ESCAP
Economic and Social Commission
for Asia and the Pacific

# MANUAL

## Sustainable and Energy Efficiency of the Freight Transport Sector

This Manual is developed based on the "Study Report on Enhancing Energy Efficiency of the Freight Transport Sector in Asia and the Pacific".

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## Acronyms and Abbreviations

| | | |
|---|---|---|
| ANPR | - | Automatic Number Plate Recognition |
| BEV | - | Battery Electric Vehicle |
| CAREC | - | Central Asia Regional Economic Cooperation |
| CNG | - | Compressed Natural Gas |
| COx | - | Carbon Oxides |
| COP | - | Conference of Parties |
| DSRC | - | Dedicated Short-Range Communications |
| EAEU | - | Eurasian Economic Union |
| ECE | - | Economic Commission for Europe |
| ESS | - | Energy Storage Systems |
| ESCAP | - | Economic and Social Commission for Asia and the Pacific |
| GPS | - | Global Processing System |
| HC | - | Hydrocarbons |
| HDV | - | Heavy-Duty Vehicle |
| HFAV | - | Highly and Fully Autonomous Vehicles |
| ICE | - | Internal Combustion Engine |
| IEA | - | International Energy Agency |
| ITS | - | Intelligent Transportation System |
| ITF | - | International Transport Forum |
| IoT | - | Internet of Things |
| LNG | - | Liquified Natural Gas |
| NOx | - | Nitrogen Oxides |
| PHEV | - | Plug-in Hybrid Electric Vehicle |
| PM | - | Particulate Matter |
| PPP | - | Public, Private Partnerships |
| R&D | - | Research and Development |

| | | |
|---|---|---|
| RFID | - | Radio Frequency Identification |
| SAE | - | Society of Automotive Engineers |
| TRACECA | - | Transport Corridor Europe-Caucasus-Asia |
| UNEP | - | United Nations Environment Program |
| UNFCCC | - | United Nations Framework Convention on Climate Change |
| WIM | - | Weigh-in-motion |
| V2I | - | Vehicle to Infrastructure |
| V2V | - | Vehicle to Vehicle |

## Purpose of the manual

This manual is intended to serve as a comprehensive guide for policymakers, planners and stakeholders involved in the development and implementation of sustainable freight transport strategies.

The objective of the manual is to provide an in-depth understanding of the various aspects of sustainable freight transport. The manual covers a wide range of topics, ranging from modal shift and multimodality to the latest in technological advancements, policy measures and regulatory frameworks. This information is crucial for informed decision-making and strategic planning.

Beyond theoretical knowledge, the manual offers practical guidance on implementing sustainable freight transport strategies. It includes step-by-step processes, examples of successful case studies, and best practices from around the world, providing a real-world context to the theoretical frameworks.

A significant focus of this manual is to assist policymakers in developing effective policies that promote sustainable freight transport. In it, various policy instruments are explored, their potential impacts are evaluated and how to tailor these policies to different regional and local contexts is explained.

The ultimate goal of the manual it to contribute to global efforts to combat climate change and environmental degradation. By equipping policymakers with the necessary knowledge and tools, it aims to drive a transition to more sustainable and eco-friendly freight transport systems globally.

Recognizing that sustainable freight transport requires a collaborative approach, this publication also serves as a platform to encourage dialogue and cooperation among stakeholders, including government agencies, industry players and community groups.

Finally, the manual functions as a reference resource for ongoing and future initiatives in sustainable freight transport. In it, a wealth of information has been compiled, including statistical data, research findings and policy analyses, making it a valuable resource for continuous learning and reference.

Through this manual, it is hoped that policymakers and stakeholders will be empowered with the knowledge and tools necessary to navigate the complexities of sustainable freight transport and to make impactful decisions that pave the way for a greener and more sustainable future in freight transportation.

## How to use this manual

The *Way to Sustainable Freight Transport: A Policymaker's Handbook* is intended to be user-friendly and accessible for individuals with various levels of expertise in the field of freight transport and policymaking. To get the most out of this manual, the user should consider the following guidelines:

- **Become familiar with the structure:** Start by reviewing the table of contents to understand the manual's structure and the range of topics covered. This gives the user a clear idea of the manual's flow and how the chapters are organized.
- **Identify needs:** Depending on the user's specific role, interests or requirements, identify the sections that are most relevant, for users new to the topic, it might be beneficial to read the manual sequentially. More experienced users may choose to focus on specific chapters or topics.
- **Engage with case studies and examples:** Throughout the manual, case studies and real-world examples are presented. These are included to provide practical insights and to demonstrate how theoretical concepts are applied in practice. Users need to take time to understand these examples as they can offer valuable learning.
- **Utilize tools and resources:** Make use of the tools, templates and resources provided in the manual. These are designed to help the users implement the concepts and strategies discussed. They can be particularly useful in planning, decision-making and policy formulation.
- **Interactive learning:** Engage with any exercises or discussion prompts provided. These interactive elements are intended to reinforce learning and to encourage critical thinking about the subject matter.
- **Maintain regular reference:** Keep the manual handy for regular reference. As situations or policies evolve, revisiting relevant sections of the manual can provide guidance and refresh your knowledge.
- **Share and discuss:** Use the manual as a tool for discussion with colleagues and stakeholders. Sharing insights and discussing concepts can enhance understanding and foster collaborative approaches.
- **Stay updated:** The field of sustainable freight transport is continuously evolving. While this manual provides a comprehensive overview, staying abreast of the latest developments, research and emerging technologies in the field is crucial.

By following these guidelines, users can effectively navigate through the manual and leverage its contents to enhance their understanding and application of sustainable freight transport strategies.

# Chapter 1: Technologies for sustainable mobility

## 1.1 Electric and alternative fuel vehicles

Electric and alternative fuel vehicles represent a significant shift in automotive technology, which is aimed at reducing dependency on fossil fuels and decreasing emissions that contribute to pollution and climate change. These vehicles come in various forms, utilizing different energy sources to power their engines, such as electricity, hydrogen and biofuels. The main types of electric and alternative fuel vehicles are described in Table 1.

**Table 1 Classification of electric and alternative fuel vehicles**

| Vehicle types | Description |
|---|---|
| Battery electric vehicles (BEVs) | Powered entirely by electricity stored in rechargeable battery packs. BEVs produce zero tailpipe emissions, making them an environmentally friendly choice. They are recharged via an electrical power source and are recognized for their efficiency and relatively low operating costs. |
| Hybrid electric vehicles (HEVs) | HEVs combine a conventional internal combustion engine (ICE) with an electric propulsion system. This dual setup allows HEVs to achieve better fuel efficiency and lower emissions than solely gasoline-powered vehicles. The electric motor can assist ICE, reducing its workload and enhancing fuel economy. |
| Plug-in hybrid electric vehicles (PHEVs) | Similar to HEVs, PHEVs have an electric motor and a gasoline engine. However, PHEVs can be plugged into an external electrical source to recharge their batteries, unlike traditional HEVs. This allows them to drive significant distances on electricity alone before switching to gasoline. |
| Fuel cell electric vehicles (FCEVs) | FCEVs are powered by hydrogen gas that is used to produce electricity through a fuel cell. The only byproduct from this process is water, making FCEVs exceptionally eco-friendly. These vehicles are also known for their quick refuelling times and long ranges. |

***Source*:** Compiled by the authors using information aggregated from various publicly available sources, including industry reports, publications, and academic studies on electric vehicles.

Countries around the world are increasingly adopting electric and alternative fuel vehicles as part of their strategies to meet environmental targets and reduce oil dependency. Governments are supporting this transition through incentives, such as tax breaks, subsidies and investment in charging infrastructure.

Leading countries in the adoption of these technologies include China, Germany and Norway, where policies have significantly driven the growth of electric vehicle sales. Additionally, international collaborations and technological advancements are helping to overcome barriers, such as high costs, limited range and charging infrastructure issues.

The use of electric and alternative fuel vehicles can significantly reduce greenhouse emissions over their life cycle, contributing to global efforts to combat climate change. Below are the key ways in which these vehicles help reduce emissions:

- ***Reduced tailpipe emissions.*** Electric vehicles, including BEVs and FCEVs, emit no tailpipe pollutants, which drastically reduces local air pollutants and greenhouse gas emissions. PHEVs and HEVs also have significantly lower emissions by combining electric drive with more efficient use of internal combustion engines.
- ***Renewable energy integration.*** When electric vehicles are charged using renewable energy sources, such as solar, wind and hydroelectric power, the overall emissions associated with their energy consumption can be negligible. This integration helps in reducing the life cycle greenhouse gas emissions substantially as compared to vehicles powered by fossil fuels.
- ***Improved energy efficiency.*** Electric motors are inherently more efficient than internal combustion engines. They convert a higher percentage of the electrical energy from the grid to power the wheels. This higher efficiency translates into reduced energy consumption per kilometre or mile travelled, thereby lowering the overall greenhouse emissions during the vehicle's operational phase.
- ***Regenerative braking.*** Many electric and hybrid vehicles feature regenerative braking systems that capture kinetic energy during braking and convert it into electricity to recharge the battery. This feature enhances the overall energy efficiency of the vehicle and contributes to further reductions in greenhouse gas emissions by minimizing the energy wastage typically associated with conventional braking systems.
- ***Life-cycle emissions from fuel production.*** Alternative fuels, such as biofuels, hydrogen (when produced from renewable resources), and synthetic fuels, can have lower carbon intensity compared to traditional fossil fuels. The production, processing, and distribution of these fuels can result in lower greenhouse emissions if managed sustainably. For instance, biofuels derived from agricultural waste or algae absorb carbon dioxide ($CO_2$) during their growth phase, which can offset the emissions generated during their combustion phase.
- ***Vehicle manufacturing and disposal.*** Although the manufacturing of electric vehicles, particularly the batteries, can be more resource and energy-intensive than conventional vehicles, ongoing advancements in material efficiency, recycling and battery technology are gradually

reducing these impacts. Moreover, the recycling of batteries and the reuse of materials help in minimizing the greenhouse gas emissions associated with the production of new materials and components.

- ***Extended vehicle lifespan.*** Due to the fewer moving parts and less mechanical wear and tear, electric vehicles often require less maintenance and can have a longer operational lifespan compared to conventional vehicles. This extended lifespan can further dilute the environmental impact of manufacturing and disposal over time, contributing to overall emissions reductions.

By focusing on these aspects, the adoption of electric and alternative fuel vehicles not only aids in reducing the immediate environmental impact of transportation, but it also supports a long-term sustainable strategy to significantly reduce global greenhouse gas emissions.

For example, a life-cycle comparison of the greenhouse gas emissions from combustion, electric, and hydrogen trucks and buses in Europe has revealed that battery electric trucks and buses outperform diesel, hydrogen, and natural gas counterparts in reducing greenhouse emissions over their lifetime: 2021 vehicle models produce at least 63 per cent lower lifetime emissions compared to diesel (O'Connell and others 2023).

Fuel cell battery trucks and buses run on hydrogen produced from fossil fuels reduce greenhouse gas emissions by 15 to 33 per cent compared to diesel counterparts in the life-cycle analysis. With hydrogen solely produced with renewable electricity, emissions decline by up to 89 per cent.

As the analyses show, greenhouse gas emissions can be reduced through different powertrain options (electric batteries, fuel cell batteries and combustion engines), and different fuel or energy choices (hydrogen, biofuels and natural gas). The climate impacts of these technologies and fuels vary over the lifetime of the vehicle model. From extracting and processing raw materials to operation and maintenance, some powertrain options are more energy intensive to build than their counterparts, while some fuel sources can produce higher emissions during their production or use.

As the adoption of electric vehicles continues to increase, managing the afterlife of electric vehicle batteries becomes a critical environmental and economic challenge. These batteries, typically lithium-ion, have a finite lifespan in vehicular applications, but they can still be useful beyond their initial purpose. Proper handling and disposal are crucial to maximize sustainability and minimize the environmental impact. The key considerations and strategies for electric vehicle battery afterlife management are outlined below.

Before recycling, the potential for second-life applications of electric vehicle batteries should be considered. Even after these batteries no longer meet the performance standards required for vehicle operation, they can still provide substantial storage capacity. This makes them suitable for less demanding applications such as the following:

- Energy storage systems (ESS) used in residential, commercial or grid-scale energy storage to provide stability, store renewable energy, or offer backup power.
- Power banks for portable devices that represent large-scale portable energy solutions for events, construction sites or emergency power supplies.
- Community energy projects may support energy needs in underdeveloped or remote areas where grid access is limited.

Reusing electric vehicle batteries in these ways can extend their useful life, delaying the environmental impact of disposal and providing economic returns on the embodied energy and materials.

When batteries are no longer suitable for any form of reuse, recycling is the next step. Recycling electric batteries is essential to recover valuable materials, such as lithium, cobalt, nickel and copper, which can be reused in new batteries or other products. The recycling process usually involves several steps:

- Disassembly, in cases in which the batteries are safely dismantled and hazardous or non-recyclable components are disposed of according to environmental regulations.
- Material recovery, in cases in which advanced mechanical and chemical processes are used to separate and purify valuable materials.
- Reintegration into supply chains through which the recovered materials are fed back into the manufacturing of new batteries or other products, reducing the need for raw material extraction and the overall environmental footprint.

