project type, bargaining power, and financing. The non-applicability of ESCOs to GFTs is due to the scale of measures involved and contractual issues. Next to this energy savings in GFTs are very difficult to monitor and to relate precisely to the implemented GFT as fuel usage depends on multiple factors many of which are external to the company. Also the impact of GFTs is relatively small compared to total fuel usage and compared to average fluctuations between trucks, routes, drivers and driving circumstance thus making it difficult to have an undisputed fuel saving related to a specific device.

6.3.2. Group Purchasing

A cooperative or group purchasing organization (GPO) is an entity that is created to leverage the purchasing power of a group of businesses to obtain discounts from vendors based on the collective buying power of the GPO members. GPOs are either funded by administrative fees that are paid by the vendors that GPOs oversee, by the buying members or by a combination of both of these methods. Group purchasing is used in many industries to purchase raw materials and supplies - alone in the US there are, based on the National Cooperative Business Association, around 250 purchasing cooperatives.

The following table gives an indication of percentage savings per area of group purchasing schemes in the US.

Table 19: Typical GPO Savings

Input	Estimated Percentage Saving
Fuel	2%
Tires	3-10%
New Trucks	1%
Oils	5%
Fleet logistics, software	8-10%
Finance/factoring	2%

Source: Truckers B2B and LCAPP website and calculations by Grütter Consulting

The majority of discounts are in the 5% or lower range.

Group purchasing has been taken up by independent companies which focus on this service as profit enterprise i.e. is not managed in general by trade and business associations. These organizations are

increasingly competing in the market with virtual buyers groups formed by social media or others on the Internet as well as through companies such as Amazon which can often offer similar discounts. It is therefore questionable if the traditional group purchase approach on a sectoral base will survive or if this will be taken over through virtual buyer associations or massive Internet-based trading companies such as Amazon.

6.3.3. International Experience with Financing GFTs

In numerous countries GFTs have been financed at least partially with subsidies paid by the government. As example small trucking companies in Chile received subsidies for acquiring aerodynamic equipment paid for by the Chilean Energy Efficiency Agency. Another example are various truck scrapping programs (e.g. in Mexico or Colombia) which subsidize early retirement of elder trucks and their replacement with new and environmentally less polluting entities.

A slightly different approach discussed in detail in the following section was taken by Cascade Sierra Solutions (CSS) in the US, by the Guangdong Green Freight Programme and in Switzerland. However, all of these approaches have in common that they have grant finance involved related to pollution, energy savings and/or the climate impact.

Cascade Sierra Solutions GF Financing

CSS founded in 2006 in the US served as a bridge between truck owners, banks and government agencies to arrange low-interest loans or grants to truck owners to purchase “green” trucks or retrofit GFTs. CSS used loan and grant capital provided for basically by government entities including primarily the US-EPA and the US Department of Energy to leverage further private investments using the funds as security to raise private capital at a ratio of up to 9:1. The bank has more confidence as the CSS loan/grant part is at risk first. When recession hit the US a high number of trucking companies defaulted on the loans to CSS and the entity had to wind down operations 2014.

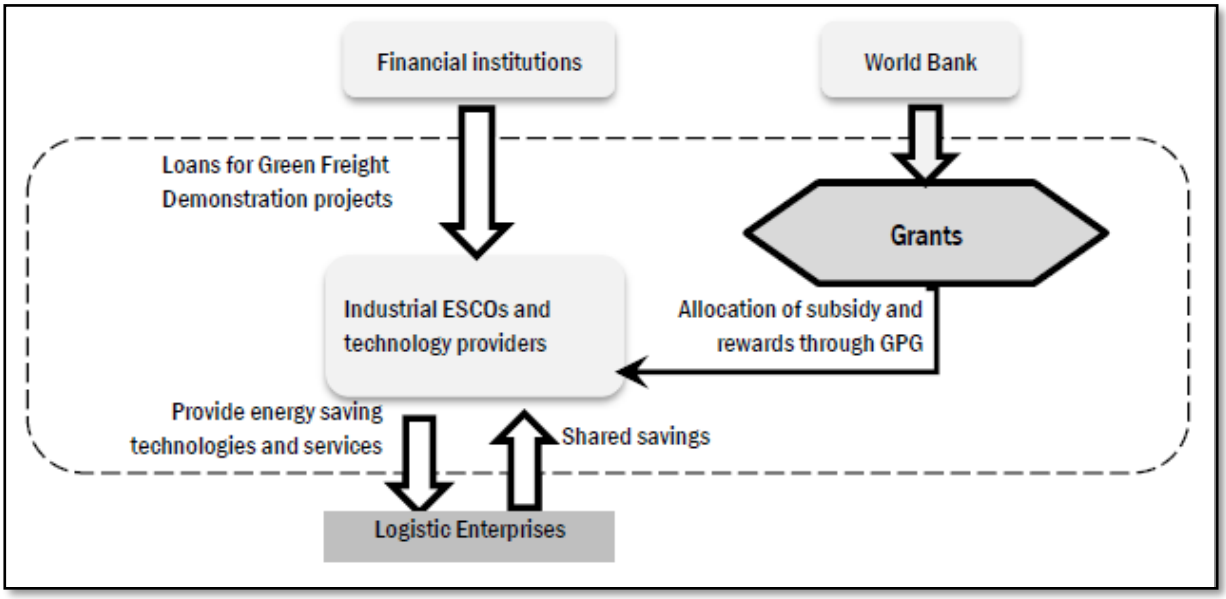
The interesting element of CSS is using grant money to leverage private capital and bring in banks. This increased considerably the scope and outreach of the program. Leverage of capital however also entails leveraging risks. Not uncommon for revolving funds the default rates and risks were systematically underestimated leading eventually to the collapse of the scheme.

