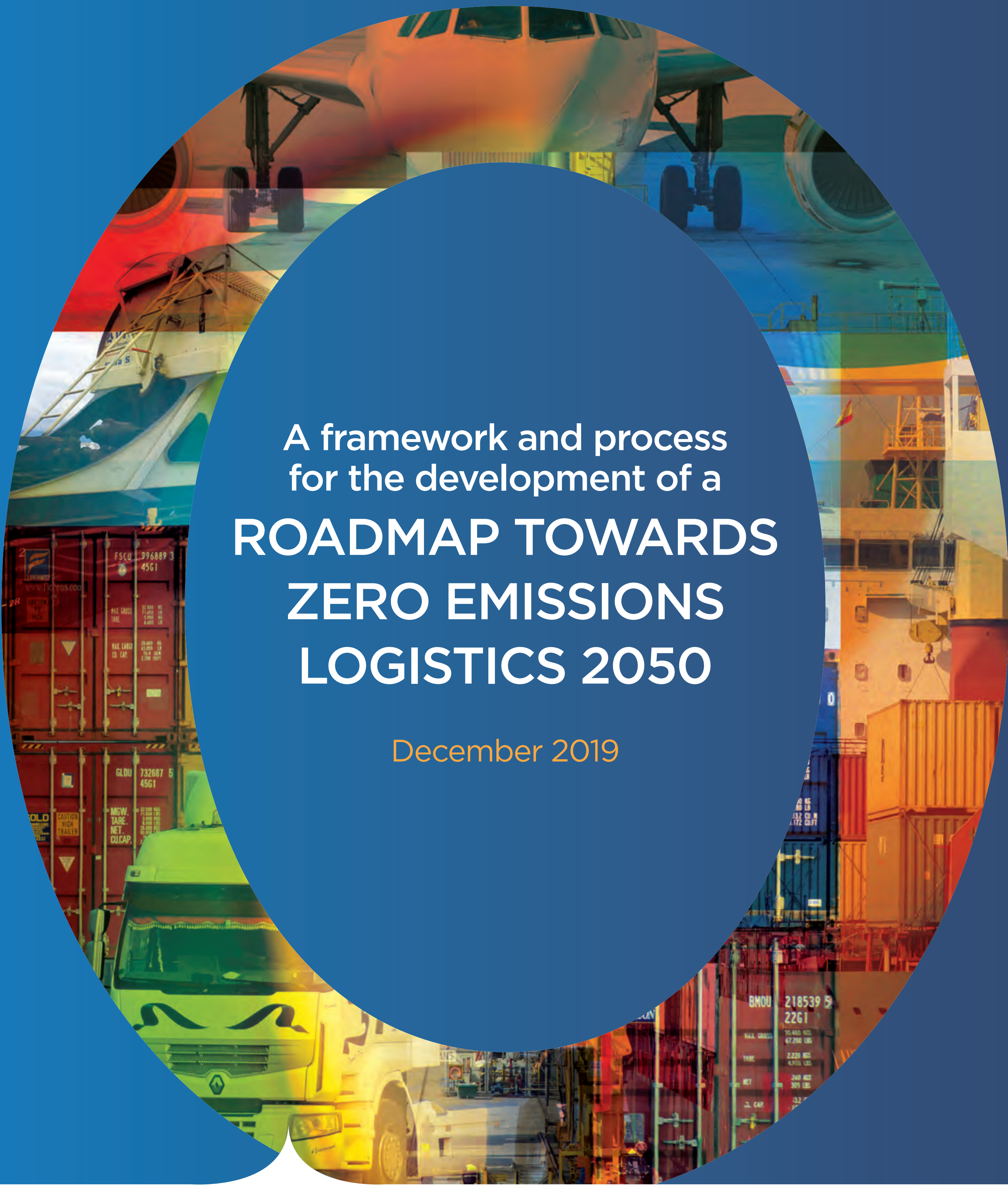
TOWARDS



A framework and process for the development of a

ROADMAP TOWARDS ZERO EMISSIONS LOGISTICS 2050

December 2019

alice | Alliance for Logistics Innovation through Collaboration in Europe

With the support of: LEARN Logistics Emissions Accounting & Reduction Network

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About ALICE-ETP
The European Technology Platform (ETP) Alliance for Logistics Innovation through Collaboration in Europe (ALICE) is set up to develop a comprehensive strategy for research, innovation and market deployment of logistics and supply chain management innovation in Europe. The platform will support and assist the implementation of the EU Program for research: Horizon 2020 and Horizon Europe.

ALICE is based on the recognition of the need for an overarching view on logistics and supply chain planning and control, in which shippers and logistics service providers closely collaborate to reach efficient logistics and supply chain operations.

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Disclaimer
This report aims to bring together the views of a wide range of stakeholders and experts in order to contribute to a Roadmap that could help companies for business decisions and emission reduction efforts, governments to develop associated policies and research and civil society to support both. The views expressed in this report are a collection of those of the different stakeholders involved in ALICE and in the different activities carried out such as workshops, surveys, etc. As such, not everyone involved in this initiative may necessarily fully support all the views expressed in the report. All the stakeholders involved do share a common interest, however: speed up decarbonisation while remaining fully competitive.

Contents

Executive summary

In response to the Paris Agreement, more and more governments, associations and businesses are setting bold climate targets. The ambition is for Europe to be the first climate-neutral continent in the world by 2050. This will be achieved with a two-step approach, designed to reduce CO_2 emissions by 50%, if not 55%, by no later than 2030.[1] While only 29% of countries' Nationally Determined Contributions (NDCs) include freight emissions, the topic is rising on national and local agendas.[2] More than 680 companies have committed to science-based targets, with some pledging to reach zero emissions by 2050.[3]

These companies are now looking for ways to turn promises into action. But when it comes to freight transport and logistics, they face challenges. Freight emissions are still increasing, in contrast to most other sectors. Global transport demand is estimated to triple by 2050, which would mean doubling carbon emissions under a business as usual scenario.[4]

Roadmaps are being developed. But most tend to be government-centric and give little guidance on how fleets are to implement their goals in practice. Many companies and organisations that use or provide freight services have yet to develop their own roadmaps. Collaboration and alignment between different players are key to encourage the integration of different roadmaps.

The Alliance for Logistic Innovation and Collaboration in Europe (ALICE) is aware of the huge challenges and deep transformation required of freight transport and logistics if we are to meet climate goals and maintain our standard of living. That is why ALICE developed a roadmap entitled *"Towards Zero Emissions Logistics 2050"* to set the challenge and direction clearly. It aims to make the roadmap towards decarbonisation more practical for companies and to clarify what roles governments, research and development institutes and civil society will have in order to make this happen.

The deployment of greener and cleaner vehicles, trains, barges, ships and airplanes as well as other technologies for a more efficient transport network is forecasted to be too slow to deliver on our climate change targets. The short-term focus, therefore, is on leveraging and finding new opportunities for efficiency gains in freight transport and logistics.

We envision large efficiency gains and benefits to all stakeholders by doing more with less. The existing idle capacity of assets and infrastructure in all modes of transport could be better used, and flows could be managed in a more integrated way. Open logistics services and networks connecting seamlessly will maximise capacity utilisation. Value creation by efficiency should be used to speed up the transition to greener and cleaner assets, instead of transport price reduction and an erosion of margins with the current assets.

This can only be achieved with sufficient investment support, smart regulation and reputation programmes. Indeed, in a scenario in which all these potential efficiencies are achieved (also referred to as the 'Physical Internet'[5]) the forecasted 300% increase in transport demand could be achieved with only 50% increase in assets. These assets would increase the productivity of the logistics and supply chains and would allow increased and sustainable investment in greener technologies. The scope and approach of this roadmap is hence looking at the entire Life Cycle, system level and 'well-to-wheel' emissions, recognizing that a zero-emission scenario will likely require the off-setting of emissions too.