Effective afterlife management of electric batteries requires robust regulatory frameworks and industry standards to ensure safe, efficient and environmentally sound practices. Governments and industry bodies must work together to achieve the following:

- Establish clear guidelines for the collection, storage and handling of used electric vehicle batteries to ensure safety and efficiency.
- Incentivize recycling and reuse through policies that encourage manufacturers and consumers to participate in sustainable afterlife practices.
- Support research and development (R&D) for improving recycling technologies and developing new methods for battery reuse and refurbishment.

The key challenges in electric vehicle battery afterlife management include technological, economic and regulatory hurdles. Technological advancements are needed to improve the efficiency and cost-effectiveness of recycling processes. Economically, the infrastructure for collection and processing must expand in tandem with electric vehicle adoption to handle increased battery volumes. Regulatory challenges involve keeping pace with the fast-evolving technology and ensuring international cooperation on standards.

Despite these challenges, the afterlife management of electric vehicle batteries presents significant opportunities. It drives innovation in recycling technologies and second-life applications and contributes to the circular economy, and supports global sustainability goals by reducing waste and conserving resources. Accordingly, properly addressing electric vehicle battery afterlife is crucial for mitigating the environmental impact of electric vehicles and supporting the sustainability of this critical transition in transportation technology.

## 1.2 Highly and fully autonomous vehicles

Highly and fully autonomous vehicles (HFAVs), also known as self-driving or driverless vehicles, are equipped with advanced technologies that allow them to navigate and operate without human intervention. These vehicles use a combination of sensors, cameras, radar, artificial intelligence and machine learning to perceive their surroundings and make decisions.

The Society of Automotive Engineers (SAE)[1] defines six levels of automation for HFAVs, ranging from level 0 to level 5. At level 0, there is no automation; the human driver is responsible for all driving tasks. Progressing to level 1, known as driver assistance, the vehicle takes over either steering or acceleration/deceleration based on the driving environment, while the human handles everything else. At level 2, partial automation is introduced in which the vehicle can manage steering and acceleration/deceleration, but the driver must still remain actively engaged and monitor the environment.

At level 3, or conditional automation, the vehicle assumes full control of all driving tasks in certain scenarios, but it requires the human driver to take over if needed. Level 4, or high automation, marks a significant advancement as the vehicle can perform all driving functions and monitor conditions without any human intervention, but only in specific environments. Finally, level 5 represents full automation under which the vehicle is completely autonomous and capable of performing all driving tasks in any condition, completely eliminating the need for human intervention.

Figure 1 illustrates the six levels of driving automation as defined by the SAE International Standard J3016. This classification helps in understanding the capabilities of vehicles from no automation (level 0) to full automation (level 5).

[1] See https://www.sae.org/

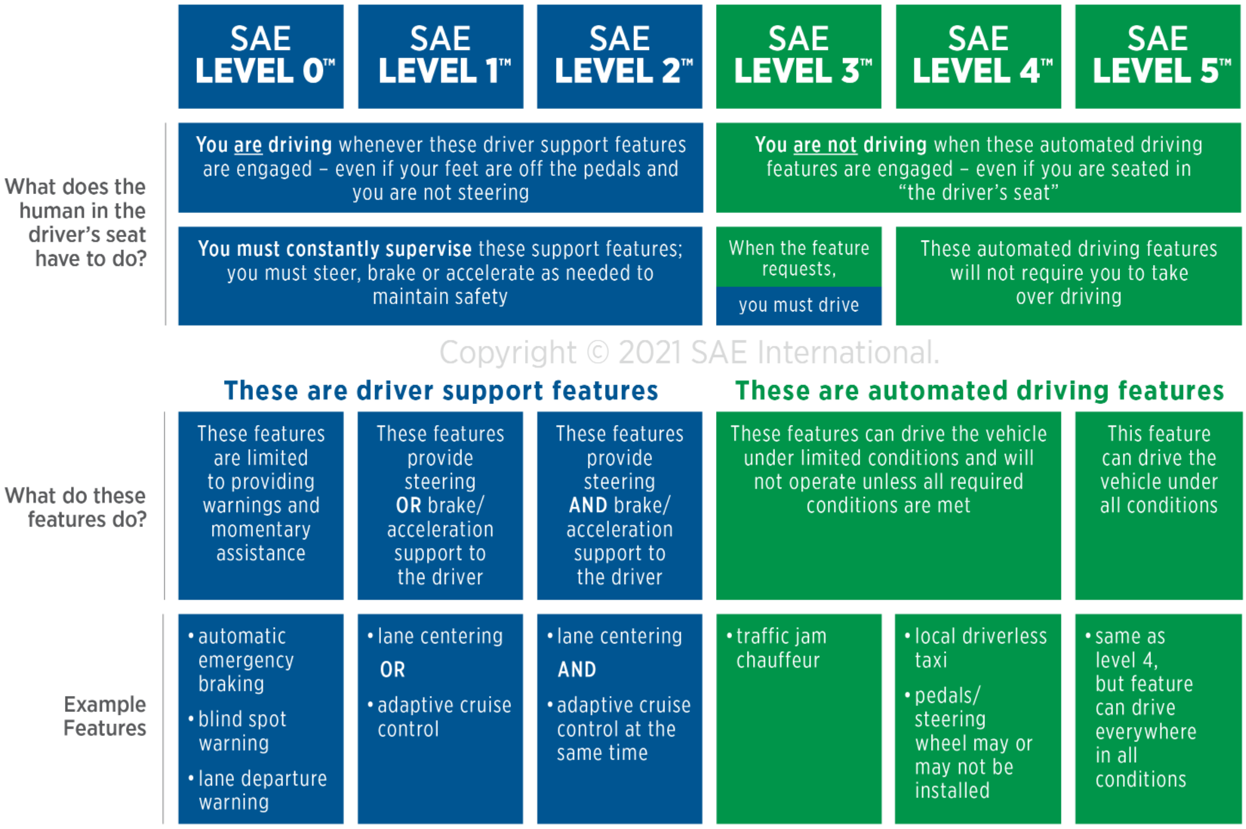


**Figure 1 SAE J3016™ levels of driving automation**

***Source*:** SAE (2021).

The development and adoption of HFAVs are progressing rapidly worldwide. China, Germany, Japan and the United States of America are at the forefront of this technology, driven by major automotive and technology companies, such as Tesla, Waymo, Audi, and Baidu these countries have established regulatory frameworks that facilitate the testing and gradual deployment of autonomous vehicles on public roads. In particular, Germany and Japan are pursuing audio visual technology, focusing on integrating it into public transportation and freight services.

Highly and fully autonomous vehicles have the potential to improve energy efficiency in various ways, leading to lower energy consumption and reduced greenhouse emissions. Some of the energy efficiency advantages associated with highly and fully autonomous vehicles are as follow:

- ***Optimized driving behaviour.*** HFAVs can employ advanced algorithms to optimize driving patterns, leading to smoother acceleration, braking and cruising. Research suggests that eco-driving algorithms can reduce energy consumption by 5-20 per cent compared to human-driven vehicles, depending on traffic conditions and vehicle types.
- ***Improved traffic flow.*** Autonomous vehicles can communicate with each other and with traffic management systems, enabling better coordination and synchronization. This vehicle-to-vehicle (V2V) and vehicle-to-infrastructure (V2I) communication can reduce traffic congestion and

minimize stop-and-go traffic patterns. Studies have shown that improved traffic flow can lead to a 15-20 per cent reduction in energy consumption.

- ***Eco-routing and navigation.*** HFAVs can use real-time traffic data and advanced algorithms to determine the most energy-efficient routes, considering factors like road grade, congestion, and weather. By optimizing routes to minimize energy consumption, it is estimated that eco-routing can reduce energy use by up to 10 per cent.
- ***Platoon driving.*** HFAVs can drive in tightly coordinated groups or platoons, which allows them to maintain a consistent speed and follow each other at closer distances. This reduces air resistance and improves aerodynamics, resulting in energy savings of approximately 4-10 per cent for the lead vehicle and 10-20 per cent for following vehicles.
- ***Lightweighting.*** As autonomous vehicles eliminate the need for certain components, such as steering wheels, pedals, mirrors and sleeping compartments, they can be designed to be lighter, further improving energy efficiency. A 10 per cent reduction in vehicle weight can result in a 6-8 per cent improvement in fuel economy.
- ***Electrification and renewable energy integration.*** HFAVs can facilitate the adoption of electric vehicles, as they can autonomously recharge during periods of low electricity demand or when renewable energy sources are abundant. This can lead to a more significant penetration of renewable energy in the transport sector and further reduce greenhouse emissions.

Accordingly, HFAVs offer significant potential to enhance the energy efficiency of road freight transport. Their innovative coupling with electric propulsion systems can substantially amplify this potential. However, there are several challenges to widespread adoption:

- Ensuring that HFAVs can handle all driving situations safely is paramount. Incidents involving autonomous vehicles raise concerns about their ability to deal with unpredictable road conditions.
- Establishing a comprehensive legal framework that addresses liability in the event of accidents involving HFAVs is crucial.
- Overcoming scepticism and fear associated with surrendering control to machines is essential for mass adoption.
- Protecting HFAVs from potential hacking and ensuring the privacy and security of data collected by these vehicles are major concerns.

As technology advances and more testing are conducted, the challenges associated with autonomous vehicles will become clearer, and solutions will emerge. Highly and fully autonomous vehicles represent a revolutionary step in the evolution of transport, promising a future in which travel is safer, more efficient and accessible.

## 1.3 Intelligent transportation systems

Intelligent transportation systems (ITS) are advanced applications, which aim to provide innovative services relating to different modes of transport and traffic management and enable various users to be better informed and make safer, more coordinated and "smarter" use of transport networks.

The key elements of ITS encompass a wide range of technologies and systems designed to enhance the safety, efficiency and sustainability of transportation networks. These elements may include, for example, traffic management systems, data collection sensors, communication networks and, traffic information systems. Together, these components work synergistically to optimize transportation infrastructure, improve traffic flow, reduce environmental impacts, and enhance the overall mobility experience. The typical functional elements of ITS are described in Table 2.

**Table 2 Key functional elements of an intelligent transportation system**

| Functional elements | Description |
|---|---|
| *Traffic management systems* | Traffic management systems are at the core of ITS. They use real-time data collection and communication technologies to manage traffic flow and reduce congestion. This includes traffic signal control systems, dynamic message signs, and congestion pricing strategies. These systems help to optimize the use of existing infrastructure and improve travel times and road safety. |
| *Data collection sensors* | Sensors play a crucial role in ITS by providing the necessary data for system operations. These include cameras, inductive loops, infrared and radar sensors, and Global Processing System (GPS) devices installed on vehicles. They collect data on traffic volumes, vehicle speeds, weather conditions, and accidents, which are essential for real-time monitoring and decision-making. |
| *Communication networks* | Communication networks facilitate the transfer of data among vehicles, infrastructure and traffic management centres. This includes vehicle-to-infrastructure (V2I) and vehicle-to-vehicle (V2V) communications. Advanced communication technologies, such as dedicated short-range communications (DSRC) and cellular networks. support the exchange of safety and operational data. |
| *Traffic information systems* | These systems analyse data collected from various sources to provide users with up-to-date information about traffic conditions, travel times, route suggestions, and accident alerts. Information is delivered to users through smartphone apps, in-vehicle navigation systems and roadside signs, helping drivers make informed decisions about their routes. |
| *Emergency response systems* | ITS enhances the capability of emergency response operations through improved accident detection and response times. Systems, such as automatic crash notification (CAN) systems send immediate alerts to emergency services when an accident occurs, along with precise location data. This rapid response can significantly improve the chances of survival and quick clearing of crash sites. |

| Functional elements | Description |
|---|---|
| *Weigh-in-motion systems* | Weigh-in-motion (WIM) systems are another crucial ITS component, which are designed to capture and record the weight of moving vehicles. Installed directly in the roadway or at specific facilities such as weigh stations, these systems allow for continuous traffic flow while ensuring that vehicle weights comply with road safety regulations. WIM systems help prevent road damage caused by overloaded vehicles and enhance safety by identifying vehicles that may pose risks due to excessive weight. The data collected can also be used for enforcement purposes and to analyse traffic loads for infrastructure maintenance and design considerations. |
| *Automated toll collection systems* | Automated toll collection systems are a significant component of ITS by facilitating efficient management of road usage fees without requiring vehicles to stop. These systems use various technologies such as radio frequency identification (RFID), DSRC and automatic number plate recognition (ANPR) to identify vehicles and process payments electronically as they pass through toll points. This not only speeds up the traffic flow on toll roads, but it also reduces congestion, lowers emissions from idling vehicles and improves the overall user experience. Implementing automated toll collection can also provide valuable data for traffic analysis and infrastructure planning. |
| *Integrated fare management and ticketing systems* | For public transport, ITS integrates various forms of fare collection and ticketing solutions that allow seamless travel across different modes of transport. Smart cards and mobile ticketing reduce the need for cash transactions and speed up boarding times, improving overall efficiency and user satisfaction. |
| *Environmental monitoring* | ITS also includes systems for monitoring environmental conditions related to transportation, such as vehicle emissions and noise levels. This information can be used to enforce environmental regulations and promote sustainable practices within the transport sector. |
| *Advanced vehicle technologies* | This includes the integration of advanced technologies in vehicles, such as adaptive cruise control, automated braking and lane-keeping assist, which enhance vehicle safety and driver comfort. These technologies are stepping stones towards fully autonomous vehicles. |

***Source*:** Compiled by the authors using information aggregated from various publicly available sources, including industry reports, publications, and academic studies on ITS.