Guangdong Green Freight Programme

The 14 MUSD Guangdong GFP is a World Bank / GEF supported demonstration program on energy efficiency and emission reduction in the freight sector and has as one of three components GFTs (GFT budget 10 MUSD). The financial mechanism is based on an ESCO. The technology providers are introduced to transport companies as industrial ESCOs. The ESCOs take on the performance risk and provide project-specific financing while holding the packages of GFTs on their balance sheets. The World Bank grants are allocated as subsides totalling around 30% of the purchasing price of the GFT to the ESCOs thus repaying the loans together with the savings from the technologies (see figure below). Savings or performance data is collected and provided for by the South China University of Technology. The individual ESCOs receive a loan of USD 100,000 from the Industrial Bank guaranteed for by the World Bank. The guarantee is provided for by the World Bank as the probability of receiving a non-guaranteed credit is considered as slim. The technology providers are thus able to provide

trucking companies with a package of fuel-efficient solutions. For banks the process is simpler as they only need to finance ESCOs and not individual trucking companies.

Figure 14: Financial Mechanism of GFP, Guangdong



Source: GIZ, Analysis of Climate Finance Policies and Innovative Finance Mechanisms in Guangdong, 2014

In practical implementation the approach has shown various limitations:

- Without the World Bank guarantee, FIs would not have issued the ESCOs credits;
- The leverage factor is marginal;
- The fuel savings impact and the measurement of latter are disputed;
- Monitored data is not transparent and unreliable;
- Long time frame for applications and high complexity to receive subsidies and rewards;
- Non-inclusion of SMEs although these form the backbone of logistics in China due to perceived risk and lack of interest;

The approach uses the provision of financing of GFT rebates and performance-based payments, without however having realized a sound monitoring protocol and structure. Performance levels and payments are therefore disputed. Whilst theoretically the model operates with shared savings in practice loans are simply repaid by companies plus by the subsidy received from the World Bank.

Swiss Climate-Based Finance Scheme

The Swiss scheme is based on a performance-based payment for GHG reduction. Companies can invest in any GFT including tires, aerodynamic equipment, truck replacement or also Eco Drive which result in reduced GHG emissions. The performance risk of equipment is thereby with the investor i.e. trucking company. A GHG baseline in terms of CO_2/tkm is established upfront, validated externally and approved by the government. The baseline and benchmark is thereby for the entire fleet i.e. fleet improvements are monitored. Monitoring based on an established monitoring protocol (includes basically fuel consumption and distance driven) is realized by the company and uploaded on an Internet-based platform. External verification of data is based on automated statistical control mechanisms as well as randomized spot verifications. Payments are based on absolute GHG emission

reductions over a specified time-period of on average 5 years. The company gets (paid) advisory services on actions with a mitigation potential but remains free on which activities to implement and also finances with own resources or with own credits mechanisms their implementation. The result-based finance is based on GHG reductions relative to the benchmark/baseline. The GHG rights are thereby transferred to the Swiss government respectively other emitters with caps within the Swiss domestic carbon trading system.

Basically companies invested in fleet renewal, LRRs, wide-based tires, Eco Drive and few in advanced aerodynamic systems. On average the GHG payment covered more than the total differential investment for LRRs and significantly more than 50% of the investment cost e.g. of aerodynamic devices or of wide-based tires[37].

To reduce transaction costs companies were pulled together into groups of 10-15 companies which received common consulting, validation and verification services thus reducing advisory and management costs and allowing also small companies with only 3-5 trucks to participate. Companies acquired individually GFTs i.e. no group-payment scheme was realized. Also companies receive payment and credits based on their individual performance and not based on group performance. The group scheme was basically set up to allow for interchange of experiences and for reducing costs of verification and consulting services.

More than 100 trucking companies have been involved in this scheme in Switzerland since 2010.

6.3.4. Climate Finance

Various GFPs have been financed with the justification of climate change. This holds true of various national initiatives (e.g. US EPA), the GEF/World Bank Guangdong GFP or the Mexican GFP co-financed by the Climate Technology Fund (CTF, 50 MUSD) and the World Bank (50 MUSD). The CTF thereby used as benchmark for interventions in this area a value of 20 USD/tCO_2[38]. However, this is not result-based finance but based on ex-ante estimates of abatement costs.