On top of decarbonisation, air quality, noise, and congestion are also important topics to be addressed. Many cities are protecting the urban environment with stricter access regulations and vehicle standards. There is a need for implementing solutions that ensure both the flow of freight in the city and safeguards the quality of life for citizens. Intelligently managing the flows within and around the city is key to achieving these complementary objectives.

This document is a first step towards such an intelligent freight management. It provides:

1. U. von der Leyen (2019) A Union that strives for more. My agenda for Europe
2. NDC Partnership. Transport and Climate Change: how Nationally Determined Contributions can accelerate transport decarbonization
3. https://sciencebasedtargets.org/
4. International Transport Forum (ITF, 2019). International Transport Outlook 2019.
5. For more information: visit www.etp-alice.eu and watch a video.

- An overview of existing roadmaps for different transport modes and regions.
- A framework for a decarbonisation roadmap (see *Figure 1*), consisting of five solution areas (see *Figure 2*), four stakeholder groups and three transition management measures where stakeholders need to collaborate over time. This framework can be applied at the global, regional, national and local levels. It can be used by businesses or other organisations individually or collectively.
- An overview of stakeholders' priorities within the solution areas and corresponding decarbonisation opportunities. Specific actions that need to be taken by the different stakeholder groups.

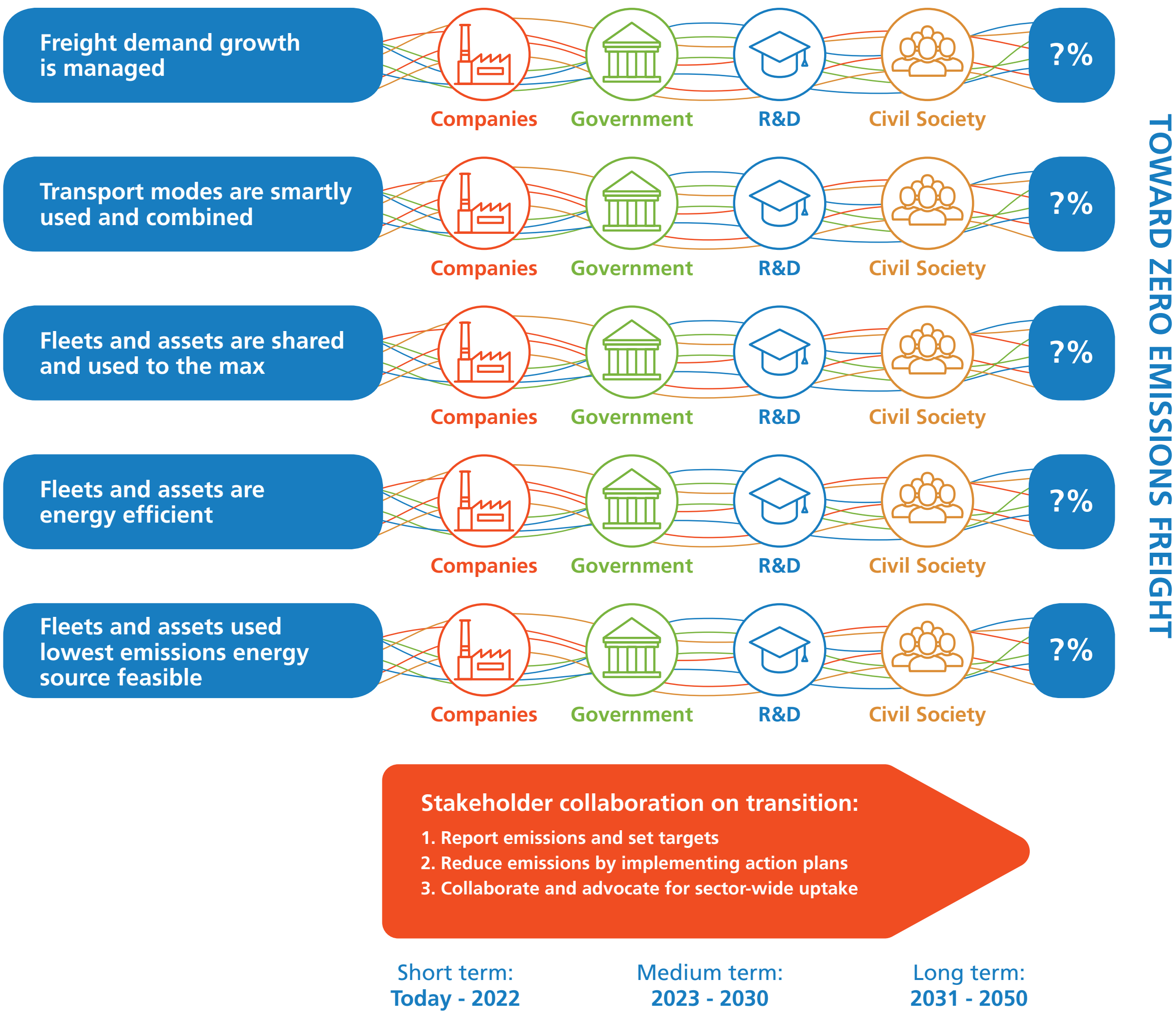

Figure 1: **Framework for freight transport and logistics decarbonisation**

FREIGHT DEMAND GROWTH IS MANAGED

- Supply chain restructuring
- Localization and nearshoring
- Decentralization of production and stockholding
- 3D printing
- Dematerialization
- Consumer behavior

TRANSPORT MODES ARE SMARTLY USED AND COMBINED

- Increased use of rail
- Increase use of short sea shipping and inland waterways
- Modular road transport
- Cargo bikes
- Multi-modal optimization
- Synchromodality

FLEETS AND ASSETS ARE SHARED AND USED TO THE MAX

- Load optimization
- Load consolidation and asset sharing
- Reduce empty moves
- Modular packaging and boxes
- Open transport networks and warehouses
- Increase storage density and energy efficiency

FLEETS AND ASSETS ARE ENERGY EFFICIENT

- Cleaner and efficient technologies
- Efficient vehicles and vessels
- High capacity vehicles / duo trailers
- Driving behavior
- Fleet operation
- Fleet maintenance

FLEETS AND ASSETS USE LOWEST EMISSIONS ENERGY SOURCE FEASIBLE

- Electric / hybrids
- Solar / Wind
- Biofuels
- Hydrogen
- CNG/bio-LNG
- Cleaner diesel
- Fuel management

Figure 2: **Solutions for freight transport and logistics decarbonisation**

According to our stakeholder consultation conducted through a survey with more than 40 respondents and three online consensus-building workshops, all five solutions areas need to be further investigated and considered when designing a decarbonisation strategy. There is a strong consensus that there is no silver bullet and all of them are needed if we want to fulfil the ambition of the Paris Agreement. With regards to the specific solutions the top ranked ones are in order of potential (i.e. considering impact and feasibility):

1. Renewable energy in combination with electrification, hybrids and hydrogen
2. Multimodal optimisation
3. Load consolidation and optimisation
4. Use of efficient vehicles, vessels and fleets
5. Synchromodality and flows synchronisation
6. Improve fleet operation
7. Supply chain restructuring
8. Consumer behaviour

The role of ALICE is primarily to facilitate the transition process in Europe, with a particular focus on scaling up solutions, implementation and collaboration as well as maintaining a link with research and innovation. ALICE will zoom in on two or three solution areas and specific solutions within these until 2021, based on the priorities of ALICE members. An existing example is the collaboration between ALICE and the POLIS network of European cities and regions on decarbonising urban freight and logistics. Together, we collect and share innovation best practices from government and companies and work out how these can be scaled up.

ALICE members are invited to share their experience in solution areas and specific solutions. ALICE will continue to help organisations reach impact at scale through collaboration and leveraging synergies between its members and other stakeholders.