By integrating these elements, ITS offer comprehensive solutions to many of the challenges facing modern transport systems. Importantly, ITS can significantly increase energy efficiency and reduce emissions in freight transport by leveraging advanced communication technologies, data analytics and automation. Some of the fundamental ways through which ITS can realize these goals encompass the following:

- ***Optimized route planning.*** ITS can help freight vehicles save up to 10-15 per cent in fuel consumption by using real-time traffic data and advanced algorithms to identify the most energy-efficient routes, according to the European Commission. This can also lead to a reduction in the $CO_2$ emissions by a similar percentage.
- ***Eco-driving assistance.*** Studies have shown that eco-driving techniques can result in fuel savings of 5-20 per cent, depending on the vehicle type and driving conditions. Real-time feedback provided by ITS can help drivers maintain optimal speeds, gear shifting, and acceleration patterns, which can significantly reduce fuel consumption and $CO_2$ emissions.
- ***Vehicle-to-vehicle (V2V) and vehicle-to-infrastructure (V2I) communication.*** By improving traffic flow and reducing congestion, V2V and V2I communication can decrease fuel consumption by up to 10 per cent and reduce $CO_2$ emissions by up to 8 per cent, according to the United States Department of Transportation.
- ***Load optimization.*** Proper load optimization can result in a 5-10 per cent reduction in fuel consumption and $CO_2$ emissions, as reported by the International Transport Forum (ITF). Efficiently distributing cargo within freight vehicles ensures they operate at their most energy-efficient capacity, leading to fewer trips and lower fuel consumption.
- ***Fleet management.*** A study by the United States National Renewable Energy Laboratory[2] found that fleet management systems could lead to a reduction of up to 15 per cent in fuel consumption and emissions by providing real-time monitoring of vehicle performance and driver behaviour.

The deployment of ITS can significantly bolster the energy efficiency of freight transport by contributing towards reducing fuel consumption, decreasing idling times and promoting overall operational efficiency. The potential for ITS to be integrated with other innovative technologies, such as autonomous vehicles, offers a promising opportunity for further advancements. Amplifying ITS deployment can thrust the freight transport industry towards enhanced sustainability, improved energy efficiency, and alignment with wider global commitments to curtail the greenhouse gas emissions.

[2] See https://www.nrel.gov/

## 1.4 Alternative fuels: types and application

Alternative fuels, such as electricity, biofuels, hydrogen and natural gas, offer a wide range of benefits, including a reduction in carbon and other pollutant emissions, improved fuel economy, and the potential that domestic production can enhance energy security.

Alternative fuels for road transportation, notably biofuels, can be derived from a range of sources, and their classification depends on various factors, such as feedstock, greenhouse gas emissions savings, technology maturity, and the product type and quality.

The feedstock used for biofuel production plays a critical role in its classification. Conventional biofuels predominantly are sourced from feedstocks that also serve as food or animal feed. Advanced biofuels leverage agricultural or forestry residues, organic waste and non-food or non-feed energy crops as feedstock. Biofuels that substantially reduce greenhouse emissions are considered advanced. In contrast, biofuels that have the potential for greenhouse savings falls below a certain threshold are categorized as conventional. Table 3 provides a description of different liquid biofuel products.

**Table 3 Liquid biofuel product description and applications in transport.**

| Product | Blending limits |
|---|---|
| Methanol | • In the United States, regulations allow a 0.3% blend of methanol in gasoline or 2.75% methanol in gasoline with equal volumes of butanol (ASTM D 4814-16b).<br>• European Union gasoline standards allow up to 3% methanol in gasoline (EN 228). ASTM D5797-16 standards for 70-85% methanol in gasoline are being updated.<br>• In China, a national standard for 85% methanol in gasoline exists (GB/T 23799-200) but standard fuel grades vary across provinces. |
| Ethanol | • In Europe and the United States, fuel standards allow for up to 10-15% ethanol in gasoline (EN 228, ASTM D 4814).<br>• In Brazil, regulation allows up to 27.5% ethanol in gasoline. Flex-fuel vehicles may use blends of up to 85% ethanol in gasoline or 100% ethanol. |
| Butanol | • United States fuel standard allows up to 16% butanol in gasoline (ASDM D 4814).<br>• European Union fuel standard allows up to 15% in gasoline (EN 228). |
| FAME - biodiesel | • European Union fuel standards allow up to 7% in diesel (EN 590).<br>• United States fuel standards allow up to 5% in diesel (ASTM D 975). |
| Fischer Tropsch fuels | • There are no regulatory limits to blending Fischer-Tropsch diesel. Fischer-Tropsch kerosene is certified for maximum 50% blends with jet fuel (ASTM D7566). |
| Hydrotreated esters and fatty acids | • There are no regulatory limits to blending hydro-treated esters and fatty acids in diesel. However, it will be blended with conventional diesel fuel to meet fuel specifications. International standard ASTM D 7566 allows up to 50% hydro treated esters and fatty acids in jet fuel. |
| Synthetic paraffinic fuel | • Iso-synthetic paraffinic fuels are certified for maximum 10% blends with jet fuel (ASTM D7566). |
| Synthetic aromatic fuel | • ASTM certification currently under way. |

***Source*:** IRENA (2016).

Alternative gas fuels encompass a broad spectrum of energy sources that can contribute to improved energy efficiency and reduced greenhouse gas emissions. One of the most well-known and extensively used alternative gas fuels is natural gas. Composed primarily of methane, natural gas can be used in vehicles as compressed natural gas (CNG) or liquefied natural gas (LNG). CNG is commonly used in passenger vehicles and light-duty trucks, while LNG, due to its higher energy density, is typically used for heavy-duty and long-haul trucking applications. Natural gas vehicles produce significantly less tailpipe emissions than gasoline or diesel counterparts, making them a popular choice in urban areas with stringent air quality standards.

Another increasingly important alternative gas fuel is hydrogen. When used in a fuel cell, hydrogen can generate electricity with water being the only by-product, making it a zero-emission fuel source. Fuel cell electric vehicles (FCEVs) powered by hydrogen are becoming more common, particularly in the passenger vehicle sector, but they are also being explored for use in heavy-duty freight applications.

Biogas, another alternative gas fuel, is produced through the anaerobic digestion or fermentation of organic matter, including manure, sewage, municipal waste or plant material. Biogas, which primarily consists of methane, can be upgraded to a quality similar to natural gas and used as a vehicle fuel.

The application of these alternative gas fuels in transportation has the potential to drastically reduce greenhouse emissions, improve energy security by diversifying fuel sources and reduce reliance on fossil fuels. Despite the challenges related to infrastructure, fuel storage, and vehicle availability, the growing interest in and implementation of these alternative fuels indicate a promising future for their use in the transport sector.

## 1.5 Renewable and nuclear energy in freight transport

Renewable energy, also known as clean energy, is derived from natural sources or processes that are continuously replenished. It offers a more sustainable alternative to conventional fossil fuels, resulting in reduced greenhouse gas emissions and less environmental degradation.

The main types of renewable energy sources are solar energy, wind energy, water energy, geothermal energy, biomass and biofuels. In the realm of freight transport, hydropower, solar and wind power surface as the most promising renewable energy sources as transport remains the sector with the lowest share of renewables, with more than 95 per cent of energy needs coming from oil and petroleum products and less than 4 per cent from biofuels and renewable electricity (2018) (SLOCAT, 2021).

Nuclear energy has also been seen as a reliable, low-carbon energy source by many countries, compared to thermal power for powering electric vehicles. According to data from the International Energy Agency (IEA), nuclear power emits an average of around 16 grams of $CO_2$ per kWh of electricity generated, while thermal power emits approximately 820 grams of $CO_2$ per kWh. This significant difference in carbon emissions highlights the potential of nuclear power to reduce greenhouse gas emissions from the transport sector.

It is, however, important to consider the potential side effects and drawbacks associated with nuclear power. One of the main concerns is the risk of accidents. The safe disposal of nuclear waste is another significant challenge, as it requires long-term storage and management to prevent potential harm to the environment and human health. Additionally, there is a concern about the potential for the proliferation of nuclear weapons technology. Accordingly, although nuclear power produces substantially lower $CO_2$ emissions compared to thermal power, it is essential to carefully evaluate the potential risks and drawbacks of nuclear energy prior to making any decisions regarding it.

Renewable energy sources hold significant potential for transforming freight transport into a more sustainable and energy-efficient system. To fully leverage this potential, it is important to pinpoint the strategic entry points for the integration of these energy sources.

The primary point of integration is the application of "green" electricity, generated from renewable energy technologies to power electric vehicles. This application extends across various types of vehicles, from light-duty electric cars to heavy-duty electric trucks and buses. As electric vehicle technology continues to mature and electric vehicle adoption rates increase, this entry point will increasingly contribute to a reduction in emissions from the transport sector.

A secondary entry point is the deployment of renewable energy in the production of "green" hydrogen, which can be used in FCEVs. While this technology is still in its developmental stages, hydrogen fuel cells have great potential for energy storage and high energy density, making them particularly suitable for heavy-duty and long-haul transport applications.

A third integration pathway is through the production of advanced biofuels using sustainable biomass feedstocks. These biofuels can serve as direct replacements for conventional fossil-based fuels, enabling the decarbonization of existing vehicles and infrastructure without requiring significant modifications.

Finally, renewable energy technologies can be integrated into the transport infrastructure itself. For example, solar panels can be installed at transport hubs or along transport routes, providing a source of locally generated "green" electricity to power infrastructure facilities or to supply charging points for electric vehicles. Similarly, wind turbines can be used in areas with favourable wind conditions.

Although nuclear energy has limited direct application in transportation, its role in decarbonizing the power sector can indirectly contribute to cleaner transportation. The application of nuclear energy for transport sector may contribute significantly to the overall increase of the freight transport energy efficiency, while reducing substantially the lifetime emissions of HDVs.

Each of these entry points represents an opportunity to harness the power of renewable energies to propel the transport sector towards a more sustainable future. However, the successful implementation of these strategies requires comprehensive policy support, significant investment and strong stakeholder collaboration, as well as continued R&D to overcome existing technical and economic barriers. By considering these factors, a smoother transition towards sustainable energy use in freight transport can be ensured.

## 1.6 Infrastructure modernization

Infrastructure modernization plays a crucial role in the sustainable transition of the freight transport sector. It involves upgrading or replacing existing transportation infrastructure with advanced, environmentally friendly alternatives that can support new technologies and practices. Some of the most common practices are considered below.

Intermodal transportation facilities enable the smooth transition of goods from one mode of transportation to another, similar to rail to road or from sea to rail. They help in achieving a modal shift by allowing more efficient use of different modes of transportation based on their comparative advantages, thus reducing fuel consumption and emissions.

Widespread adoption of electric or alternative fuel vehicles depends on the availability of charging stations or refuelling infrastructure. Modern infrastructure should, therefore, include a network of these stations that are strategically located across cities and highways.

Modernization of infrastructure also involves integrating information technology with transportation infrastructure to manage and control traffic, optimize routing, improve safety, and reduce environmental impacts. This could include technologies, such as real-time traffic management systems, connected and autonomous vehicles, and truck platooning technologies.

Being eco-friendly versions of traditional logistics centres and ports, green logistics hubs and ports are equipped with renewable energy sources, advanced energy management systems and low-emission handling equipment. They help in reducing the energy consumption and emissions associated with goods handling and storage.

Railway electrification is another key aspect of infrastructure modernization in the context of sustainable freight transport. It enhances the efficiency of train tractions, bolstering the appeal of rail over road transportation. This not only stimulates a modal shift, but it also plays a pivotal role in slashing greenhouse emissions. This reduction is particularly pronounced in countries that are harnessing renewable or nuclear energy sources.

In 2021, the level of railway electrification worldwide neared 30 per cent or approximately about 375,000 kilometres (kms) of electrified rails out of 1.3 million in total.[3] The degree of electrification among ESCAP countries ranged from 2 per cent in Pakistan to 100 per cent in the Philippines (2021), with the lengthiest electrified network attributed to China.[4]

Overall, railways are up to nine times more energy efficient as compared to road for long distance freight, four times more economical in terms of land use, and six times more cost effective versus road in terms of construction costs for comparable levels of traffic. Among the modes of rail transport, electric traction is the most energy efficient. The greenhouse gas emissions from trains are 60-75 per cent lower (OCS Middle East, n.d.).

In summary, the modernization of transport infrastructure is a strategic endeavour that spans the long term, necessitating substantial financial resources, comprehensive planning, and coordination among a multitude of stakeholders. Public-private partnerships (PPPs) often emerge as a viable model for funding such extensive infrastructure initiatives. Simultaneously, it is imperative to design and execute infrastructure modernization initiatives with an eye towards future resilience. This includes considerations for rapid technological advancements, the effects of climate change and adaptability to potential challenges, such as shifts in logistics flows, even those induced by geopolitical variations.

[3] See https://www.railwaypro.com.
[4] Based on the analysis conducted by the authors using data aggregated from various publicly available sources, including, among them, industry reports and publications.