No CDM (Clean Development Mechanism) or VCS (Verified Carbon Standard) project with GFTs has been registered. However as previously mentioned a domestic Swiss program has included more than 100 trucking companies with result-based finance based on GHG emission reductions.

No Nationally Appropriate Mitigation Action (NAMA) has yet been funded or has been prepared for freight. A unilateral NAMA in Colombia for the scrapping and replacement of trucks exists (it was formulated as a NAMA to evidence Colombian commitment to climate change but the program was already in operation prior NAMA formulation). In Mexico GIZ is preparing a NAMA for freight including GFT measures.

Various windows exist for financing GFTs based on the climate impact including funds from multilateral banks, the CTF, NAMAs as well as the Green Climate Fund (GCF) which has sustainable transport as one of 4 core areas within mitigation projects. GHG reductions as well as the impact towards sustainable development are thereby crucial. GF measures not only reduce fuel consumption but also

[37] The payment per tCO_2 offset was around 130 USD/tCO_2

[38] See Climate Investment Funds, CTF Investment Plan for Mexico: Phase II, 10/2013, p.52

diesel exhaust ultrafine particles and Black Carbon. The Climate and Clean Air Coalition (CCAC) has for example an initiative of "Reducing Black Carbon Emissions from Heavy Duty Diesel Vehicles and Engines"[39] as BC is a significant driver of climate change, especially in the short-term, and particle emissions are a major air pollution problem. Diesel exhaust emissions are thereby a major factor of BC emissions. A GFP therefore fits well within national and international strategies to combat climate change and air pollution.

A financial structuring could be based around a Green Freight Fund which gives grants and technical assistance to GF technologies and activities. Grant elements of such a fund could be phase out within a period of 3-5 years. The structure for such a fund could be established within a NAMA with finance e.g. from the GCF.

[39] http://www.unep.org/ccac/Initiatives/ReducingEmissionsFromHeavyDutyDiesel/tabid/133573/Default.aspx

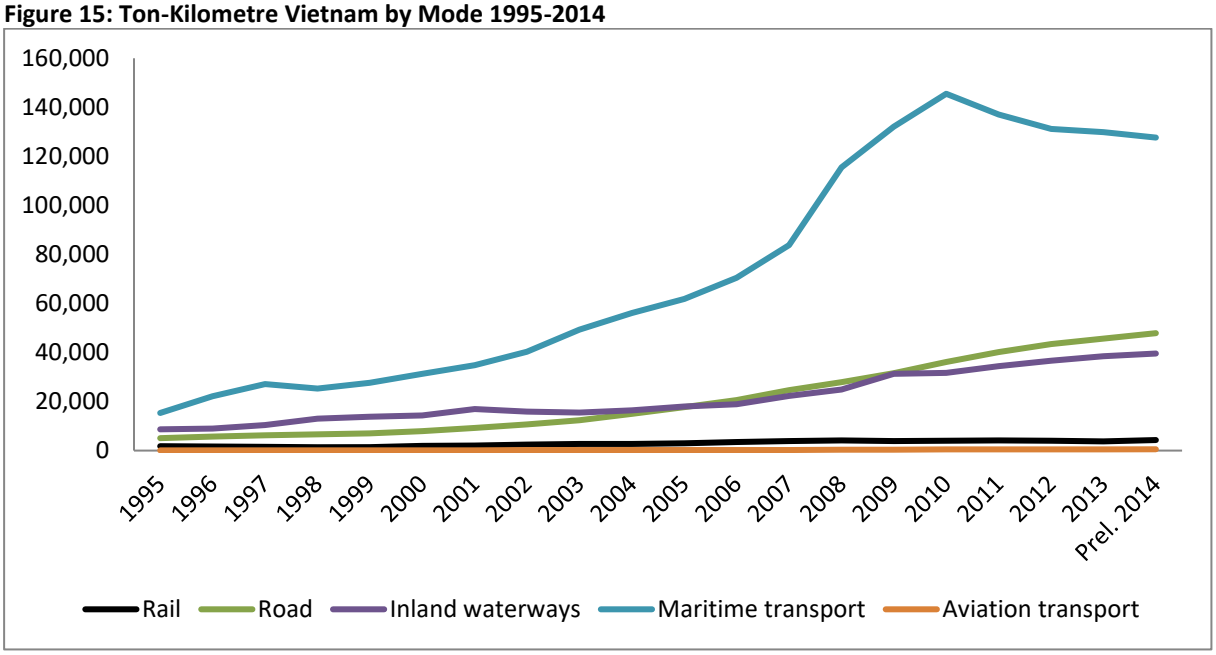
7. Steps Forward

7.1. Potential Viet Nam

Total GHG emissions of Vietnam 2010 were 226 $MtCO_{2e}$ of which the energy sector accounted for 141 $MtCO_{2e}$ or 63%. It is expected that total GHG emissions will increase under Business as Usual (BAU) by 2020 to 474 $MtCO_{2e}$ and by 2030 to 787 $MtCO_{2e}$ i.e. a 3.5x increase compared to 2010[40]. Transport emissions which form part of the energy sector represent in 2010 around 32 $MtCO_{2e}$ (23% of energy emissions or 14% of total GHG emissions[41]) and are expected under BAU to increase by the factor 2.8 until 2020. Within the transport sector, road transport accounts for roughly 88% of GHG emissions in 2010[42]. By 2012 Vietnam had around 39 million vehicles dominated by around 95% motorcycles[43].