1. INTRODUCTION

1.1

Logistics emissions worldwide and in Europe

Transport as a sector is considered a growing contributor to global climate change. According to the International Transport Forum (ITF), freight transport accounts for about 39% of transport CO_2 emissions and around 8% of CO_2 emissions worldwide. It's also a major contributor to air pollution. Road constitutes 62% (50% non-urban, 12% urban) of emissions, while sea contributes 27%, air 6%, rail 3% and inland waterways 2%[6]. In Europe, freight constitutes 6% of total CO_2 emissions and 30% of transport CO_2 emissions.[6]

As it stands, the total emissions from freight need to be almost fully decarbonised by 2050 compared to the 2015 levels if we are to meet the climate ambitions set out in the Paris Agreement, which came into force in 2016. However, the real challenge facing us is that demand for freight transport is predicted to triple and associated CO_2 emissions to more than double over the same period, according to the ITF. This means that nothing short of a transformational shift towards decarbonising the global freight sector is necessary in order to meet our shared global climate targets.

President-elect of the European Commission, Ursula von der Leyen said in her opening statement to the European Parliament plenary session: "I want Europe to become the first climate-neutral continent in the world by 2050. To make this happen, we must take bold steps together. Our current goal of reducing our emissions by 40% by 2030 is not enough. We must go further. We must strive for more. A two-step approach is needed to reduce CO_2 emissions by 2030 by 50, if not 55%".[7]

1.2

The need for an integrated roadmap

Freight transport and logistics transcends the influence sphere of individual countries and companies. Individual businesses need broader support from the private and public sectors, governments and civil society. Only with such support can companies take their efforts to the supply chain level and unlock the enormous potential for the freight transport and logistics sector to further optimise efficiency and reduce emissions. Therefore, coordinated efforts within industry, in partnership with government, research and development institutes and civil society, are key. We need leadership from all.

In response to the Paris Climate Agreement, governments, associations and businesses are looking for ways to turn promises into action. Many have started developing roadmaps towards low-emissions freight and logistics, with the ultimate vision of zero emissions by 2050. However, only 29% of countries' Nationally Determined Contributions (NDCs)

6. EC-DC R&I (2018). Final Report of the High-Level Panel of the European Decarbonisation Pathways Initiative

7. U. von der Leyen (2019) A Union that strives for more. My agenda for Europe

include freight[8]. And many companies and organisations that use or provide freight transport and logistics services have yet to develop their own roadmaps.

Collaboration and alignment between different players are key to encouraging the integration of different roadmaps. An important observation is that there is currently no integrated roadmap that covers all modes, logistics sites and transhipment hubs for the entire world, or even for the EU. The closest attempt was presented by World Economic Forum and Professor Alan McKinnon, who explored how a combination of solutions across the logistics supply chain can lead to sizable emissions cuts.

This roadmap aims to provide a common framework for businesses, governments and other stakeholders who want to contribute to decarbonising freight transport and logistics by developing their own roadmaps. This is done through:

- Presenting an overview of roadmaps and key studies globally, in particular for Europe, and identifying gaps and making recommendations for improvement.
- Giving an overview of decarbonisation solutions available — an insight into their potential, which ones can be implemented immediately and where planning for future implementation is necessary.
- Describing the roles of four stakeholder groups to make decarbonisation happen from now until 2050: private sector, government, research and development, and civil society.
- Explaining how this transition is to be managed by using improved methods of emissions-calculation, targets, action plans, collaboration and advocacy.

1.3

Existing roadmaps for decarbonising freight

Existing roadmaps and overarching studies exist that we can use and build on. We have listed some of these roadmaps, with an emphasis on Europe, below. This list will be updated as new roadmaps are published.

Table 1. Key existing roadmaps and studies for freight transport and logistics decarbonisation

SCOPE	SOURCE	TITLE AND DESCRIPTION
Global transport	International Transport Forum / OECD (ITF, 2019)	**ITF Transport Outlook 2019** Long-term projections for freight-transport demand (covering maritime, air and surface) and passenger transport and related CO_2 emissions under different policy scenarios.
Global transport	World Bank, SUM4All (2019)	**Global Roadmap of Action Toward Sustainable Mobility** Combination of policy measures covering mobility as a whole and six specific goals: rural universal access, urban universal access, efficiency, safety, green mobility and gender.
Global freight & logistics	World Economic Forum (WEF, 2009)	**Supply Chain Decarbonization - The role of Logistics and Transport in reducing Supply Chain Emissions** Overview of freight transport emissions and supply chain decarbonisation opportunities.

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8. NDC Partnership. Transport and Climate Change: how Nationally Determined Contributions can accelerate transport decarbonization

SCOPE	SOURCE	TITLE AND DESCRIPTION
Global freight & logistics	Alan McKinnon (2018)	**Decarbonizing Logistics – Distributing goods in a low carbon world** Details the extent of the climate-change challenge for logistics. Shows through a detailed assessment of available options what companies and governments can do to meet this challenge. Book and Presentation at ALICE/LEARN Workshop.
Global, maritime, air and heavy trucking	Energy Transition Commission (2018)	**Mission Possible: Reaching net-zero carbon emissions from harder-to-abate sectors by mid-century** Possible routes to fully decarbonise six different sectors, with detailed appendices for each, including three that are freight-related: trucking, shipping and aviation.
Global, maritime shipping	International Maritime Organization (IMO, 2018)	**Initial IMO Strategy on the reduction of GHG emissions from ships** The Initial Strategy identifies levels of ambition for the international shipping sector including an energy efficiency design index (EEDI) for new ships, reducing the carbon intensity of international shipping (>40% by 2030 and 70% by 2050, compared to 2008), and reducing total annual GHG emissions (>50% by 2050 compared to 2008).
Global maritime shipping	International Transport Forum / OECD (ITF, 2018)	**Decarbonising Maritime Transport Pathways to zero-carbon shipping by 2035** Examines technological, operational and alternative fuels measures needed to achieve zero CO_2 emissions from international maritime transport by 2035 using different pathways and gives policy recommendations to incentivise decarbonisation.
Global, air transport	International Air Trade Association (IATA, 2009) and International Civil Aviation Organization (ICAO, 2018)	**Aviation and Climate Change: Pathway to carbon-neutral growth in 2020** (IATA) and On **Board a Sustainable Future** (ICAO) IATA and ICAO committed to an annual average fuel efficiency of 1.5% from 2009-2020, carbon-neutral growth from 2020 onwards, and a 50% reduction by 2050 from 2005 levels. Strategies include technologies, operations, infrastructure and market-based measures.
Global, road freight	International Energy Agency (IEA, 2017)	**The Future of Trucking – Implications for energy and the environment** Outlines emission reductions and policy requirements under a modern truck scenario through vehicle efficiency technologies, systemic improvements in logistics and supply chain operations, and alternative fuels.
Global, road freight	International Transport Forum / OECD (ITF, 2018)	**Towards Road Freight Decarbonisation – Trends, Measures and Policies** Identifies proven measures that decrease road freight's CO_2 emissions, highlights priority policy areas that need adjustment and points to fields where more robust evidence through further research is needed.
Europe, road transport, trucks	International Road Transport Union (IRU, 2017)	**Commercial Vehicle of the Future. A roadmap towards fully sustainable truck operations** An action plan for long-haul, regional and urban delivery using trucks to reach a 30% reduction in CO_2 emissions by 2030 and a 60% reduction by 2050.
Europe, heavy duty trucks	European Climate Foundation (ECF, 2018)	**Trucking into a Greener Future** Scenarios for reducing the carbon content of fuel for heavy-duty trucking in Europe, with the consideration of fuel efficiency technologies that can be fitted onto trucks and the technical, social, environmental and economic impacts.
Europe road transport, new heavy-duty vehicles	European Automobile Manufacturers' Association (ACEA, updated 2018)	**Position paper: European Commission proposal on CO_2 standards for new heavy-duty vehicles** An integrated approach for new heavy-duty vehicles in Europe to cut 16% of CO_2 emissions by 2030 compared to 2019. The strategy is structured around ambition-level and timing. It outlines enablers of decarbonisation, including compliance frameworks and monitoring strategies. *Note that recently, higher targets for 2030 were adopted at EU level.*
Europe, long distance freight	TRANSFORuM EU project (2014)	**Long-distance Freight Roadmap** Solutions for long-distance freight in Europe — covering road, rail and waterways —and policies supporting their implementation.