## 1.7 Self-test quiz for chapter 1

**1. What is a primary advantage of electric vehicles in sustainable mobility?**

A) Higher speed capabilities

B) Dependence on non-renewable energy sources

C) Reduced greenhouse gas emissions

D) Larger vehicle design options

**Answer:** ________________

**2. Which system is essential for the functioning of intelligent transportation systems?**

A) Independent/onboard vehicle systems.

B) Real-time data processing and communication.

C) Video surveillance for traffic rules enforcement purposes.

D) Traditional traffic management.

**Answer:** ________________

**3. How does nuclear energy contribute to sustainable mobility?**

A) By directly powering vehicles.

B) As an alternative fuel source for combustion engines.

C) By providing electricity for charging electric vehicles and for hydrogen production.

D) It has no role in sustainable mobility.

**Answer:** ________________

**4. Which of the following best describes the role of intelligent transportation systems in sustainable mobility?**

A) Increasing the efficiency of public transit systems only.

B) Reducing environmental impact through improved traffic management.

C) Increasing the use of personal vehicles.

D) None of the above.

**Answer:** ________________

**5. Fill in the blank:**

____________ fuels are important for reducing dependency on petroleum and decreasing emissions in freight transport.

**Answer:** ________________

# Chapter 2: Policy and regulatory measures

## 2.1 Vehicle emission and fuel economy standards

The greenhouse gas emission and fuel economy standards represent one of the principal regulatory strategies adopted by governments globally to encourage the shift towards sustainable road freight transport (Chatti, 2020). These standards set specific limits on the emissions and fuel consumption of vehicles, pushing manufacturers to design and produce cleaner, more efficient vehicles.

In terms of emissions, standards are often aimed at controlling the output of $CO_2$, nitrogen oxides ($NO_X$), particulate matter (PM), and other harmful pollutants. By setting limits on these emissions, governments can mitigate the environmental and public health impacts of road transport.

Fuel economy standards, on the other hand, directly influence the energy efficiency of vehicles. By requiring vehicles to travel a certain distance on a given volume of fuel, these standards can significantly reduce fuel consumption, leading to lower greenhouse emissions and energy use.

The implementation of these standards has shown to have a significant impact on reducing emissions. At the same time, the current pace of conventional fuel economy improvements is insufficient, as supported by the *International Energy Agency's Global EV Outlook 2020*. Several factors contribute to fuel consumption, including fuel prices, technology adoption influenced by regulations and standards, and vehicle size and power. The recent trend towards larger vehicles in many markets has exacerbated the issue, leading to increased average fuel consumption and higher emissions.

Governments worldwide have recognized the importance of addressing this issue and have taken steps to implement fuel economy and greenhouse gas emission standards. Some countries have announced an ambition to achieve 100 per cent zero-emission vehicle sales or phase out ICE vehicles by 2050.

In the ESCAP region, countries such as China, Japan and the Republic of Korea have taken the lead in implementing stringent GHG emission standards for HDVs. For instance, China has introduced China VI standards, while Japan has enforced the Post New Long-Term Emission Standards, both of which are equivalent to the Euro VI standards. The Republic of Korea has also implemented the Korea Stage 7 (KNR 07) standards, targeting reduced emissions of pollutants, such as $CO_2$, HC, $NO_X$, and PM.

India adopted the Bharat Stage (BS) VI emission standards, which are on par with Euro VI, and implemented them in 2020. Thailand has implemented the Euro IV emission standards and has plans to move towards the Euro V standards. Indonesia has enforced Euro IV-equivalent standards and is in the process of developing a road map for implementing Euro V and Euro VI standards. However, there are still countries in the region that have yet to implement comprehensive and stringent greenhouse gas emission standards for HDVs.

## 2.2 Greenhouse gas emissions pricing

Greenhouse gas emissions pricing is an effective regulatory measure that governments can implement to reduce emissions, including those from the transport sector. It is based on the "polluter pays" principle, which places a financial cost on the emission of greenhouse gas. This can be done through mechanisms, such as carbon taxes or emissions trading systems.

A carbon tax is a fee imposed on the carbon content of fuels. This means that the more a person or business pollutes, the more they have to pay. The objective is to incentivize individuals and businesses to reduce their carbon emissions by adopting cleaner technologies and practices.

An emissions trading system, also known as cap-and-trade, sets a cap on the total amount of greenhouse gases that can be emitted by certain sectors. Companies or other groups can buy or sell emission allowances, which gives them the right to emit a specified amount. The cap is reduced over time, so that total emissions fall.

The application of greenhouse gas emissions pricing in the freight transport sector would encourage operators to switch to more fuel-efficient vehicles or alternative fuels, reduce the number of vehicle miles travelled or improve logistics and operational efficiency. It can also stimulate innovation and the development of new technologies and practices in the sector.

Some of the challenges to implementing greenhouse gas emissions pricing are setting the right price, dealing with potential competitiveness impacts, and ensuring fairness and equity, particularly for low-income households or small businesses. The effectiveness of greenhouse gas also depends on the broader policy context, including, for example, existing energy and transport policies.

## 2.3 Modal shift to low-carbon modes

Transport modes significantly vary in their $CO_2$ emissions per unit of freight movement. Figure 2 presents the average carbon intensity of various freight transport modes measured in $gCO_2$/tonne-km.

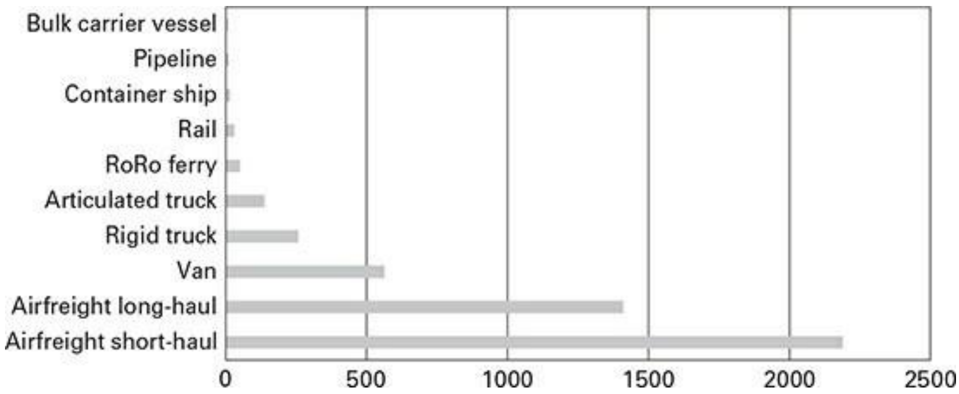


**Figure 2 Average carbon intensity of freight transport modes: $gCO_2$/tonne-km**

***Source*:** United Kingdom, Department for Environment, Food and Rural Affairs (2017).

The aim of the modal shift is to enhance energy efficiency, alleviate traffic congestion and reduce greenhouse gas emissions. This is achieved by transitioning from less environmentally friendly transport modes, such as heavy road freight, to more sustainable alternatives, such as rail, maritime or inland waterways.

To foster a modal shift, policymakers have several strategies at their disposal. Investing in infrastructure is crucial; enhancing facilities for electric vehicles, rail and water transport can make these options more reliable and effective. Financial incentives can also play a critical role, for instance, by implementing tolls for high-emission vehicles or offering tax breaks for companies that adopt green logistics practices. Regulatory measures might include restricting high-emission vehicles or promoting car-free zones. Additionally, raising awareness and educating the public about the advantages of sustainable transport modes can influence both personal and business transportation choices.

However, promoting a modal shift comes with challenges. There can be resistance from the public and businesses due to issues related to convenience, perceived costs or lack of awareness. Substantial funding is required to build infrastructure and implement new technologies. Moreover, integrating various modes and services demands robust management and technological support.

To effectively promote modal shift, comprehensive planning that integrates transportation with the national development and environmental policies is essential. Policymakers should engage with all stakeholders, including the public, businesses and transport providers, to ensure cooperation and build consensus. It's also crucial to continuously monitor the effectiveness of implemented policies and infrastructure investments, making adjustments based on performance and feedback. Highlighting the personal and community benefits of sustainable transportation, such as improved health, reduced expenses and better quality of life, can also foster greater acceptance and enthusiasm for modal shifts.

Most studies consider that shippers and logistics service providers play a decisive role in the choice of delivery modalities. Common considerations include, among others, cost, travel time, reliability, flexibility, freight tracking and tracing, use of infrastructure, volume and freight characteristics, terminal services, legislation (including legal bottlenecks and advantages), and safety and security. However, transitioning shippers from road freight to other forms of intermodal transport has proven to be a complex task as it involves dealing with geographical, temporal and operational disadvantages.

First of all, lower-carbon modes rail and waterways have much lower density and connectivity than road networks, which, in practice, means that goods have to be transhipped at least two more times loading and unloading between road and rail or waterways as only a few industrial premises have direct access to rail or waterways.

Rail and waterborne transport services are, in general, slower than road transport. This may be a disadvantage for the transport of more time-sensitive, higher-value cargo. The average speed of trains and vessels is much slower than the average speed of trucks. Another disadvantage of railways is that they are bound to fixed and tight schedules as other (passenger) trains use the same rail tracks. In modern transport operations, flexibility is important, but also reliability and sometimes also the just-in-time principle. In those cases, shippers often choose to use road transport, which can be easier planned and controlled, and is more flexible.

The consignment size across road, rail, and waterborne transport vary significantly: road transport typically handles 20-40 tons, rail deals with 1,000-2,000 tons, and maritime vessels, depending on their size, can carry significantly larger volumes. As such, vessels and rail systems must operate at maximum capacity to maintain cost-efficiency.

Despite all the challenges that a policy to conduct a modal shift from road to low-carbon transport modalities has been facing, it will remain on the agenda of most countries in the world. Many governments, in cooperation with international organizations and institutions, will continue to facilitate and promote the use of intermodal transport services.

## 2.4 Integration in national development policies

Integration into national development policies is an effective measure to promote environmentally friendly and economically sustainable transportation systems. This approach ensures that transport policies align with broader economic, social and environmental objectives, facilitating cohesive development efforts across sectors.

The integration typically involves setting specific goals for reducing emissions, promoting energy efficiency, and enhancing the accessibility and affordability of transport services. It can take various forms, such as legislative reforms, strategic planning and investment in infrastructure that supports sustainable modes of transport, such as electric and alternative fuel vehicles, modal shift and public transit.

Key components of integrating sustainable transport into national policies may include the following:

- ***Policy alignment.*** Ensuring that transport policies complement other national policies, such as those related to urban development, energy and environmental protection.
- ***Investment in sustainable infrastructure*.** Allocating resources to develop infrastructure that supports low-emission transport modes.
- ***State support and incentives for green technology.*** Implementing tax incentives, subsidies or grants to encourage the adoption of energy-efficient vehicles and technologies.
- ***Regulatory measures.*** Establishing standards and regulations that mandate or encourage sustainable practices within the transport sector.

Across the ESCAP region, many countries have implemented initiatives to enhance energy efficiency in freight transport. These initiatives form an integral part of their national development policies, strategies and programmes. Table 4 presents a summary of a few such noteworthy endeavours.

**Table 4 Summary of energy efficiency measures and specific targets for freight transport within national development policies of selected countries of the Economic and Social Commission for Asia and the Pacific**

| Country | Policy documents | Key measures and targets |
|---|---|---|
| **Pakistan** | • Electric Vehicle Policy | • Aims to transition 30% of all new vehicles to electric by 2030<br>• Provides for 20% reduction in $CO_2$ emissions by 2030 |
| **Russian Federation** | • Concept for the Development of Production and Use of Electric Road Transport in the Russian Federation to 2030<br>• Energy and Environmental Development Strategy to 2030 | • Envisages electrification and gasification of public transport<br>• Introduces automatic driving systems, automated control, monitoring and positioning systems<br>• Provides for transitioning road transport to hybrid modes and the development of charging infrastructure for electric vehicles |

| Country | Policy documents | Key measures and targets |
|---|---|---|
| **Republic of Korea** | • Electric Vehicle Promotion Plan | • Provides subsidies and tax breaks for the purchase of electric vehicles<br>• Introduces mandatory fuel efficiency standards for HDVs, requiring a 15% reduction in $CO^2$ emissions by 2025 compared to 2012 levels |
| **Sri Lanka** | • National Transport Policy 2019<br>• National Environmental Policy<br>• National Energy Policy 2019 | • Reduces transport energy use by promoting "avoid, shift, and improve" strategies<br>• Links vehicle taxation to fuel efficiency of vehicles<br>• Aims to increase the distribution of oil by rail up to 40% of the total volume in 2022 |
| **Thailand** | • Sustainable Transport Development Strategy | • Promotes green and environmentally friendly transport, as well as clean and alternative fuels<br>• Encourages the adoption of environmental-friendly transport technology |
| **Turkey** | • National Energy Efficiency Action Plan (NEEAP)<br>• Green Ports Initiative | • Increases the share of environmentally friendly vehicles<br>• Promotes public transportation<br>• Improves energy efficiency in the freight sector<br>• Minimizes the environmental impact of port operations, including the freight transport sector |
| **Philippines** | • Green Freight Initiative | • Promotes sustainable transport, including the development of energy-efficient public transportation, the expansion of electric vehicle charging infrastructure and the promotion of sustainable urban mobility plans |

***Source***: Compiled by the authors using information aggregated from various publicly available sources and government publications.