In freight transport ton-kilometre (tkm) growth in period 1996-2014 has been factor 7 which corresponds to an annual growth rate of 11% (see figure below). For 2030 it is expected that tkm demand will be approximately 3x the 2014 level[44].

Figure 15: Ton-Kilometre Vietnam by Mode 1995-2014

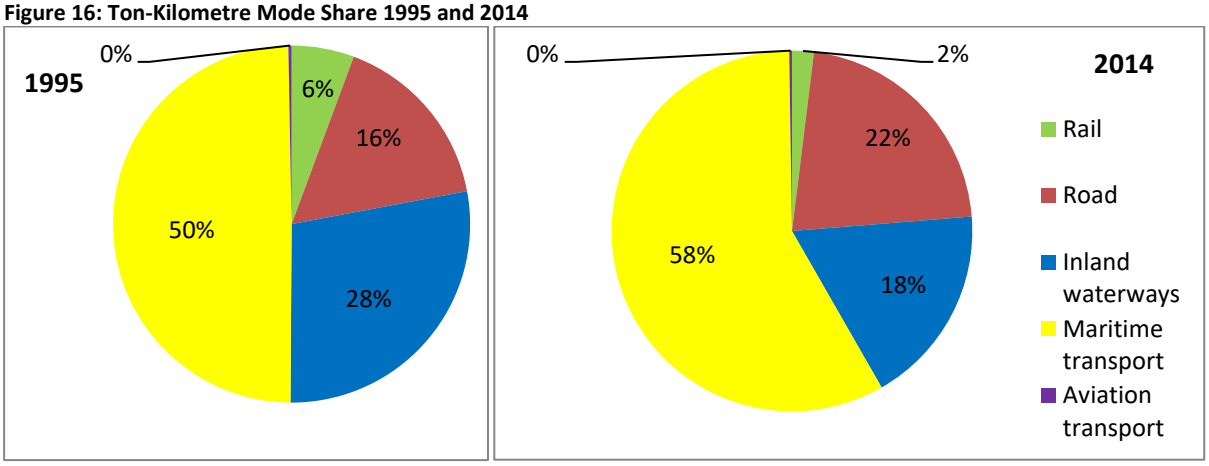


Source: General Statistics Office Vietnam, 2016

Maritime transport continues to be the dominant mode of transport. However, in absolute numbers it is decreasing since 2010 whilst road transport is steadily growing increasing its mode share of tkm between 1995 and 2014 from 16 to 22% (see figure below).

[40] MONRE, 2014
[41] MONRE, Table 2.4., 2014
[42] MONRE, 2014
[43] Vietnam registry; see GIZ, 2015
[44] Almec, 2010

Figure 16: Ton-Kilometre Mode Share 1995 and 2014



Source: General Statistics Office Vietnam, 2016

Considering only volume of freight, road transport dominates with 77% of all transported freight volume[45]. Maritime transport has however a much higher average trip distance i.e. for long-distance freight transport, the mode of choice in Vietnam remains maritime transport, also due to the long coastal line of the country.

Vietnam's **Intended Nationally Determined Contribution** (INDC) has as unconditional contribution a reduction of GHG emissions compared to BAU by 2030 of 8% in which the emission intensity per unit of GDP shall decline by 20% compared to 2010 levels[46].

Within the INDC as example the implementation of vehicle maintenance is included as mitigation option[47].

The potential GHG impact of a GF program depends basically on the number of trucks participating in the program. A low scenario (25% of trucks participating) and a high scenario (50% of trucks participating) has been modelled. The following table shows the projected GHG reductions annually in tCO_2 by 2030.