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SCOPE	SOURCE	TITLE AND DESCRIPTION
Netherlands, city logistics	Top Sector Logistiek (2017)	**Outlook City Logistics 2017** Overview of emissions trends and drivers for city logistics in the Netherlands. Covers emissions-reduction outlooks for different segments: parcel and express, facilities logistics, construction logistics, waste collection.
Netherlands, international goods transport	Top Sector Logistiek (2018)	**Outlook Hinterland and Continental Freight 2018** Overview of emissions trends and drivers for international goods transport leaving the Netherlands and emissions-reduction outlooks for different segments: dry bulk, liquid bulk, perishables, non-perishable consumer goods, semi-finished products.
Europe, Chemicals industry	European Chemical Industry Council (CEFIC, 2011)	**Measuring and Managing CO_2 Emissions of European Chemical Transport** An overview of current CO_2 emissions — across modes — from chemicals transport. Covers potential decarbonisation measures available to the chemical industry and the possible challenges to achieve these.
Europe, forest, fibre and paper industry	Confederation of European Paper Industries (CEPI, 2017)	**Decarbonising transport and logistics chains in Europe? Discussion Paper** The forest-fibre and paper industry assessment and perspectives of its 2050 roadmap, scoping the pathways, transformative investments and policy frameworks required for realising an 80% reduction of GHG emissions and a 50% growth in the added-value delivered by the forest-fibres and paper industries in Europe.
Cities / Regions	Various	Cities and regions with known urban freight plans or roadmaps include (but are not limited to) Belo Horizonte, Brussels, California State, London, Paris, Seattle, Stockholm, Tokyo, Washington State.
Cities	Transport Decarbonisation Alliance (2019)	**Zero Emission Urban Freight** A whitepaper on how to reach zero emission urban freight by uniting countries, cities/regions and companies.
Cities	TRANSFORuM EU project (2014)	**Roadmap on clean urban mobility** Solutions for urban mobility, including passenger and freight transport, and policies supporting their implementation.

2. STRUCTURE OF THE ROADMAP

2.1

Scope

The roadmap focuses on the freight transport and logistics sector and GHG emissions. It recognises and it is framed in a broader context (*Figure 3*):

- Life-cycle GHG impacts from freight transport and logistics, including energy ('well to wheel'), infrastructure and equipment. For example, a World Bank report pointed to a significant GHG and environmental impact arising from minerals and metals needed to manufacture vehicle batteries for a low-carbon future.

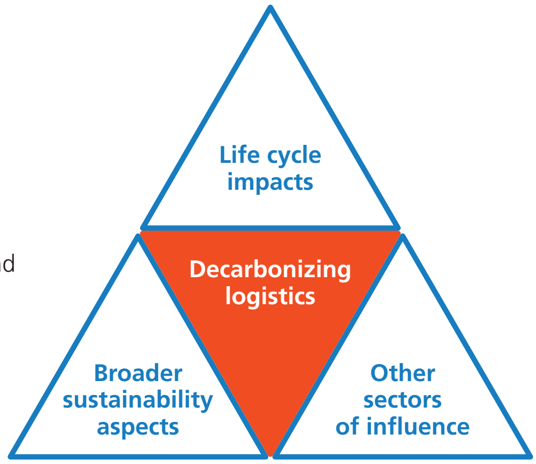

Figure 3: **Putting Roadmap into context**

- Broader sustainability aspects, including environmental (e.g. air pollution, deforestation for road construction), socio-economic (e.g. working conditions of truck and train drivers, seamen and road safety).

- Influence and problem ownership of other sectors, as freight and logistics is a service provided to other sectors, such as manufacturing, retail, construction and other, and depends on what happens in other sectors, such as the shift of the energy sectors towards renewable energy sources.

2.2

Overall structure

The overall roadmap structure is made up of

- **Five solutions areas** and respective emission reduction potentials based on Prof. Alan McKinnon's *Decarbonizing Logistics* book[9], which in combination can achieve an 83% reduction in CO_2/tonne-km to realise Europe's target for freight transport by 2050.

- **Four stakeholder groups**, including companies, government, R&D institutes and civil society, who interact as a "quadruple helix" in a sustainable and innovation society, as introduced by Carayannis and D.F.J. Campbell.[10]

9. A. McKinnon (2018). Decarbonizing Logistics – Distributing goods in a low carbon world
10. E.G. Carayannis and D.F.J. Campbell (2011), Mode 3 Knowledge Production in Quadruple Helix Innovation Systems, SpringerBriefs in Business 7, DOI 10.1007/978-1-4614-2062-0_1

- **Three transition management measures** to move the quadruple helix in the right direction, using the Smart Freight Leadership behaviours for zero-emissions logistics as a starting point.[11] This involves all stakeholders working together to report and set targets, reduce emissions by implementing action plans, and collaboration and advocacy for long-term public policy.