Accordingly, by aligning transport initiatives with national development goals, countries can contribute to comprehensive progress towards economic resilience, social welfare, and environmental sustainability. This integration requires ongoing assessment, adaptation, and collaboration across various sectors and stakeholders to effectively address the evolving challenges and opportunities within the transport sector.

## 2.5 Financial incentives and subsidies

Governments around the world are effectively implementing incentive schemes aimed at fostering environmentally friendly practices and bolstering energy efficiency within the road freight transport sector. They are leveraging a range of fiscal and taxation incentives to catalyse this much-needed transformation. Financial incentives play a crucial role in fostering sustainable freight road transport by stimulating businesses to adopt more environmentally friendly practices.

One common type of incentive is the implementation of fuel taxes or levies. Higher fuel taxes can encourage freight carriers to adopt more fuel-efficient vehicles and practices. For example, in countries with large distances between cities or limited alternatives to road freight transportation, lower fuel taxes may be in place. Conversely, some countries have moved to eliminate diesel fuel subsidies to discourage the use of polluting fuels.

Another type of incentive is the implementation of tax credits or rebates for the adoption of cleaner technologies. Governments may provide tax incentives for the purchase of low-emission vehicles or for the installation of energy-efficient equipment in freight vehicles. For instance, in the United States, the Government offers tax credits for the purchase of electric and hybrid vehicles (Kaack and others, 2018).

Fiscal policies targeting infrastructure investments and internalizing external costs of road freight can promote modal shift and decarbonization of the freight transportation sector. These policies can include incentives for rail and water transport, as well as taxes or charges on road freight to internalize the environmental costs (Kaack and others, 2018).

Financial incentives have also been effective in promoting sustainable transport services. Minnich, Rau, and Schlüter (2020) conducted a large-scale field experiment and found that monetary and non-monetary incentives increased the demand for a sustainable Demand Responsive Transport (DRT) system. Financial incentives, such as vouchers, were particularly effective in increasing the demand for the service.

Another emerging trend leaning towards energy-efficient vehicles encompasses the implementation of fleet renewal subsidy schemes, typically introduced as facets of comprehensive environmental and economic strategies. The primary objectives of these initiatives include bolstering the automobile industry, reducing both economic and environmental costs of transport, decreasing $CO_2$ emissions and enhancing air quality, lessening reliance on imported oil, and boosting road safety. By replacing older, less efficient vehicles with new, environmentally friendly alternatives, these programmes are intended to stimulate economic growth and promote sustainable practices in the automotive sector.

## 2.6 Role of international climate initiatives

Over the past decades, a myriad of international climate initiatives has been launched with the purpose of mitigating climate change and driving sustainability across all sectors of the global economy, including freight transport. They represent the international community's commitment to a shared vision of reduced greenhouse gas emissions, energy efficiency, and a sustainable and resilient global economy. Understanding these conventions and their implications for the freight transport sector is critical for aligning the sector's practices with global climate goals.

ผิดพลาด! ไม่พบแหล่งการอ้างอิง gives a summary of important international treaties, agreements, and organizations focused on combating climate change and enhancing sustainable transport. It aims to aid policymakers and stakeholders in understanding the global landscape of initiatives that influence environmental and transport policies, helping to inform decisions and strategies in the realm of sustainable development and climate action.

**Table 5 Summary of key international treaties, agreements, and organizations focused on combating climate change and promoting sustainable transport**

| Title | Year | Purpose / Targets | Website |
|---|---|---|---|
| United Nations Framework Convention on Climate Change (UNFCCC) | 1992 | Framework for intergovernmental efforts to tackle climate change | unfccc.int |
| Kyoto Protocol | 1997 | Binding emission reduction targets for developed countries | unfccc.int |
| Paris Agreement | 2015 | Limit global warming to well below 2°C, pursue efforts to limit it to 1.5°C | unfccc.int |
| United Nations Environment Programme'(UNEP) Global Electric Mobility Programme | 2020 | Promote the adoption of electric mobility to reduce emissions | unep.org |
| United Nations Climate Change Conference (COP) | Annual | Annual meeting to assess progress in dealing with climate change | unfccc.int |
| International Energy Agency (IEA) | 1974 | Promote energy efficiency and renewable energy, provide data and policy advice | iea.org |
| European Union Clean Vehicles Directive | 2019 (updated) | Promote clean and energy-efficient road transport vehicles | europa.eu |
| G20 Energy Efficiency Leading Programme | 2014 | Enhance global energy efficiency as part of a broader energy and environmental strategy | g20.org |
| Smart Freight Centres Global Logistics Emissions Council (GLEC) Framework | 2014 | Standardize the calculation and reporting of logistics greenhouse emissions | smartfreightcentre.org |
| Transport Decarbonization Alliance (TDA) | 2018 | Accelerate the transformation of the transport sector towards a net-zero emission mobility system by 2050 | tda-mobility.org |

***Source*:** Compiled by the authors using information aggregated from various publicly available sources and publications.

These initiatives, agreements and programmes play an essential role in promoting energy efficiency and sustainable freight transport by providing policy guidance, technical support and sharing best practices among countries and stakeholders.

## 2.7 Self-test quiz for chapter 2

**1. Fill in the blank:**

____________ measures the amount of fuel used per unit of distance (such as litres per 100 km), reflecting the energy efficiency of road vehicles.

**Answer:** _________________

**2. What is the primary purpose of greenhouse gas emissions pricing?**

A) To generate revenue for government budgets.

B) To incentivize reductions in greenhouse gas emissions.

C) To regulate the energy market prices.

D) To support the fossil fuel industry.

**Answer:** _________________

**3. Fill in the blank:**

____________ measures the amount of $CO_2$ emitted per tonne-km, indicating the environmental impact of road freight transport.

**Answer:** _________________

**4. Match the policy measures to their intended impacts:**

Measures:

A) Greenhouse gas emissions pricing

B) Financial incentives

C) Modal shift

Impacts:

1) Supports a reduction in reliance on heavy road vehicles.

2) Implements economic measures to encourage lower emissions.

3) Offers economic benefits for adopting environmentally friendly transportation technologies.

**Answer:** _________________

**5. Fill in the blank:**

Integration of sustainable transport policies into____________ ensures their contribution to broader developmental objectives.

**Answer:** _________________

# Chapter 3: Design of a regional road map

## 3.1 The concept of a regional road map

The development of a regional road map towards a sustainable and energy efficient freight transport requires a comprehensive approach that considers a range of factors, including, among them, infrastructure, policy, technology and stakeholder engagement A regional road map towards sustainable and energy efficient freight transport in Asia and Pacific may consist of five steps as shown in fFigure 3:

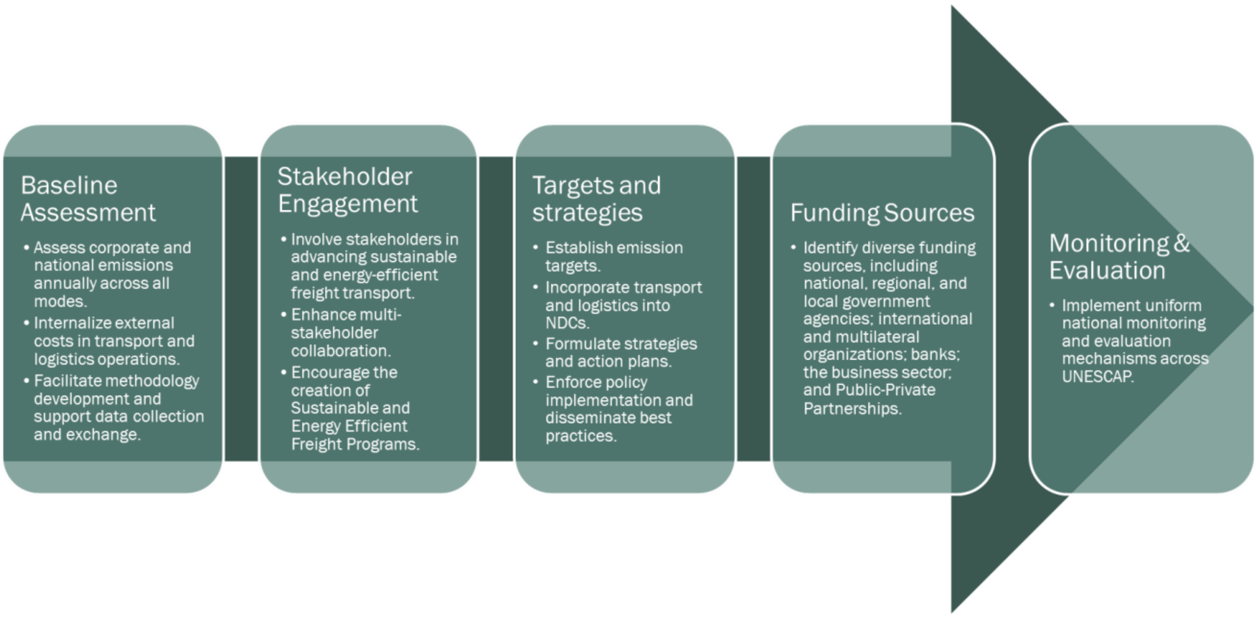


**Figure 3 The five steps for developing regional road map towards sustainable and energy efficient freight transport in Asia and Pacific**

Conducting a **baseline assessment** is a foundational step in evaluating the status of transport and logistics emissions at the corporate and national levels. This assessment involves the systematic measurement and annual reporting of emissions across various modes of transport and transshipment centres, including dry ports. It serves as a critical tool for understanding the extent of emissions and identifying key areas for improvement. Additionally, this process includes the application of internalization strategies for external costs in transport and logistics operations, which aligns financial incentives with environmental impacts, encouraging more sustainable practices.

To enhance the effectiveness and consistency of these assessments, there is a concerted effort to develop and support a common methodology within the ESCAP domain. This initiative ensures that all stakeholders have a unified approach to measuring and managing emissions. Furthermore, robust support for data collection and data exchange within the ESCAP domain is provided, facilitating improved decision-making based on accurate and timely information.

The development of a **stakeholder engagement plan** aims to facilitate the transition towards sustainable and energy-efficient freight transport. This plan begins by identifying and defining key stakeholders involved in freight transportation, including policymakers, business operators and community representatives, ensuring their active involvement in the sustainability initiatives. It focuses on fostering robust mechanisms for collaboration horizontally, across the same level of operations and vertically, integrating different levels of input and authority.

The stakeholder engagement plan actively promotes the creation and refinement of sustainable and energy efficient freight programmes. These programmes are designed to address specific areas of need within the freight sector, aiming to enhance operational efficiency and reduce environmental impacts. By encouraging diverse stakeholder participation, the plan enhances the commitment and accountability among all parties involved, ensuring a cohesive approach to achieving sustainable freight transport goals.

The process of **setting targets and developing strategies** for reducing emissions in the transport and logistics sectors is a multifaceted approach that encompasses the creation of national, sectoral and corporate emission targets. These targets are integral to aligning the broader goals of reducing environmental impact with specific, actionable objectives for each stakeholder group. Moreover, these targets are incorporated into the nationally determined contributions, ensuring that the efforts in transport and logistics contribute to national commitments under international climate agreements.

To achieve these targets, comprehensive national and corporate strategies and action plans are developed. These plans cover various aspects of the transport and logistics sector, including the enhancement of infrastructure, modernization of vehicles, trains and vessels, and optimization of operations. Each strategy is tailored to address the unique challenges and opportunities within the respective scopes of influence, ensuring a holistic approach to emissions reduction.

Additionally, these strategies are supported by the development and enforcement of relevant policies. These policies are designed to ensure compliance and facilitate the effective implementation of the planned measures. To foster continual improvement and adaptation, examples and best practices from successful implementations at the system level — including logistics corridors, supply chains and cross-border regions — are disseminated. These examples serve as valuable learning tools, showcasing effective strategies and actions that have led to significant improvements at local, company or pilot project levels, thereby encouraging widespread adoption of proven solutions.

The **identification of funding sources** is a critical component in supporting initiatives aimed at improving sustainability and efficiency in transport and logistics. This process involves a systematic approach to pinpointing potential financial contributors across various levels and sectors. Key funding sources are national, regional and local government agencies, which may offer grants, subsidies or other financial incentives to promote greener transport solutions. Additionally, international and multilateral organizations often provide funding for projects that align with global sustainability goals.

Banks and the broader business sector also play significant roles, offering loans, investments or partnerships that drive innovation and infrastructure development. Furthermore, PPPs are explored as viable mechanisms for funding, leveraging the strengths and resources of public and private entities to achieve mutual benefits and shared goals in sustainable transport development. Identifying and securing these diverse funding sources is essential for initiating and sustaining the necessary changes within the transport and logistics sectors.

The **establishment of uniform national monitoring and evaluation mechanisms** within the ESCAP domain is essential for assessing the effectiveness and progress of initiatives aimed at enhancing sustainability and efficiency in transport and logistics. This involves creating standardized procedures and criteria across all member countries to consistently measure performance against predefined targets and objectives. These mechanisms ensure accountability, provide valuable insights into the outcomes of implemented policies and strategies, and facilitate data-driven decision-making. By harmonizing monitoring and evaluation practices, ESCAP aims to foster transparency, facilitate comparative analysis and promote best practices across the region, ultimately contributing to the continuous improvement of transport and logistics operations.