Table 20: Annual Potential GHG Reductions of GFP by 2030 in tCO_{2e} (WTW incl. BC)

Option	Value (low to high)
Operational measures (technical options and Eco Drive)	600,000-1,200,000
Operational measures plus Diesel Particle Filter	900,000-1,800,000
Operational measures + DPF + increase of average GVW by 5t[48]	1,100,000-2,200,000

Source: All calculations by Grütter Consulting (tkm data based on road-based tkm projections of JICA)

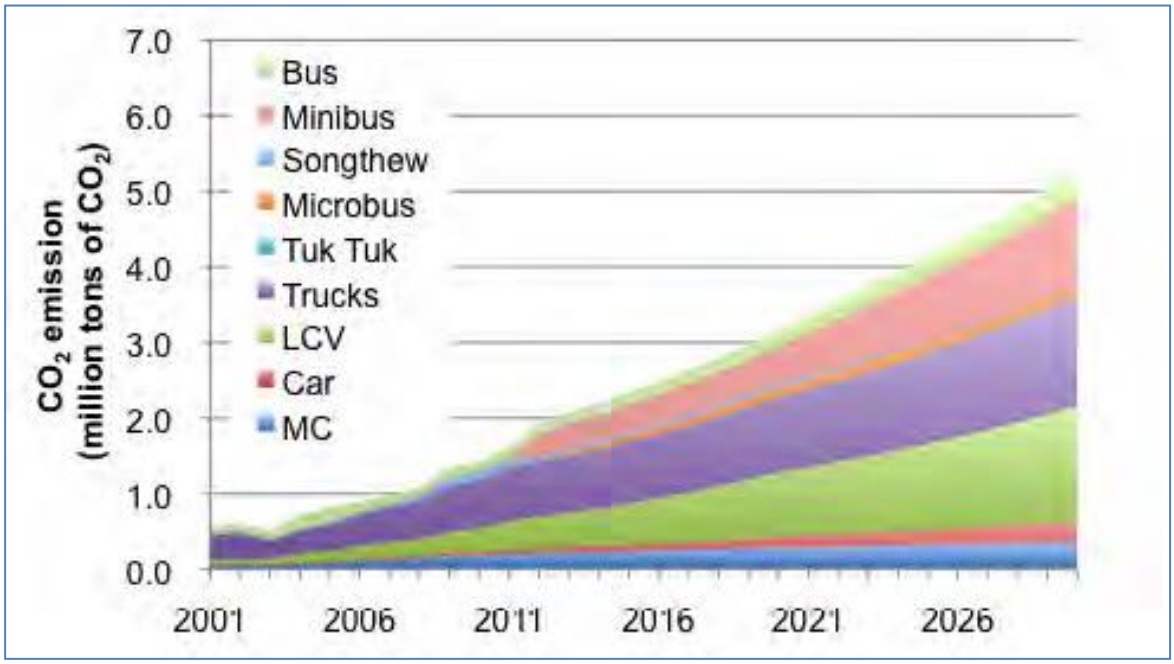
7.2. Potential Lao PDR

According to Lao PDR Second National Communication, total GHG emissions in 2000 were 50 $MtCO_{2eq}$, of which the energy sector accounted for 2% of the total GHG emissions. Within the energy sector

[45] GSO, 2016
[46] Government of Vietnam, 2015
[47] http://www4.unfccc.int/submissions/indc/Submission%20Pages/submissions.aspx
[48] assuming constant average load factor per tkm

transport is responsible for around 50% of emissions[49]. However, transport-related CO_2 emissions are increasing rapidly from around 650,000 tCO_2 in 2001 to 2.2 million tCO_2 in 2011[50]. The major sources of emission are from trucks and light commercial vehicles. This data also matches calculations based on reported gasoline and diesel transport consumption values of 2014[51] which result in GHG transport emissions for the year 2014 of 2.3 $MtCO_2$. It is projected that transport sector emission will reach nearly 4 million tCO_2 by 2020 and 6.3 $MtCO_2$ in 2030.

Figure 17: Projected CO_2 Emissions of the Transport Sector



Source: Almec, 2012

Road transport dominates the transport systems in Lao PDR. Road transport represents 95% of total passenger-kilometres travelled and 88% of freight-kilometres travelled[52]. Transport activities for both passengers and freight have grown rapidly during 2005-2010. Freight transport has increased from 260 to 510 million tkm, which represents an almost double (97%) increase within 5 years.

In 2011, there were around 200,000 cars, 900,000 motorcycles and 26,000 other vehicles (trucks, buses, trailers, three wheelers). In 2030, it is projected that the total number of motor vehicles in the country will increase to almost 2 million vehicles[53].

According to Lao PDR's **INDC** (2015)[54], the country intends to undertake a number of mitigation actions to reduce its future emissions, subject to provision of international support. However, the INDC does not provide any specific target.

The following table shows the potential GHG reductions of a GFP annually in tCO_2 by 2030.

[49] As electricity in Laos is generated almost 100% from hydropower, emission from energy generation is almost negligible.
[50] Almec, 2012
[51] Ministry of Energy and Mines, 2015
[52] Almec, 2012
[53] Almec, 2012.
[54] MONRE, 2015

Table 21: Annual Projected GHG Reductions of GFP by 2030 in tCO_{2e} (WTW incl. BC)

Option	Value (low to high)
Operational measures (technical options and Eco Drive)	8,000-17,000
Operational measures plus Diesel Particle Filter	11,000-22,000

Source: All calculations by Grütter Consulting

Emission reductions are thus in a relatively low range due to the limited number of trucks and freight movement in Lao PDR with around 20-20,000 tCO_{2e} reduced per annum.