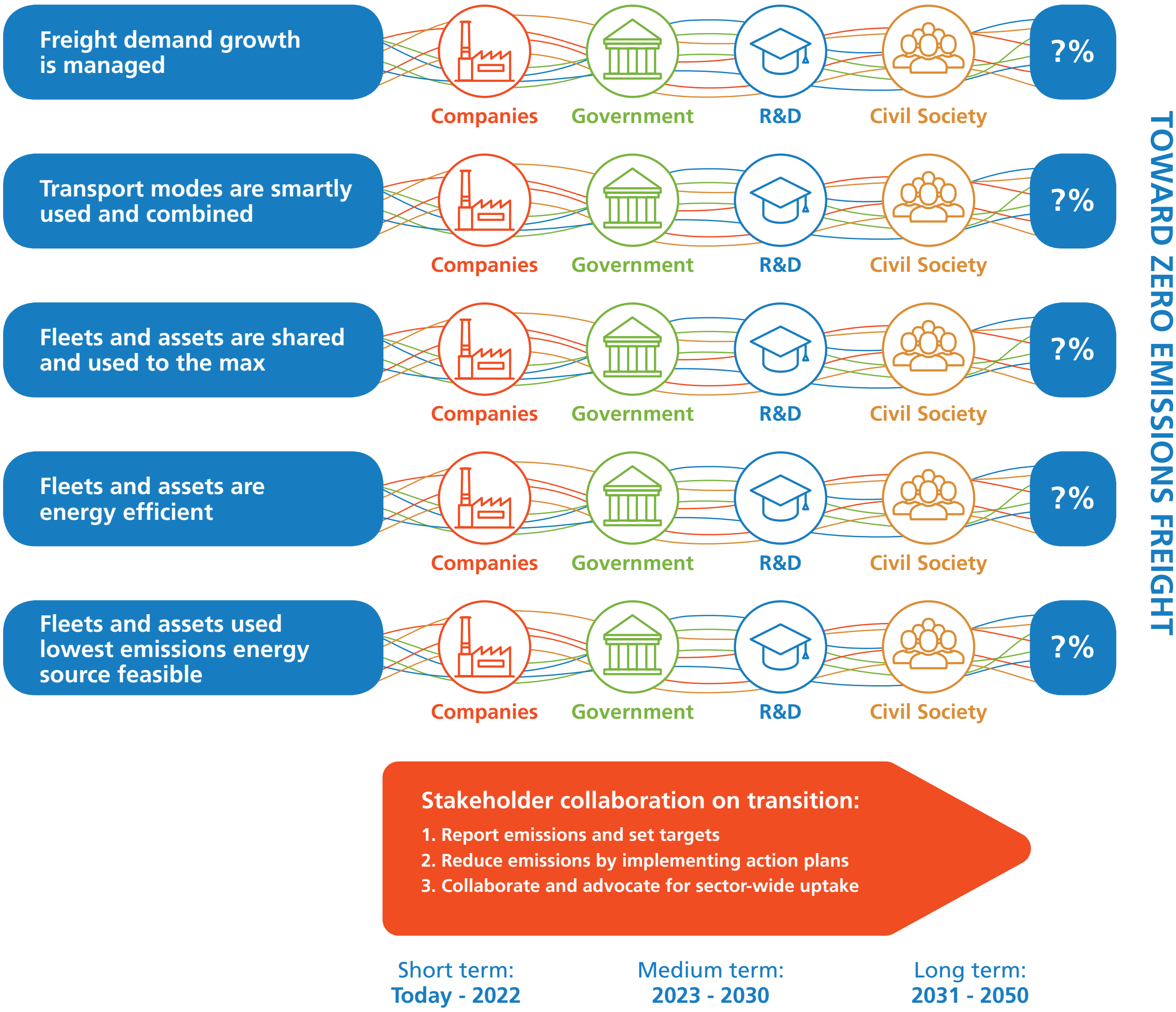

Figure 4: **Framework for freight transport and logistics decarbonisation**

11. Smart Freight Centre (2017). Smart Freight Leadership

2.3

Five solutions areas

According to the literature, achieving the targets set for global warming is not only dependent on the outcome (i.e. reaching to be climate neutral by a certain date) but also the way this is achieved. Moving fast through short term reductions is helping to gain time for the implementation of more advanced solutions. Moreover, there are other challenges not directly related to emissions that need to be addressed too.

For example, one might think that focussing resources on electrification and on increasing the share of renewable energy is the way forward. However, we are unlikely to have fully electric/decarbonized heavy-goods vehicles for long distances widely available in the next ten years. And according to EU targets, the renewable electricity in the energy mix is expected to be just 32%, even by 2030[12]. In this context, relying solely on the electrification of transport will not, on its own, allow us to hit our emissions targets. Moreover, given the expected growth of the transport sector, it may be difficult to fund electrification on the scale required fast enough to meet our targets in the required time.

To ensure we meet our targets, a more holistic approach is required in which different solution pathways and areas are combined towards the emissions-reduction goals while minimising the investments required to reach them. In this regard, and in particular in the freight transport and logistics field, gains in efficiency need to work hand-in-hand with emissions reduction. There are very simple and cost-effective ways to maximise a reduction in emissions including NOX and PM as opposed to just CO_2. However, in other cases the investments required could make the business case unworkable.

Solutions that directly lead to emissions reductions (i.e. as opposed to policy and research that incentivise their adoption) can be clustered into five groups which are mapped and identified. The solutions are classified in the five different areas described below.

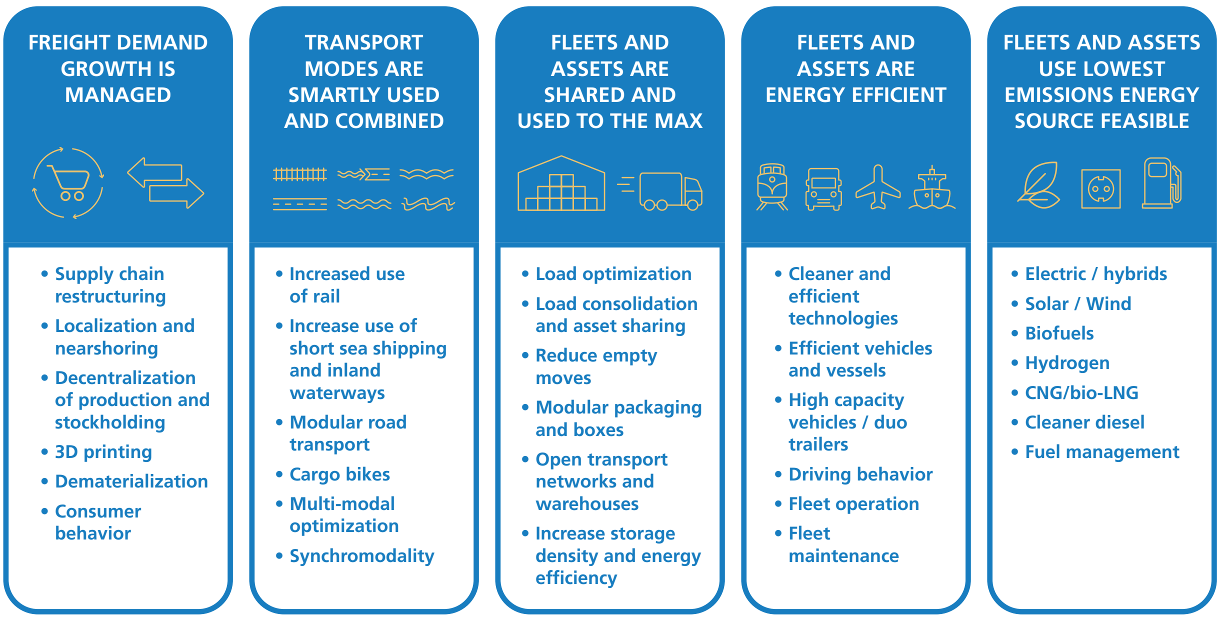

Figure 5: **Solutions for logistics decarbonisation**

12. European Council (2014). 2030 Energy Strategy.

Freight transport demand growth is managed

These solutions can provide citizens and industry with the same kind of welfare and access to goods and services but without exponentially increasing the supply of freight transport and logistics services. Within this category, we may consider supply chain restructuring, 3D printing, dematerialisation, localising production close to consumption and nearshoring of inbound materials, stocks decentralisation, and influencing consumer purchasing behaviours.

Transport modes are smartly used and combined

Freight movements can be made more efficient through the optimum use of every available mode. Considering that in Europe the vast majority of road transport operations today are below 150 km in terms of tonnage and below 300 km in terms of tonne/km, a massive shift from roads to other modes of transport will not be feasibel.[13,14] In addition to efficiency improvements within modes (explained next), it is important to increase the performance of rail, water and combined multimodal transport in terms of the comparable price, quality, service and flexibility of road transport. This will encourage modal complementarity and a wider range of modal options available to shippers. At the same time, within road transport, other logistics solutions including bikes and motorbikes could be deployed. Moreover, concepts such as synchromodality that focus on optimal and flexible use of multiple modes and speeds/lead times in transport are expected to contribute to this solution area.[15]

Fleets and assets are shared and used to the max

Optimising asset utilisation accommodates more freight transport demand with the same infrastructure and capital investment. There is a huge opportunity to increase load factors, as well as the capacity of individual vehicle combinations, and at the same time reduce empty runs in road, rail and maritime freight transport. This can be achieved through solutions such as load optimisation and consolidation, sharing of assets, and better management of logistics centres, warehouses and transport infrastructure. Transport predictability and flexibility is an important enabler for this solutions area. An important side-benefit is reduced congestion and need for storage space. Control towers and marketplaces are used to reduce empty running with a limited impact so far.

Fleets and assets are energy efficient

A holistic approach to fleet energy efficiency, whether vehicles or vessels, looks at the management of fleet, and not merely at the deployment of technologies. Freight transport operators could invest in more efficient vehicles and vessels and equip them with technologies that contribute to energy efficiency. Management options include improving driving behaviour, and better fleet operations, improved and dynamic planning skills (human factor), and maintenance and monitoring that increasingly makes use of information and communications technology (ICT).

Fleets and assets use lowest emissions energy sources feasible

In this solution area the focus is on reducing the carbon content of energy sources, while also considering air pollution impacts. Options available are using cleaner and lower-carbon fuels, such as biofuels, blended fuels, hydrogen, and electrification that ideally uses renewable energy. It is important that this is combined with sound fuel management practices. Low emissions energy sources also apply to logistics sites and equipment used such as forklifts, cranes, reach stackers and conveyer technologies. When 'well-to-wheel' emissions are being considered for freight transport, a net zero-emission scenario will likely require off-setting of emissions too.