A widely accepted strategy for decarbonizing the transport sector relies on three core policy pillars: “Avoid”, “Shift” and “Improve”.[5] This method, as detailed in the referenced report, incorporates a robust set of 17 targeted measures, cohesively designed to mutually reinforce each other, contributing to a comprehensive approach to transport decarbonization. The outlined measures encompass a wide range of interventions, from technological advancements and infrastructural improvements to behavioural changes and regulatory mechanisms.

In addition, relevant for drafting a regional road map are the two ambition policy scenarios (Current Ambition and Hight Ambition) for freight demand and choice as well as the transition to cleaner vehicle fleets developed by the *ITF Transport Outlook 2023*.

In general, a successful regional road map towards a sustainable and energy efficient freight transport system requires a collaborative and iterative approach that involves multiple stakeholders and considers a range of factors. By taking these steps, regions can make meaningful progress towards a more sustainable and efficient future for freight.

[5] NewClimate Institute. "Transport Roadmap Report." Retrieved from this URL (last accessed May 2023).

## 3.2 Framework regional road map for promoting energy-efficient freight transport

Building on the discussions of policy scenarios and tools, an outline of a proposed regional road map for sustainable and energy-efficient freight transport is given in table 6. This road map is intended to be a flexible framework that can be adapted to meet the distinct needs, priorities and resources of individual countries. It offers a strategic direction, recognizing that each country is at a different stage in its pursuit of sustainable transport solutions. The design of the road map is focused on customization, encouraging countries to tailor their recommendations to specific contexts. This approach ensures that the solutions are relevant and effective, addressing unique national challenges and optimizing the use of local resources

**Table 6 Framework regional road map for energy-efficient freight transport**

| Directions and activities | Target indicators | Implementation timing | Responsible entities | Form of deliverables | Data sources for monitoring |
|---|---|---|---|---|---|
| **1. Develop and implement fuel economy standards for vehicles** | | | | | |
| • Develop fuel economy standards for passenger cars, light-duty vehicles and HDVs in line with international best practices<br>• Conduct a study to assess the potential impact of the standards on fuel consumption and greenhouse gas emissions<br>• Implement the fuel economy standards through regulation and enforcement | • Reduction in fuel consumption and greenhouse emissions from vehicles<br>• Increase in the adoption of fuel-efficient vehicles | • Year 1: Develop fuel economy standards<br>• Year 2-3: Conduct study and finalize standards<br>• Year 4-10: Implement fuel economy standards through regulation and enforcement | • Ministry of Transportation and Communications<br>• Environmental Protection Agency<br>• Customs and Border Protection | • Fuel economy standards document<br>• Study report on the potential impact of fuel economy standards<br>• Regulation on fuel economy standards | • Vehicle registration data<br>• Fuel consumption data<br>• Greenhouse gas emissions data |

| Directions and activities | Target indicators | Implementation timing | Responsible entities | Form of deliverables | Data sources for monitoring |
|---|---|---|---|---|---|
| **2. Promote the use of alternative fuels and renewables** | | | | | |
| • Develop comprehensive policies, incentives and support mechanisms to encourage the integration of alternative fuels and renewable energy sources in the freight transport sector.<br>• Develop financial incentives<br>• Develop infrastructure to support alternative fuels, such as charging stations for electric vehicles and CNG filling stations<br>• Conduct public awareness campaigns to promote the benefits of alternative fuels | • Increase in the adoption of alternative fuels and electric vehicles<br>• Increase in the availability of infrastructure to support alternative fuels<br>• Reduction in greenhouse gas emissions from the transport sector | • Year 1-2: Develop policies, financial incentives and infrastructure to support alternative fuels<br>• Year 3-4: Conduct public awareness campaigns<br>• Year 5-10: Monitor and adjust policies and initiatives, as needed | • Ministry of Transportation and Communications<br>• Environmental Protection Agency<br>• Local governments | • Financial incentive programmes<br>• Infrastructure development plans<br>• Public awareness campaign materials | • Adoption rate of alternative fuels<br>• Availability of infrastructure to support alternative fuels<br>• Greenhouse gas emissions data |
| **3. Encourage the use of intermodal transport** | | | | | |
| • Develop and implement policies and regulations to promote intermodal transport, such as reducing road freight congestion and improving railway and waterway infrastructure<br>• Establish logistics centres and freight villages to improve the efficiency of the logistics system and reduce unnecessary trips made by freight vehicles | • Increase in the use of intermodal transport modes, such as rail and waterway transport<br>• Reduction in the number of unnecessary trips made by freight vehicles | • Year 1-2: Develop policies and regulations to promote intermodal transport<br>• Year 3-5: Establish logistics centres and freight villages<br>• Year 6-10: Develop transportation systems to support logistics centres and freight villages | • Ministry of Transportation and Communications<br>• Environmental Protection Agency<br>• Local governments | • Policy and regulation documents<br>• Logistics centre and freight village plans<br>• Transportation data | • Use of intermodal transport modes<br>• Number of unnecessary trips made by freight vehicles |

| Directions and activities | Target indicators | Implementation timing | Responsible entities | Form of deliverables | Data sources for monitoring |
|---|---|---|---|---|---|
| **4. Develop and implement policies and regulations to reduce environmental impact** | | | | | |
| • Develop and implement policies and regulations to reduce air pollution and noise pollution from freight transport, such as emissions standards for vehicles and noise limits for freight operations<br>• Implement energy-efficient technologies in the transport sector, such as the use of fuel-efficient engines and energy-efficient driving practices | • Reduction in air pollution and noise pollution from freight transport<br>• Increase in the adoption of energy-efficient technologies in the transport sector | • Year 1-2: Develop policies and regulations to reduce environmental impact<br>• Year 3-4: Implement policies and regulations<br>• Year 5-10: Monitor and adjust policies and initiatives as needed | • Ministry of Transportation and Communications<br>• Environmental Protection Agency<br>• Local governments | • Policy and regulation documents<br>• Technology adoption reports<br>• Environmental impact assessments | • Air pollution data<br>• Noise pollution data<br>• Adoption rate of energy-efficient technologies |
| **5. Establish logistics centres and freight villages** | | | | | |
| • Identify key transport hubs for logistics centres and freight villages<br>• Develop and implement plans for logistics centres and freight villages, including consolidation and distribution of goods, customs clearance and warehousing services<br>• Develop and implement transportation systems to support logistics centres and freight villages, such as rail and waterway transport | • Improvement in the efficiency of the logistics system<br>• Reduction in the number of unnecessary trips made by freight vehicles | • Year 1-2: Identify key transport hubs and develop plans<br>• Year 3-5: Establish logistics centres and freight villages<br>• Year 6-10: Develop transportation systems to support logistics centres and freight villages | • Ministry of Transportation and Communications<br>• Environmental Protection Agency<br>• Local governments | • Logistics centre and freight village plans<br>• Transportation system development plans<br>• Freight vehicle trip reduction reports | • Logistics efficiency data<br>• Number of unnecessary trips made by freight vehicles |

| Directions and activities | Target indicators | Implementation timing | Responsible entities | Form of deliverables | Data sources for monitoring |
|---|---|---|---|---|---|
| **6. Encourage the use of low-carbon transport modes** | | | | | |
| • Develop and implement policies and regulations to encourage the use of low-carbon transport modes<br>• Develop infrastructure to support low-carbon transport modes<br>• Conduct public awareness campaigns to promote the benefits of low-carbon transport modes | • Increase in the use of low-carbon transport modes<br>• Reduction in greenhouse gas emissions from the transport sector | • Year 1-2: Develop policies and regulations to encourage the use of low-carbon transport modes<br>• Year 3-4: Develop infrastructure to support low-carbon transport modes<br>• Year 5-10: Conduct public awareness campaigns | • Ministry of Transportation and Communications<br>• Environmental Protection Agency<br>• Local governments | • Policy and regulation documents<br>• Infrastructure development plans<br>• Public awareness campaign materials | • Use of low-carbon transport modes<br>• Greenhouse gas emissions data |
| **7. Develop and implement freight route optimization strategies** | | | | | |
| • Develop and implement technologies and policies to optimize freight routes, such as route planning software and road pricing schemes<br>• Encourage the use of off-peak delivery times to reduce road congestion<br>• Implement measures to reduce empty vehicle miles, such as promoting backhauling and load consolidation | • Improvement in the efficiency of freight transport<br>• Reduction in road congestion and traffic-related emissions | • Year 1-2: Develop and test freight route optimization technologies and policies<br>• Year 3-4: Implement freight route optimization measures<br>• Year 5-10: Monitor and adjust policies and initiatives, as needed | • Ministry of Transportation and Communications<br>• Environmental Protection Agency<br>• Local governments | • Route optimization technologies and policies<br>• Off-peak delivery policies and guidelines<br>• Measures to reduce empty vehicle miles | • Freight transport efficiency data<br>• Road congestion data |

| Directions and activities | Target indicators | Implementation timing | Responsible entities | Form of deliverables | Data sources for monitoring |
|---|---|---|---|---|---|
| **8. Provide heavy-duty vehicle scrappage subsidies** | | | | | |
| • Develop and implement a programme to provide subsidies for scrapping old and high-emission HDVs and replacing them with new, low-emission HDVs<br>• Establish eligibility criteria, such as age and emission standards, for HDVs to qualify for the subsidy<br>• Conduct public awareness campaigns to promote the benefits of HDV scrappage and replacement | • Reduction in emissions from HDVs<br>• Increase in the adoption of low-emission HDVs | • Year 1-2: Develop and implement HDV scrappage subsidy programme<br>• Year 3-5: Monitor and adjust the programme as needed<br>• Year 6-10: Increase the subsidy amount and expand the programme if necessary | • Ministry of Transportation and Communications<br>• Environmental Protection Agency<br>• Local governments | • HDV scrappage subsidy program guidelines<br>• Eligibility criteria and application process<br>• Public awareness campaign materials | • HDV scrappage and replacement data<br>• Emissions reduction data |
| **9. Stimulate modal shift to less emitting modes from road freight** | | | | | |
| • Develop and implement policies and initiatives to promote the shift from road freight to less-emitting modes, such as rail, waterway and pipeline transport<br>• Establish incentive schemes to encourage shippers and logistics companies to use less-emitting modes<br>• Develop infrastructure to support less-emitting modes, such as rail terminals and waterway ports | • Increase in the use of less-emitting modes for freight transport<br>• Reduction in emissions from the transport sector | • Year 1-2: Develop policies and initiatives to promote modal shift to less-emitting modes<br>• Year 3-4: Establish incentive schemes<br>• Year 5-10: Develop infrastructure to support less-emitting modes | • Ministry of Transportation and Communications<br>• Environmental Protection Agency<br>• Local governments | • Policy and initiative documents<br>• Incentive scheme guidelines<br>• Infrastructure development plans | • Modal shift data<br>• Emissions reduction data |

| Directions and activities | Target indicators | Implementation timing | Responsible entities | Form of deliverables | Data sources for monitoring |
|---|---|---|---|---|---|
| **10. Join international conventions and treaties promoting energy-efficient freight transport** | | | | | |
| • Join international conventions and treaties promoting energy-efficient freight transport, such as the Kyoto Protocol, Paris Agreement, and the IEA Fuel Economy Campaign<br>• Align national development policies with the goals and principles of these conventions and treaties<br>• Establish monitoring and evaluation systems to track progress towards meeting the goals of these conventions and treaties | • Alignment of national development policies with international conventions and treaties promoting energy-efficient freight transport<br>• Progress towards meeting the goals of international conventions and treaties | • Year 1-2: Join relevant international conventions and treaties<br>• Year 3-4: Align national development policies with the goals and principles of these conventions and treaties<br>• Year 5-10: Establish monitoring and evaluation systems | • Ministry of Transportation and Communications<br>• Environmental Protection Agency<br>• Ministry of Foreign Affairs | • International convention and treaty membership documents<br>• National development policy alignment documents<br>• Monitoring and evaluation system guidelines | • Progress towards meeting the goals of international conventions and treaties<br>• Alignment of national development policies |
| **11. Integrate target indicators for freight transport efficiency in national development policies** | | | | | |
| • Develop and implement policies and initiatives to integrate target indicators for freight transport efficiency into national development policies<br>• Establish a monitoring and evaluation system to track progress towards the target indicators<br>• Provide regular reports and updates on progress towards the target indicators to stakeholders | • Improvement in freight transport efficiency<br>• Reduction in emissions from the transport sector | • Year 1-2: Develop policies and initiatives to integrate target indicators for freight transport efficiency<br>• Year 3-4: Establish a monitoring and evaluation system<br>• Year 5-10: Provide regular reports and updates on progress towards the target indicators | • Ministry of Transportation and Communications<br>• Environmental Protection Agency<br>• National Development Planning Agency | • Policy and initiative documents<br>• Monitoring and evaluation system guidelines<br>• Progress reports | • Freight transport efficiency data<br>• Emissions reduction data |

***Source***: Compiled by the authors.

## 3.3 Self-test quiz for Chapter 3

**1. What is the primary purpose of a regional road map in the context of sustainable transport?**

A) To promote the interests of automotive industry.

B) To provide a detailed plan for increasing fossil fuel consumption.

C) To outline strategies for enhancing energy efficiency in freight transport across a specific region

D) To limit the involvement of unnecessary stakeholders in transport planning.