7.3. Potential Measures and Approaches

Implementation of efficiency measures which have a small and hardly felt impact but a clear additional upfront cost are difficult to implement on a widespread base. In the following section strategies are outlined which are considered to be the most promising to be able to reap the GHG and environmental benefits as well as the financial advantages of GFTs.

For **Eco Drive** the path proposed is to include Eco drive components in the compulsory curricula for driver training. This path is being followed in both countries due to active support of the project. A curricula adapted to national circumstances and needs has been developed and the national authorities are including core Eco drive elements in the curricula for driver training. This path has been followed by many other countries worldwide with good success. Continuous feedback and an incentive system or telematics are however required to reap the full potential of Eco Drive.

For **LRRs** the most promising pathway is considered to have national regulations concerning CORs of tires. Within the EU regulations exist which specify minimum requirements for COR. The current requirements are a maximum of 8.0 kg/t for tires sold after 1.11.2016 and maximum 6.5 kg/t for new type approvals of tires (for tires sold this value will be enforced from 1.11.2020 onwards). The EU also introduced a standardised tire label including energy efficiency based on the COR, wet grip and noise, effective as from the year 2012. As first step an energy efficiency label comparable to the well-known energy labels of consumer goods can be introduced, followed by compulsory or market based performance standards for tires. This allows for a widespread market penetration of high-efficient tires and is a cost-effective approach.

For other **GFTs** such as aerodynamic devices, Diesel Particle Filters (DPFs) to reduce PM and thereby BC, usage of low-carbon trucks and fuels as well as other measures a GF climate finance fund could be implemented which reduces upfront costs of such technologies based on their GHG impact thereby increasing significantly the attractiveness of GFTs. Such a climate fund could be coupled with technical assistance as well as dissemination of best practices. The fund could be financed on a non-reimbursable manner through climate funds based on the social cost of carbon. Comparable funds have been successful in the transportation industry e.g. in the promotion of low-carbon buses: examples are the Green Bus Fund of the UK or Chinese funds for hybrid and electric units which could be downsized or completely phased out after a short time and created a transformational impact in promoting new technologies.

For **logistics** a possible pathway is the increased usage of telematics combined with carbon tracking and the increased penetration of green logistics and low carbon transport resulting in a demand for

improved logistics more sensitive towards GHG emissions. This can increase the attractiveness of platforms and other means to increase the load factor of trucks.

Other measures which could also be explored further include the usage of larger trucks with more payload thereby reducing GHG emissions per tkm and improving traffic fluidity thereby reducing stop and go traffic and increasing the average speed of trucks. Also the establishment of fuel consumption standards for new trucks, as introduced e.g. in the US, is a pathway worth exploring.

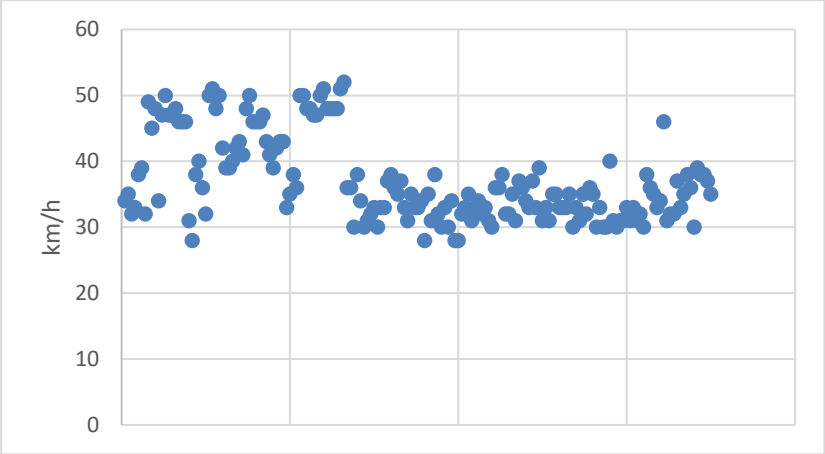
8. Implementation Experience

The following points summarize the main project implementation experiences.

Localize the Project

Local driving circumstances, especially speed, are very important. Experiences from international, especially US or European GF programs are only partially valid as speeds driven vary considerably resulting in no impact of various GFTs e.g. most aerodynamic equipment (see figure below for average speeds).