According to ALICE members, all solutions areas need to be further investigated in terms of challenges and opportunities and should be considered when designing a decarbonisation strategy. Managing the growing freight transport demand is seen as the one with slightly less potential while the other four solution areas were given similar weights.

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13. Eurostat (2019). EU Transport in Figures, Statistical Pocketbook 2019
14. Transformer project deliverable: Report on End Users Requirements. (http://www.transformers-project.eu/userdata/file/Public%20deliverables/TRANSFORMERS-D1.1-Report%20on%20End%20User%20requirements-FINAL-2014.07.10.pdf)
15. Synchromodality is defined as an evolution of inter- and co-modal transport concepts, where stakeholders of the transport chain actively interact within a cooperative network to flexibly plan transport processes and to be able to switch in real-time between transport speeds and modes tailored to available resources and needs. *ALICE Corridors, Hubs & Synchromodality Research & Innovation Roadmap*. http://www.etp-logistics.eu/wp-content/uploads/2015/08/W26mayo-kopie.pdf

2.4

Four stakeholder groups

To achieve emissions reduction goals for freight transport and logistics, many innovations will have to be made. The necessary new technologies, organisations and business models will all need to be identified, designed, tested and applied successfully together. If the specific target of net zero emissions is to be achieved by a certain year, the efforts of different stakeholders, including companies, government, research and development institutes and civil society, need to be aligned (or balanced). The process to achieve this alignment is not straightforward, nor is its management. Below we discuss the strengths and archetypical roles of stakeholders and the role of transition management as a process to guide all efforts to achieve one goal.

Companies

Companies, both private and public, are the main driving actor of the roadmap, working within and around logistics markets that provide the economic thrust for change towards net zero emissions. This includes — amongst others — the manufacturers of goods, the wholesale and retail services sectors, logistics services providers, ports, ICT products, service and software providers, energy providers (including charging facilities), financial companies and engineering and consultancy services. As virtually all products and services on the market are created by the industry, change is driven by the managers making decisions about the strategy, the tactics and the operations of supply chains. New products, services, technologies and the associated redesign of business models and business processes are the main contributions of industry to the ALICE roadmap. It is noted that especially shippers or cargo-owners, as customers of freight and logistics service providers, can play a significant role.

Research and development

Research and development (R&D) actively develop the data, information and knowledge needed for innovation. Also, they protect and disseminate this knowledge so that broad uptake can take place within a protected environment. R&D activities are needed to develop new services and products, and increase the 'technology readiness level' of solutions. Research activities create and maintain the knowledge needed to build innovations based on facts and concepts tested and proven for effectiveness and efficiency. Development activities design and test innovations within a specific application context, such as an industry sector, typically at higher technology readiness levels (TRL 5-9). Typically, the closer the R&D activities are to deployment, the larger the interest and contribution of other stakeholders will be.

Government

Government's main role is to support markets, where necessary, against unwanted external effects of industry activity. Through public-incentives, including funding, governments support the creation of the knowledge, physical and information infrastructure that is needed for innovation. Actions to create favourable conditions for the innovation and adoption of low-emissions solutions include planning; the creation of infrastructure; traffic management; passing relevant legislation, regulations and standards; financing and incentives. Government agencies and affiliated organisations at the national, provincial and local levels all have a role to play.

Civil society

Of key importance is civil society: the non-profit or non-governmental organisations (NGOs) and citizen initiatives. These groups are able to voice concerns about combined market and government failure. This stimulates complex societal re-organisational processes, which neither state nor market can address individually. Related to this, awareness raising and educating citizens on the impacts of purchasing behaviours and what actions they can take is vital and can be linked to government policies. Especially in the field of sustainable freight transport and logistics, this group of societal actors has a major role to play. Beyond their obvious information provision and advocacy roles, NGOs and citizens may also take a role as moderator to create and maintain a complex, multi-stakeholder innovation agenda.

2.5

Stakeholder collaboration to drive the transition

As also embodied in the European innovation programmes and platforms, to be effective together, stakeholders need to align their objectives, resources and actions. This is a community process. For a sectoral community like ALICE to realise its objectives, much concertation is needed. The design and implementation of solutions must be brought onto the agendas of all the actors. Sensitivities and risks need to be understood and addressed. Commitments need to be secured and progress needs to be monitored, while implementation is ongoing. If this community process works well, the stakeholders work together in a quadruple helix model (formerly known as triple helix without civil society) and objectives can be achieved over time.

The transition management should give a lot of emphasis on the short-term initially (i.e. until 2022) as the window of opportunity to stay within 2ºC is closing, while continuously preparing for the medium- and long-term.

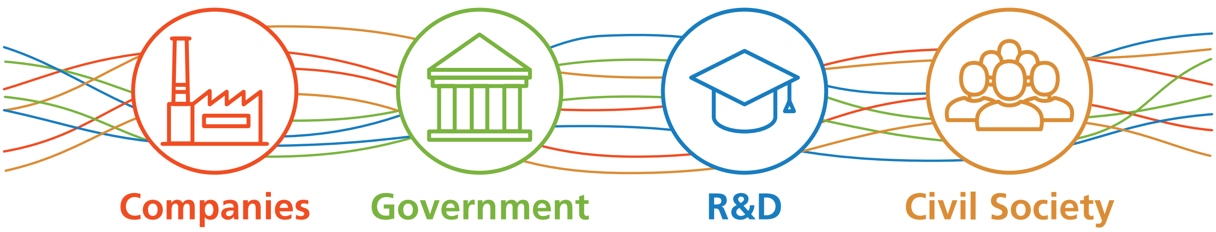

Figure 6: **The Quadruple Helix (Carayannis & Campbell, 2011)**

All stakeholder groups have a role to play to facilitate transition management to drive this roadmap process forward. We will use the five Smart Freight Leadership behaviours as a starting point but modified to suit both companies and governments.[16]

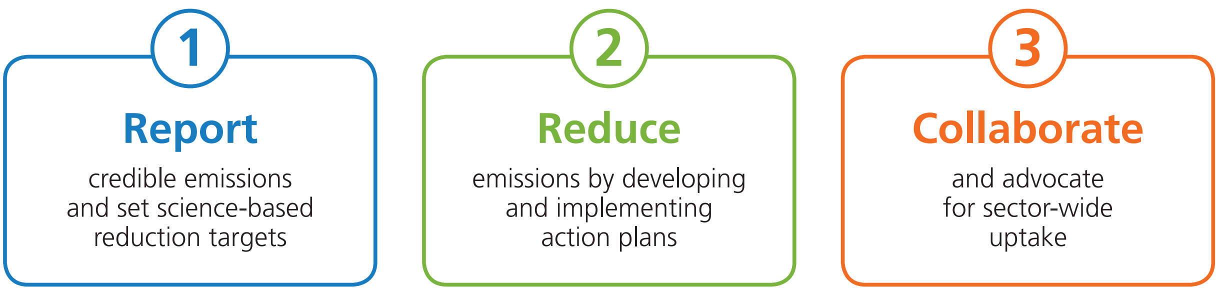

Figure 7: **Smart Freight Leadership to drive the transition towards zero logistics emissions**

16. Smart Freight Centre (2017). Smart Freight Leadership

Report and set targets

What you don't measure, you can't manage. This also applies to emissions resulting from freight movement and logistics activities. Realistic and reliable calculation and reporting of emissions should be a priority for businesses and organisations with high logistics supply-chain emissions as a portion of total emissions. To facilitate this, the GLEC Framework[17] was first released in 2016 and updated in 2019. It is the only globally recognised, harmonised method for calculating and reporting emissions across the multi-modal logistics supply chain. In parallel, governments, associations and service providers should create and make available tools to calculate and report logistics at the regional, national, local and industry-sector levels to guide and track progress on emission reduction strategies.