**Answer:** ________________

**2. What role do stakeholder engagements play in the development of a regional road map?**

A) Their participation is desirable but not critical.

B) They are critical to ensure that the road map is comprehensive and addresses the needs and capabilities of all regional actors.

C) They are only consulted in the final stages of road map approval process

D) Their opinions are noted but not integrated into the road map.

**Answer:** ________________

**3. How does a regional road map contribute to the overall sustainability of freight transport?**

A) By promoting the exclusive use of road freight transport.

B) By outlining specific actions and policies that lead to a decrease in energy consumption and emissions.

C) By encouraging the use of traditional transport technologies.

D) By prioritizing transportation planning over other policy frameworks.

**Answer:** ________________

**4. What is a critical first step in developing a regional road map for sustainable transport?**

A) Disregarding existing transport and environmental data.

B) Setting clear, measurable objectives aligned with long-term sustainability goals

C) Prioritizing the benefits for individual stakeholders.

D) Assuming that no changes to current policies are necessary.

**Answer:** ________________

**5. In the context of a regional road map, how important is the adaptation to specific regional characteristics and needs?**

A) Not important; one-size-fits-all approaches are preferred whenever applicable.

B) Slightly important; minor adjustments may be made.

C) Critically important; custom solutions enhance the effectiveness and acceptance of the road map.

D) Unimportant; regional characteristics do not impact transport policies.

**Answer:** ________________

# Chapter 4. Logical framework approach[6]

The logical framework approach (LogFrame) is a strategic tool used for planning, managing and evaluating projects. Its structured format and systematic process make it particularly effective in transport policymaking in which complex, multi-stakeholder initiatives require clear alignment of objectives, resources and outcomes. This section is intended to guide policymakers through the application of LogFrame in designing and implementing transport policies effectively.

## Step 1: Assess sector performance

The first step in applying the logical framework approach to sustainable and energy-efficient freight transport involves assessing the performance of the transport sector. This is accomplished by using specific performance indicators that gauge the sector's contribution to the broader economy and its impact on the quality of life. Table 7 gives suggestions of several key performance indicators directly related to the energy efficiency of freight transport across different transport modes.

**Table 7 An Example of performance indicators for various transport modes**

| Transport sector | Performance indicator | Description |
|---|---|---|
| **Road transport** | Fuel efficiency | Measures the amount of fuel used per unit of distance (such as litres per 100 km), reflecting the energy efficiency of road vehicles. |
| | Carbon intensity | Measures the amount of $CO_2$ emitted per ton-km, indicating the environmental impact of road freight transport. |
| | Idle time reduction | Tracks the reduction in the time vehicles spend idling without moving, which decreases unnecessary fuel consumption and emissions. |
| **Rail transport** | Energy consumption per ton-km | Measures the energy used to transport one ton of goods one kilometre, indicating the efficiency of rail freight operations. |
| | Electrification percentage | The proportion of the rail network that is electrified, as electric trains typically offer greater energy efficiency than diesel trains. |
| | Modal shift to rail | Tracks the shift of freight transport from less energy-efficient modes (such as road) to rail, which is generally more energy-efficient. |
| **Air transport** | Fuel burn efficiency | Measures the fuel efficiency of aircraft, reflecting how effectively fuel is used for freight operations. |
| | Load factor | The percentage of available freight capacity that is used, reflecting operational efficiency and energy use optimization. |

[6] This chapter is based on the LogFrame approach as outlined in ADB (1998).

| Transport sector | Performance indicator | Description |
|---|---|---|
| **Maritime transport** | Fuel efficiency | Measures the amount of fuel used per container per kilometre, which reflects the energy efficiency of maritime vessels. |
| | Slow Steaming adoption | The adoption rate of slow steaming practices, which involve operating ships at lower speeds to reduce fuel consumption and emissions. |
| | Green ship technology adoption | Tracks the adoption of advanced technologies and designs in ships that enhance energy efficiency and reduce emissions. |

***Source*:** Developed by the authors as a hypothetical example for educational and illustrative purposes only.

The selected indicators highlight areas that directly influence sustainability and efficiency. By measuring these indicators, the policymakers can identify key areas for improvement, understand existing challenges, and pinpoint opportunities for enhancing the sector's environmental and economic contributions. This assessment forms the basis for informed decision-making and strategic planning in the subsequent steps of the project or programme design.

## Step 2: Identify Sector Performance Problems/Opportunities

Once the performance indicators have been determined, the next step involves identifying specific problems or opportunities within these parameters. In the context of sustainable and energy-efficient freight transport, Table 8 links specific problems or opportunities directly to indicators determined in step 1.

**Table 8 An example of problems identified for various transport modes.**[7]

| Transport sector | Performance indicator | Problem/opportunity identified | Description |
|---|---|---|---|
| **Road transport** | Fuel efficiency | Low fuel efficiency | Many vehicles in the fleet have lower fuel efficiency, leading to higher fuel consumption and increased emissions. |
| | Carbon Intensity | High carbon emissions | |
| | Idle time reduction | Excessive idling | |
| **Rail transport** | Energy consumption per ton-km | High energy use per ton-km | Rail freight is consuming more energy than optimal per ton-km, suggesting possibilities for system efficiency improvements. |
| | Electrification percentage | Low electrification rates | |
| | Modal shift to rail | Insufficient modal shift | |

[7] Developed by the authors as a hypothetical example for educational and illustrative purposes only.

| Transport sector | Performance indicator | Problem/opportunity identified | Description |
|---|---|---|---|
| **Air transport** | Fuel burn efficiency | Inefficient fuel use | Aircraft fuel efficiency is below potential, indicating a need for newer, more efficient aircraft or better operational practices. |
| | Load factor | Underutilized cargo capacity | |
| **Maritime transport** | Fuel efficiency | Suboptimal fuel consumption | Ships are not meeting potential fuel efficiency, pointing to the need for engine upgrades or operational adjustments. |
| | Slow steaming adoption | Resistance to slow steaming | |
| | Green ship technology adoption | Low adoption of energy-efficient technologies | |

***Source*:** Developed by the authors as a hypothetical example for educational and illustrative purposes only.

It is important that the identified problems are directly linked to the sector performance indicators identified in step 1. For instance, if "energy consumption" is a key indicator, an identified opportunity could be the potential for integrating renewable energy sources or adopting more energy-efficient vehicles and practices. Similarly, if "emission levels" are a concern, the focus might shift towards reducing reliance on conventional fuels and enhancing the use of electric or hybrid vehicles.

### Step 3: Cause-effect analysis of problems/opportunities

The third step in the logical framework approach involves conducting a detailed cause-effect analysis of the identified problems or opportunities. This critical analysis helps to understand the root causes and the broader impacts of these issues on the transport sector's performance and its contributions towards sustainability and efficiency.

Table 9 prevents a summary of the results of a cause-effect analysis conducted following steps 1 and 2 above.

**Table 9  An example of cause-effect analysis for various transport modes**

| Transport sector | Problem/opportunity | Causes | Effects |
|---|---|---|---|
| **Road transport** | Low fuel efficiency | • Older, less efficient vehicles<br>• Lack of stringent fuel efficiency regulations<br>• Inadequate driver training | • Increased operational costs<br>• Higher emissions<br>• Reduced competitiveness |
| | High-carbon emissions | • High dependence on fossil fuels<br>• Inefficient route management<br>• Suboptimal vehicle maintenance | • Contribution to climate change<br>• Health issues from poor air quality<br>• Regulatory and reputational risks |
| | Excessive idling | • Traffic congestion<br>• Lack of smart traffic signals<br>• Old driving habits | • Wasted fuel<br>• Increased vehicle wear and tear<br>• Elevated local air pollution |
| **Rail Transport** | High energy use per ton-km | • Inefficient locomotives<br>• Poor track layout<br>• Lack of modern technology investment | • Higher energy costs<br>• Larger carbon footprint<br>• Difficulty attracting eco-conscious shippers |
| | Low electrification rates | • High costs of electrification<br>• Limited funding<br>• Regulatory hurdles | • Continued reliance on diesel<br>• Missed renewable integration<br>• Lagging environmental targets |
| | Insufficient modal shift | • Competitive pricing of road transport<br>• Lack of transport integration<br>• Inadequate rail infrastructure | • Dominance of road transport<br>• Road infrastructure wear<br>• Underutilized rail capacity |
| **Air transport** | Inefficient fuel use | • Ageing aircraft fleet<br>• Suboptimal flight routes<br>• Obsolete aerodynamic designs | • Increased fuel costs<br>• Greater carbon footprint<br>• Reduced competitiveness |
| | Underutilized cargo capacity | • Cargo space-demand mismatch<br>• Inefficient cargo management<br>• Inflexible cargo routing | • Lower revenue per flight<br>• Increased flights and emissions<br>• Reduced logistics efficiency |

| Transport sector | Problem/opportunity | Causes | Effects |
|---|---|---|---|
| **Maritime transport** | Suboptimal fuel consumption | • Outdated propulsion systems<br>• Poor vessel maintenance<br>• Reluctance to adopt new technologies | • Higher operating costs<br>• Increased greenhouse gas emissions and pollutants<br>• Non-compliance with regulations |
| | Resistance to slow steaming | • Market pressure for fast delivery<br>• Lack of regulatory incentives<br>• Schedule impact concerns | • Continued high fuel consumption<br>• Increased maintenance costs<br>• Missed environmental opportunities |
| | Low Adoption of Energy-Efficient Technologies | • High upfront costs<br>• Lack of incentives<br>• Scepticism about technology effectiveness | • Continued use of outdated methods<br>• Slower progress towards environmental goals<br>• Missed competitive advantages |

***Source***: Developed by the authors as a hypothetical example for educational and illustrative purposes only.

In the practice of the LogFrame approach, relationships between root causes and their subsequent impacts are often visualized using a "problem tree". Figure 4 below illustrates a simplified model of a problem tree, constructed from the cause-effect analysis results for the road freight transport sector.

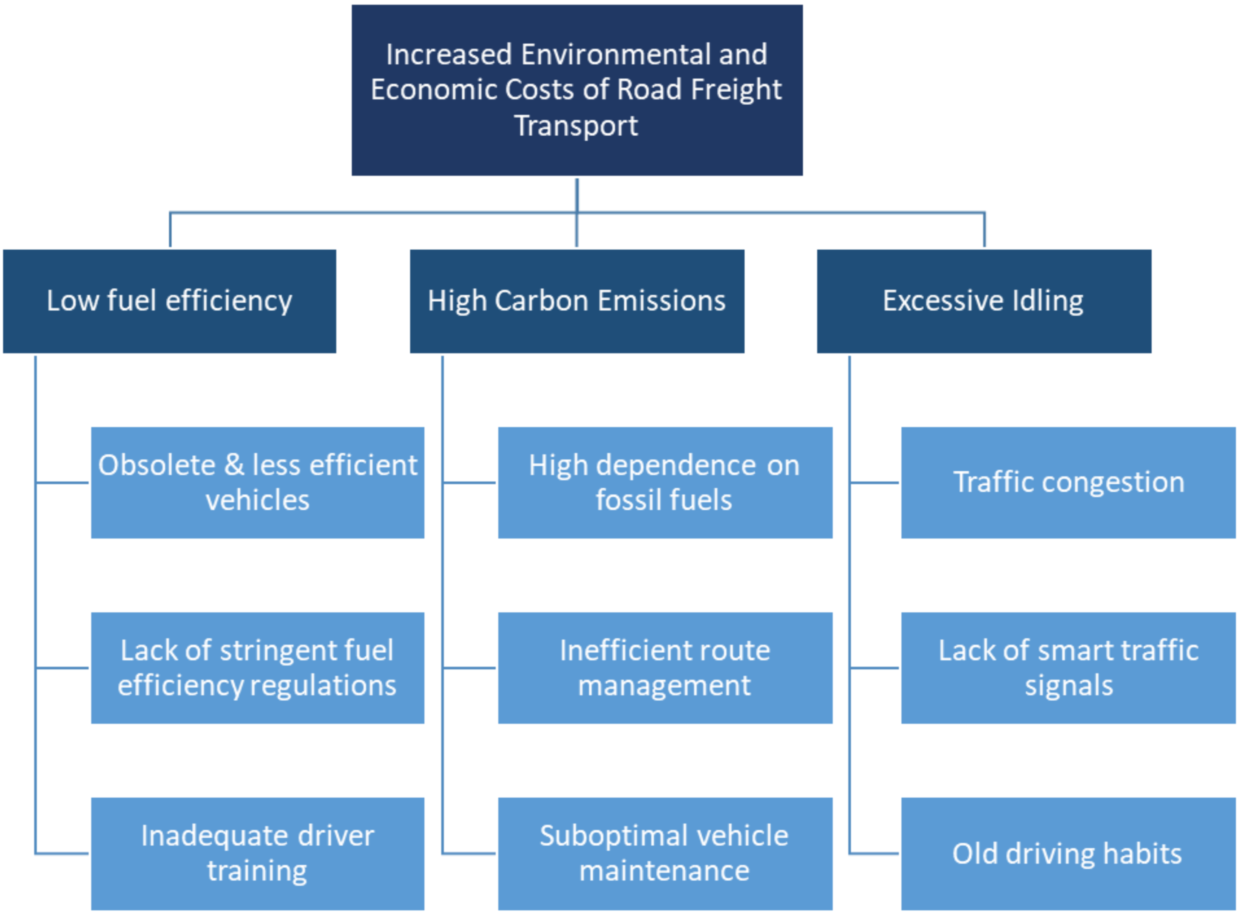


**Figure 4 Sample Problem Tree for the Road Freight Transport Sector.**[8]

***Source*:** Developed by the authors as a hypothetical example for educational and illustrative purposes only.

This structured analysis highlights the multifaceted impacts of the problem and identifies leverage points where interventions could be most effective. Understanding the causes helps in crafting strategic solutions that directly address these factors (step 4).