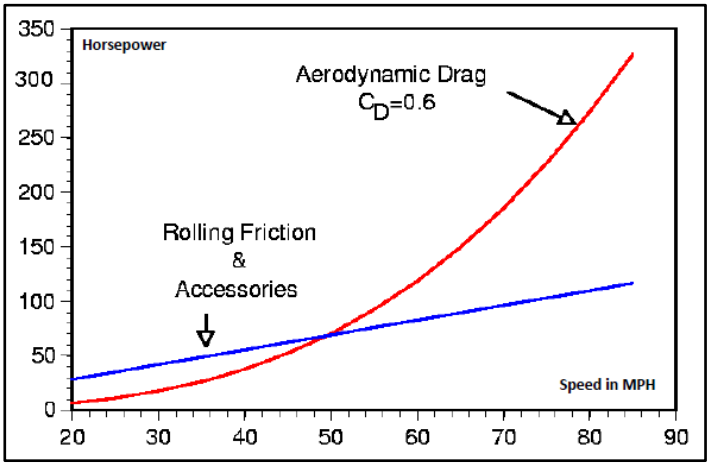
Figure 18: Average Driving Speeds Long-Haul Trucks Viet Nam and Lao PDR



Source: Grütter Consulting based on GPS measurements during various months

Average driving speeds for long-haul trucks were in both countries around 40km/h whilst in the US the average on high-ways is 90km/h[55]. The figure below shows the implications for any aerodynamic equipment.

Figure 19: Power Required to Overcome Aerodynamic Drag at Different Speeds



Source: F. Browand, USC Viterbi, Reducing Aerodynamic Drag and Fuel Consumption, 2005

[55]http://www.statista.com/statistics/195100/average-operating-truck-speed-on-selected-us-interstate-highways/

Also idling fuel losses are very much higher in the US or Europe due to truck cabins equipped with many devices and due to sleeping in cabins with AC whilst in Viet Nam or Lao PDR truck cabins are less equipped, AC is not commonly used and often drivers do not sleep in cabins.

GF programs therefore need to be adapted to local circumstances.

Availability of Technologies

Availability of low-cost efficient tires is in general not given. Only high quality brands such as Michelin or Bridgestone offer LRRs. These are however high price brands. The majority of truck tires used are however low cost brands or re-treaded tires. The absolute price difference between a commonly used tire and a LRR is therefore significant (around double) due primarily to brand differences (the average difference between same brand LRR and conventional tire is only 40-50 USD per tire). This limits the application of LRRs due to limited market availability. Also in many countries truckers still use tube tires whilst LRR tires are basically for tubeless tires requiring an additional investment in rims. Tube tires are preferred by many truckers as they are cheaper and allow for overloading with less potential of blow-outs.

Low technology availability can result therefore in significant additional GFT costs.

Fuel Monitoring and Fuel Management by Companies

The majority model used for "fuel management" by trucking companies in both countries is to pay drivers a fixed allowance for fuel based on the trip realized[56]. This avoids fuel stealing or haggling with drivers. The down-point is that reliable fuel consumption data lacks and that companies are not very interested in fuel saving technologies as they have to pay the additional investment but the savings are pocketed by the driver. This creates a significant barrier for monitoring GF programs and for creating interest for implementing measures. This situation might change in the future with more telematics included in trucks and with electronic fuel payment. However, as of today it constitutes a significant barrier towards monitoring and adoption of GFTs, especially of smaller and less organized companies.

Load Measurement

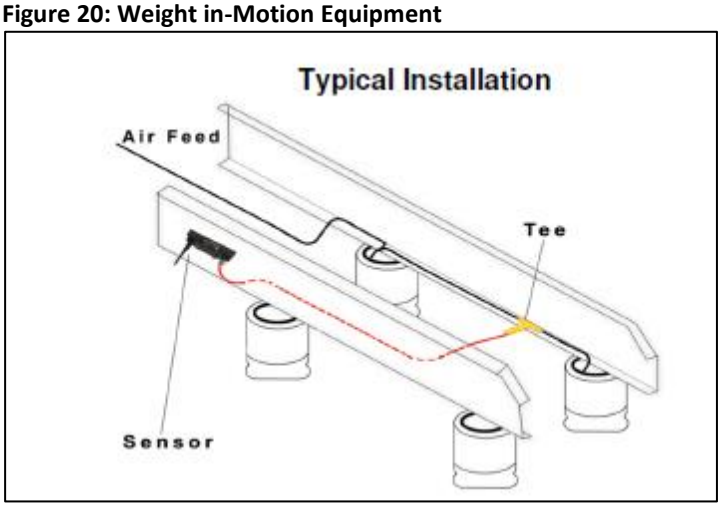
Data on actual load factor per goods type and direction are important to identify promising logistics improvement options. Empty backhaul numbers are often exaggerated and not put into context with potentially asymmetric good flows thus overestimating improvement potentials. Again, international bets practice needs to be contrasted with local circumstances and this involves collection of primary data as latter is often not available to assess the current situation in a detailed manner.

Trucks lack telematics to monitor actual weight. Monitoring per tkm, which would be optimal for tracking GHG efficiency, is therefore hardly possible. Data from companies and freight documents have proven to be unreliable and not precise enough. Therefore, installation of weight in-motion equipment which automatically weights truck tonnage would be advisable. Typically, such equipment reads pressure and strain changes in the rig's air or mechanical suspension systems. Tiny sensors are

[56] In various trucks the driver dismantled the installed equipment for fuel measurement indicating that it hindered truck performance. The equipment has no incidence on truck performance but obviously the driver feared that knowledge over actual fuel consumption would result in reducing his payment for fuel.

mounted to the suspension of the tractor or trailer. Weight measurement accuracy is within 0.3 to 2% of the gross vehicle weight.