Setting and tracking progress against 'science-based targets' are important to help ensure that the global freight transport and logistics sector does its bit in keeping global atmospheric CO_2 concentrations below the level that corresponds with a 1,5-2°C temperature rise compared to pre-industrial times. Setting targets applies to companies but also to countries and sectors. Companies setting emission-related targets have the benefit of knowing what they are aiming for. They can also avoid the situation where their actions individually may look impressive but nevertheless fail to deliver emission reductions at scale. Shippers and customers play a pivotal role: their targets will help them to convince logistics service providers and carriers that reduction efforts are important to them and will be a factor in their procurement choices.

Reporting and targets can be reinforced with key performance indicators (KPIs) and corporate or government policies.

Reduce emissions through action plans

Delivering against targets is put into practice by developing and implementing an action plan that contains concrete measures to reduce the carbon footprint. Action plans or roadmaps can be developed by countries (following their Nationally Determined Contributions or NDCs) and by companies or organisations. Action plans combine concrete reduction measures from the five solution areas with broader business decisions, such as procurement policies, collaboration with other businesses and investment in carbon credits.

Collaborate and advocate for sector-wide action

Businesses and organisations that have worked to improve fuel efficiency and reduce emissions realise that there is a limit to what they can achieve within their organisational boundaries. Collaboration is essential to work towards our common decarbonisation goal. Firstly, it involves players within the specific logistics supply chains. These include: shippers and cargo owners (businesses or organisations), logistics service providers, freight operators and carriers, and operators of logistics sites. They can choose to cooperate bilaterally or through green freight programs and initiatives that focus on different countries, modes or solutions. Secondly, it requires collaboration between companies, governments, R&D institutes and civil society organisations. Thirdly, scalable logistics structures need to be developed to enable and support collaboration and sharing of resources and assets whilst at the same time preventing the development of cartels.

In parallel, advocacy by all key stakeholders for long-term strategies and public policy is an essential piece of the puzzle to achieve Paris Climate Agreement and relevant sustainable development goals. Businesses and organisations as customers and providers of freight transport and logistics services have the greatest ability to implement emissions-reduction solutions. However, in practice they are heavily dependent on government and other private-sector players to provide a quality transport system. Governments can facilitate the uptake of actions by businesses through planning, infrastructure, legislation, regulation, standards; financing and other incentives; and strategic support.

17. Smart Freight Centre in collaboration with the Global Logistics Emissions Council GLEC (2019). GLEC Framework for Logistics Emissions Accounting and Reporting.

3. SOLUTIONS FOR LOGISTICS DECARBONISATION

This chapter provides for each of the five solutions areas, a list and brief description of specific solutions. It should be noted that only solutions **directly** leading to emission reductions are described (i.e. as opposed to policy and research that incentivise their adoption, which are covered in chapter 4).

In addition, solutions are mapped based on their **indicative**

- Potential impact on emission reductions if introduced at scale: low (0-10%), medium (10-20%) or high (20+%).
- Likely timescale for implementation: short term (today until 2022), medium term (2023-2030) or in the long term (beyond 2031-2050).

The aim of these indications is to help companies and organisations to decide what options to focus on now and which ones to plan for in the future. It can also help governments, R&D institutes and civil society organisations to determine what help they can offer and when. It was not possible with the resources available to consider costs or return-on-investment for different solutions, and this is recommended as a future area for ALICE or other stakeholders to explore.

There is also a link with the Physical Internet that combines many of these solutions. It is expected that the increase in efficiency and productivity of freight transport and logistics will bring the savings and value needed to enable companies to pay for the required asset transition (i.e. towards the greening of all transport assets). In *Figure 8*, an estimation of the potential emission reductions from a better use of resources and from applying Physical-Internet concepts is included. In brief, this is the aggregated contribution of different solutions — as part of better management of freight-transport demand — to optimising freight transport modes and increasing asset utilisation. ALICE is, in parallel, developing a roadmap on the Physical Internet in which the solutions and the path to be followed will be addressed in detail.

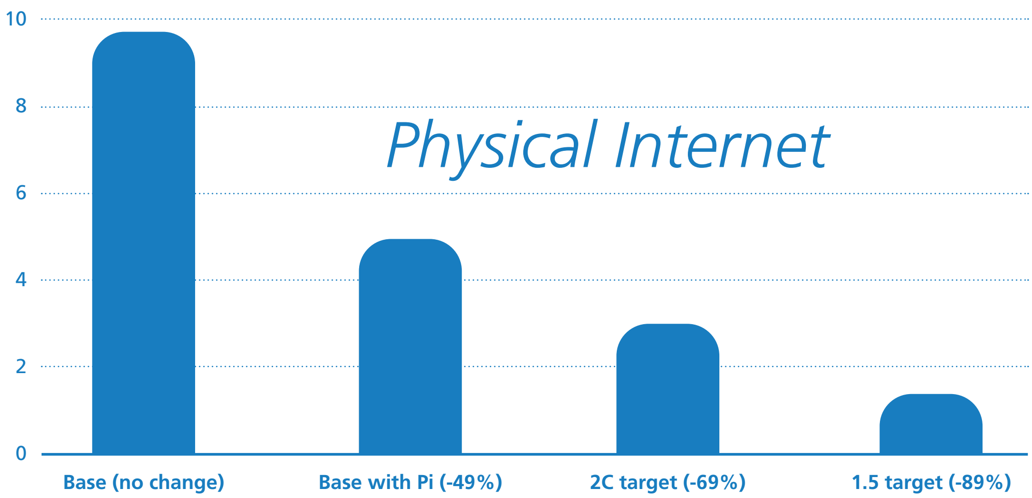

Figure 8: **Scenarios for freight-transport emissions in Europe including Physical Internet (PI) (in billion tonnes CO_2)**

3.1

Freight transport demand growth is managed

Solutions to manage freight transport demand growth are described in the table below. Several different solutions are included that may impact freight-transport demand but that also consider factors such as the welfare of service operators and users and access to goods and services. Because we have assumed the twin objectives of lowering emissions while also meeting citizen and consumer demand, regulations and restrictions with regards to limiting freight transport that may affect access to goods and services, are not included in this solutions area.

In 2014 ALICE developed the roadmap on *Sustainable, Safe and Secure Supply Chains*[18] in which some of these solutions (supply-chain restructuring, decentralisation, etc.) were proposed as strategies for sustainable development from a closed loop supply chain perspective. In the ALICE roadmap on Information Systems for Interconnected Logistics[19], 3-D printing and dematerialisation were addressed as potential trends impacting logistics.

Table 2. Logistics decarbonisation solutions that manage growth in freight transport demand

SOLUTIONS	DESCRIPTION	MORE INFO
Supply chain restructuring	Redesign of a logistics network's nodal points, distribution hierarchy and inter-related transport flows to minimise distances travelled and optimise load factors.	WEF, 2009 ALICE, 2014[18]
Localisation and nearshoring	Localising production close to consumption where feasible, such as agriculture produce, and nearshoring of inbound materials closer to manufacturing.	WEF, 2009
Decentralisation of production and stockholding	Moving production stockholding and sales closer to consumers. As an example, we can see many retailers that are expanding their inventory management to include stores.	McKinnon, 2018
3-D printing	3-D printing of spare parts, selected products or parts of products that can be combined with manufacturing closer to markets, while acknowledging that raw materials still need to be transported.	ALICE, 2014[19]
Dematerialisation	Reducing the physical quantity of goods, products and packaging needed to deliver consumer value. Possibilities are product re-design, waste minimisation, recycling, digitisation, miniaturisation, material substitution, and postponement of dispersing products to new markets.	McKinnon, 2018 ALICE, 2014[19]
Consumer (customer) behaviour	Influencing consumer behaviour through awareness-raising and education on their purchasing habits and encouraging re-use, refurbishment, remanufacturing and recycling. Whether last-mile home delivery reduces carbon emissions depends on how this service is delivered and if it replaces a consumer shopping journey with a motorised vehicle that generates more emissions. It needs to consider lead time and delivery time and move in the opposite direction of the "one hour" and "same day" delivery.	WEF, 2009

18. ALICE (2014). ALICE Sustainable, safe and secure supply chain research & innovation roadmap. www.etp-alice.eu
19. ALICE (2014). ALICE Information Systems for Interconnected Logistics Research and Innovation Roadmap. www.etp-alice.eu

Of the different solutions, consumer (customer) behaviour and supply chain restructuring are considered as the solutions with most potential in terms of impact and feasibility.