**Step 4: Objectives tree**

Following the cause-effect analysis, the next step is to transform the insights gained from the problem tree into an objectives tree. This critical transition shifts the focus from diagnosing problems to formulating actionable solutions aimed at improving sector performance.

The objectives tree reinterprets the identified causative factors and effects into specific, achievable objectives. Each branch of the tree, which previously depicted a negative aspect or a challenge, is converted into a positive action goal that contributes towards resolving the core issues. This transformation allows planners to visually map out and articulate a comprehensive range of solutions and objectives that directly address each element of the cause-effect analysis. A sample objective tree for the road freight transport sector is shown in Figure 5:

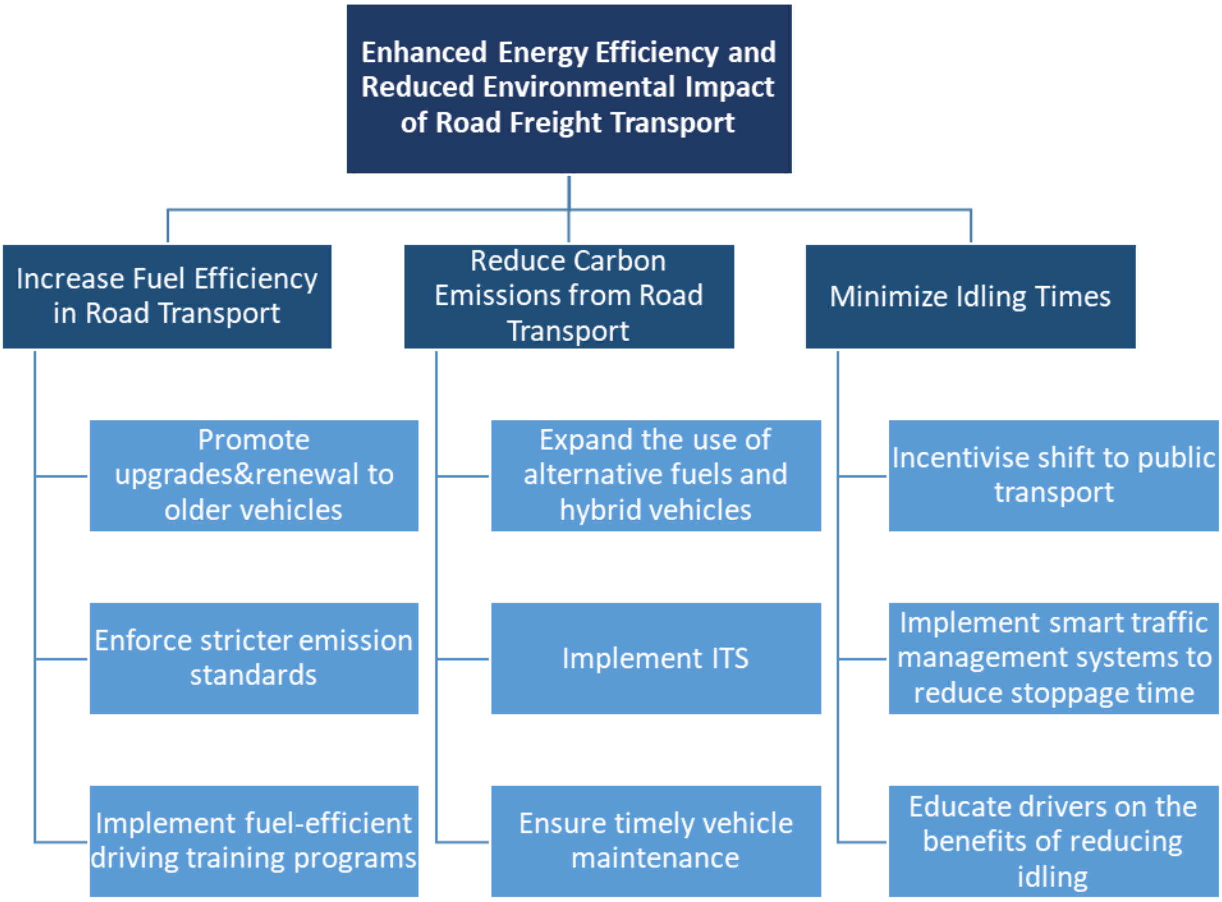


**Figure 5 Sample objective tree for the road freight transport sector.**

***Source***: Developed by the authors as a hypothetical example for educational and illustrative purposes only. [9]

For example, if the cause-effect analysis for "increasing traffic congestion" identified inadequate public transport systems as a root cause, the objectives tree would include goals, such as "enhance public transport infrastructure" or "increase the availability and reliability of public transit options". Similarly, effects, such as increased emissions, would be countered with objectives such as "reduce greenhouse gas emissions from the transport sector".

This objectives tree, therefore, serves as a blueprint for the strategic actions required to tackle the identified problems or seize the opportunities. It not only guides the development of detailed strategies and action plans, but it also ensures that these plans are aligned with the overarching goals of sustainability and efficiency in the transport sector. This structured approach helps ensure that every intervention is targeted and coherent, maximizing the potential for successful outcomes.

### Step 5: Alternatives analysis

The fifth step in the logical framework approach involves analysing various potential courses of action that have been outlined in the objectives tree. This step is crucial for identifying the most effective and efficient strategies to improve sector performance related to the identified performance indicators.

During the alternatives analysis, each potential action derived from the objectives tree is thoroughly evaluated. This evaluation involves comparing the options against a set of predefined criteria, which may include factors, such as cost-effectiveness, feasibility, impact on emissions reduction, potential for improving traffic flow, and alignment with broader environmental and economic goals. Additional considerations might involve regulatory constraints, stakeholder acceptance, and potential for technological integration.

This systematic assessment helps in weighing the advantages and disadvantages of each option, facilitating informed decision-making. The process ensures that the selected strategy not only addresses the core issues identified in the cause-effect analysis but that it also does so in a manner that is practical and sustainable given the specific circumstances of the transport sector.

Ultimately, this step leads to the selection of the most appropriate action plan that promises to deliver the best balance of benefits across various dimensions.

## Step 6: Project design using the logical framework

The final step in the logical framework approach involves translating the selected course of action into a structured project or programme design. This step is critical as it delineates the project or programme in terms of its intended objectives, outputs and activities using a logical framework matrix (LogFrame).

The logical framework matrix serves as a comprehensive tool that clearly outlines the hierarchy of objectives, starting from the overall goal down to specific objectives, and further detailing the expected outputs and the key activities required to achieve these outputs. This structured format allows for a clear visualization of the causal relationships between inputs (activities), outputs, outcomes and the ultimate impact of the project.

The LogFrame also incorporates indicators for each objective and output, providing clear criteria for measurement and evaluation. This helps in monitoring progress and assessing the effectiveness of the project or programme once implemented.

The key steps of building a project design matrix are described below:

- ***Define objectives and goals.*** Start by clearly defining the ultimate goal of the transport policy. This might be to reduce traffic congestion, lower carbon emissions or improve public transport facilities. The goal should be aligned with broader government objectives and sustainable development targets.
- ***Identify inputs and activities.*** Specify the resources and activities required to achieve these goals. For transport policy, inputs could include legislative changes, infrastructure investments, and public awareness campaigns. Activities might involve constructing bike lanes, implementing electronic toll systems or conducting safety workshops.
- ***Determine outputs.*** Define the concrete outputs result from the completed activities. In the context of transport policy, outputs might include the number of miles of safe cycling paths created, the reduction in travel time due to improved traffic signal, or the percentage increase in public transport usage.
- ***Set indicators and means of verification.*** For each output, establish measurable indicators that make it possible to evaluate the success of the policy. Indicators should be SMART: specific, measurable, achievable, relevant, and time-bound. Means of verification are the sources or methods through which these indicators are assessed, such as traffic studies, emissions testing or user surveys.
- ***Assess assumptions and risks.*** Identify external factors that could impact the policy's success. These might include economic conditions, technological advancements or public acceptance. Understanding these assumptions helps in anticipating challenges and planning mitigating strategies.

Following this algorithm, a sample project design framework for road freight transport is illustrated in Table 10:

**Table 10 Sample project design framework for road freight transport**

| Component | Performance targets | Monitoring mechanisms | Assumptions and risks |
|---|---|---|---|
| **Goal:** | | | |
| Enhanced energy efficiency and reduced environmental impact of road freight transport | Reduction in national road transport emissions by X% by 2030. | Annual environmental impact assessments and emissions reporting. | Stable regulatory environment and continued government support for green policies. |

| Component | Performance targets | Monitoring mechanisms | Assumptions and risks |
|---|---|---|---|
| **Objectives:** | | | |
| Increase fuel efficiency | Increase in fleet average fuel efficiency by Y% by 2025. | Regular fuel consumption audits and efficiency reporting. | Availability of latest fuel-efficient technologies and market acceptance. |
| Reduce carbon emissions | Decrease in $CO_2$ emissions from road freight by Z% by 2025. | Continuous monitoring of emissions levels via approved testing centres. | Effective implementation of new emissions standards without significant pushback from industry. |
| Minimize Idling times | Reduction in average idling times by W% across all road transport operations. | Use of Global Positioning System and telematics to monitor vehicle operational patterns. | Adoption of smart traffic technologies and driver compliance with idling reduction initiatives. |
| **Outputs:** | | | |
| Increased adoption of energy-efficient vehicles | XX% increase in the use of energy-efficient or alternative fuel vehicles. | Sales data analysis and vehicle registration tracking. | Economic viability and customer acceptance of alternative fuel vehicles. |
| Enhanced traffic management systems implemented | YY% decrease in traffic congestion in targeted urban areas. | Traffic flow analysis before and after system implementation. | Continued investment in smart city infrastructures and public acceptance. |
| **Inputs:** | | | |
| Educational programmes for drivers | Training 10,000 drivers annually in fuel-efficient practices. | Training completion records and follow-up surveys on practice adoption. | Sufficient funding for training programs and availability of skilled trainers. |
| Installation of vehicle charging stations | 500 new charging stations by 2025. | Monitoring of station installation and utilization rates. | Adequate infrastructure investment and uninterrupted power supplies. |

***Source***: Developed by the authors as a hypothetical example for educational and illustrative purposes only.

In conclusion, the LogFrame serves as a dynamic tool for monitoring and evaluation. By regularly reviewing the indicators and adjusting activities and outputs as needed, policymakers can ensure that the transport policy remains effective and responsive to changing conditions. This iterative process is key to successful policy implementation and helps in achieving the long-term sustainability of transport systems.

## 4.1 Self-test quiz for chapter 4

**1. What is the primary purpose of a regional road map in the context of sustainable transport?**

A) To promote the interests of automotive industry.

B) To provide a detailed plan for increasing fossil fuel consumption.

C) To outline strategies for enhancing energy efficiency in freight transport across a specific region.

D) To limit the involvement of unnecessary stakeholders in transport planning.

**Answer:** ___________________

**2. What role do stakeholder engagements play in the development of a regional road map?**

A) Their participation is desirable but not critical.

B) They are critical for ensuring that the road map is comprehensive and addresses the needs and capabilities of all regional actors.

C) They are only consulted in the final stages of road map approval.

D) Their opinions are noted but not integrated into the road map.

**Answer:** ___________________

**3. How does a regional road map contribute to the overall sustainability of freight transport?**

A) By promoting the exclusive use of road freight transport.

B) By outlining specific actions and policies that lead to a decrease in energy consumption and emissions.

C) By encouraging the use of traditional transport technologies.

D) By prioritizing transportation planning over other policy frameworks.

**Answer:** ___________________

**4. What is a critical first step in developing a regional road map for sustainable transport?**

A) Disregarding existing transport and environmental data.

B) Setting clear, measurable objectives aligned with long-term sustainability goals.

C) Prioritizing the benefits for individual stakeholders.

D) Assuming that no changes to current policies are necessary.

**Answer:** ___________________

**5. In the context of a regional road map, how important is the adaptation to specific regional characteristics and needs?**

A) Not important; one-size-fits-all approaches are preferred whenever applicable.

B) Slightly important; minor adjustments may be made.

C) Critically important; custom solutions enhance the effectiveness and acceptance of the road map.

D) Unimportant; regional characteristics do not impact transport policies.

**Answer:** ___________________

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## Answers to self-test quizzes

| Question | Chapter 1 | Chapter 2 | Chapter 3 | Chapter 4 |
|---|---|---|---|---|
| **1** | C | Fuel efficiency | C | B |
| **2** | B | B | B | B |
| **3** | C | Carbon intensity | B | B |
| **4** | B | A-2, B-3, C-1 | B | A |
| **5** | Alternative | National development policies | C | A-3, B-1, C-2 |

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