Figure 20: Weight in-Motion Equipment



Source: http://www.truckweight.com/manuals.html

On the other hand, the experience has also been made that over various months, average load factors remain fairly constant and therefore monitoring approaches using long enough periods and using only data of fuel efficiency per kilometre are sufficiently reliable.

Usage of telematics which provide continuous data on actual load factors can be used for monitoring as well as for logistics data (combined with freight papers to identify goods transported). However, such equipment can be costly, is locally not available and companies have currently little incentive to install such equipment (the major reason in some countries to install such equipment is for load tracking and safety reasons i.e. to be advised of unplanned off-loading).

Measurement

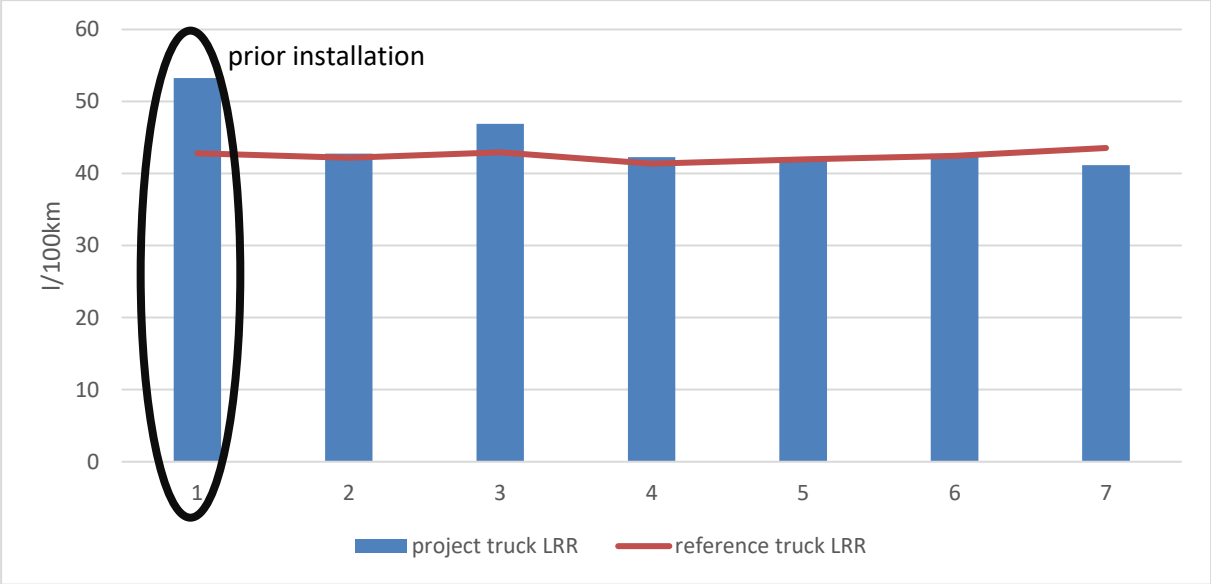
Reliable and local data over the impact of GF measures is scarce. Measurements are either not made at all, without adequate equipment, with a to small sample of units or with a faulty methodological approach. As example US Smart Way is often used to project GF potentials thereby largely overstating e.g. the impact of aerodynamic devices due to differing vehicle speeds and traffic circumstances. Another example is Eco Drive where often the improvement values of training courses are taken which are of limited value. The program has proven to be effective in designing and implementing a high-quality GFT measurement system thereby producing local impact data of value also for other GF interventions.

Monitoring

The monitoring approach based on comparison before-after has proven to be the most reliable approach. The test-run can be very standardized. However, variations between routes, trucks, drivers and driving circumstances make the result of just one test-run of little validity. The method of comparing project with reference trucks is complex. Inherent differences (external to the technology applied) exist between trucks (even of the same brand and make) and drivers. Therefore, such an approach is **only** valid if measurements of both trucks are also made sufficient time before installing any equipment to identify the difference of fuel consumption between both trucks already before. This

approach allows to separate the external fuel usage difference from project induced differences (see following graph as example). The most reliable approach is however considered to be the comparison before-after. However, this requires sufficient time (best 3-6 months) of monitoring before installing equipment and thereafter to filter out standard monthly variations.

Figure 21: Comparison Project and Reference Truck



Source: Grütter Consulting; example of two identical trucks; project truck equipped with aerodynamics

The example in the figure above shows that if only a comparison had been made between the reference and the project truck after installation of the equipment (months 2-7) there would have been no measurable impact of the aerodynamic device. However, the truck where the aerodynamic device was installed had in the months prior installation (summarized under “1” in the figure above) a significantly higher fuel consumption than the reference truck. Therefore, an approach using reference trucks needs to include a measurement already prior installation of equipment.

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