This solution area is quite controversial as many experts understand it as imposing constrains and regulations to limit and restrict freight transport. Most of the experts believe that freight transport demand will continue to increase and that overall, the impact of this solution area will be very limited.

At the same time, unmanaged growth is already posing a problem for cities. For example, New York has 1.5 million deliveries per day and freight delivery is still growing exponentially. It seems to be physically impossible to support this growth without major implications for quality of life in the city. We have to use the existing infrastructure in a smarter way and manage the growth in freight demand, especially for cities.

The following *figure* gives an indication of the potential impact these solutions could have on emissions reduction if implemented at scale. It also shows whether they can be implemented now or in the medium or long term. Note that the uncertainty of this category of measures is high.

		Timeframe		
		Short (today–2022)	Medium (2023–2030)	Long (2031–2050)
GHG Emissions Reduction Impact	High>20%		• Consumer behaviour (negative impact possible) • Supply chain restructuring	
	Medium 10-20%		• Decentralisation of production and stockholding • Localisation and nearshoring • 3D printing products	• Decentralisation
	Low<10%	• 3D printing spare parts and health care products		

Figure 9: **Impact and timeframe of solutions that manage growth in freight transport demand *(indication only)***

3.2

Transport modes are smartly used and combined

Solutions designed to provide the best transport modes to use and combine are described in the table below.

Table 3. Logistics decarbonisation solutions that use and combine the best transport modes

SOLUTIONS	DESCRIPTION	MORE INFO
Increased use of rail, waterborne and low emissions modes	Providing a wider free modal choice other than road has been a long-time ambitious objective to achieve lower emissions per tonne-km. To realise this opportunity, it is important that rail, waterborne and low emission modes deliver more against the needs of the users in the different contexts: price, quality, service level, reliability and flexibility. For example, light modes (i.e. cargo bikes, etc.) are already delivering against these KPIs in specific city contexts.	WEF, 2009 McKinnon, 2018 ERRAC, 2012[20]
Multi-modal optimisation	Optimising the combination and complementarity of different modes and linkages between them by adding, providing better access to, and optimising transhipment possibilities. An example is optimising ship-port interfaces to reduce the waiting time for ships. It includes minimising waiting times for trucks (or other modes) at terminals. Another example is the use of high capacity road freight transport vehicles, including the European Modular System, in the first and last road legs of combined and multimodal transport operations which could reduce the number of vehicles used by one-third.	ITF, 2018 WEF, 2009 ALICE, 2014[21]
Synchromodality	Optimising and flexible use of different modes and routes in a network under the direction of a logistics service provider, so that the customer (shipper or forwarder) is offered an integrated solution for its (inland) transport[22]. It also includes the combination of cargo with different time speeds requirements or that could act as ballast for other goods (i.e. the usage of the network is maximised).	McKinnon, 2018 ALICE, 2014[21]

Of the different solutions, multimodal optimisation and synchromodality are considered to bethe solutions with most potential in terms of impact and feasibility followed by wider modal choice (including increased use of rail and waterborne) and use of light modes in urban freight.

The following *figure* gives an indication of the impact on emissions reduction of the solutions if implemented at scale as well as whether they can be implemented now or in the medium or long term.

20. ERRAC (2012) Encouraging modal shift (long distance) and decongesting transport corridors. Freight Roadmap. www.errac.org
21. ALICE (2014). ALICE Corridors, Hubs and Synchromodality Research and Innovation Roadmap. www.etp-alice.eu
22. TU Delft

GHG Emissions Reduction Impact	Timeframe: Short (today–2022)	Medium (2023–2030)	Long (2031–2050)
High>20%		• Synchromodality	
Medium 10-20%	• Increased use of rail and waterborne transport (tactical)	• Multimodal optimisation • Light modes in urban freight • Increased use of rail and water transport (structural)	
Low<10%			

Figure 10: **Impact and timeframe of solutions that use and combine the best freight transport modes *(indication only)***

3.3

Fleets and assets are shared and used to the max

Solutions to increase the utilisation of assets are described in the table below.

Table 4. Logistics decarbonisation solutions that share and use fleets and assets to the max

SOLUTIONS	DESCRIPTION	MORE INFO
Load optimisation	• **Adjust truck size to load**. Higher freight efficiency is achieved as the amount of freight hauled per litre of fuel used is reduced. So, the fuller the load compartment the better overall efficiency. Matching the size of the vehicle with the load volume or weight contributes to efficiency. • **Optimising use of vehicle space**. Optimise the loading of vehicles taking the vehicle and freight dimensions into account, which can be enhanced using software. Improvements of the load factor of the vehicle through physical techniques such as efficient unit loads, and a combination of mechanical and manual loading may be necessary.	IEA, 2017 ALICE, 2014[23]

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23. ALICE (2014). ALICE Supply Network Coordination and Collaboration Research & Innovation Roadmap. www.etp-alice.eu

SOLUTIONS	DESCRIPTION	MORE INFO
Load consolidation and asset sharing	Bundling shipments across product categories with similar shipment characteristics (destination, time constraints). This can be realised through: • Horizontal collaboration (companies at the same level of the logistics chain, either shippers or providers, form partnerships to bundle loads or make use of the same vehicles/assets). • Combined freight and warehouse exchange platforms (platforms for exchanging information between carriers, freight forwarders, logistics service providers (LSPs) and shippers to facilitate new orders and collaboration, including backhauling). • Pooling and bundling/cross-docking that are optimised to facilitate load consolidation from different suppliers and shippers. • Mixed load and weight volume. Non-traditional heterogeneous pallets built from a mixture of products where the degree of pallet density is lower compared to their traditional counterparts. • Urban consolidation centres (group shipments from multiple shippers are consolidated onto a single truck/transport vehicle for delivery within a city or urban area). • Crowd-shipping (recruiting citizens to serve as couriers using their private vehicles to pick up and drop off parcels along routes they are taking anyway). • High capacity vehicles can consolidate bigger load volumes and weights for longer distances. • Many software management tools are available to help reduce empty running by finding additional freight to haul given each fleet's capabilities with routes, equipment, time, and other variables. • Utilisation of public transport modes such as underground freight trains during non-operating hours or even combining freight and public transport in a way that does not affect current schedules.	IEA, 2017 WEF, 2009 ALICE, 2014[23]
Modular packaging and boxes	Redesign of product packaging, transport boxes and containers for optimal fit to product and for modularity, to allow efficient handling, consolidation and pooling. This can be combined with re-usable containers (RCs), in anticipation of the implementation of the Physical Internet concept.	ALICE, 2019[24]
Back-hauling	Refers to the practice of picking up or delivering cargo on return or round trips as compared to returning with empty vehicles or vessels.	IEA, 2017
Open warehouses and transport networks	This solution looks for a systemic load consolidation and optimisation in which the capacity in logistics sites and transport networks could be made available for the use of the stakeholders in a more optimised way (i.e. following physical internet principles). This includes the possibility of a different approach in which flows from different stakeholders are combined: multi supplier-multi-retailer. Software, operative and business models available are still not capable to provide collaborative tactical and operational planning, do not support dynamic planning, cannot link to traffic data and they are not able to support arrangement of multi-party transport flows and inventory management via shared hubs and warehouses, paperless processes, cost sharing and allocation.	ALICE, 2019[24]

It is noted that solutions can be combined. For example, consolidation centres outside city boundaries with low or zero emission vehicles for last-mile delivery can be linked with barges by constructing wharfs adjacent to large building contracts.

24. Physical Internet Knowledge Platform (https://knowledgeplatform.etp-logistics.eu/)

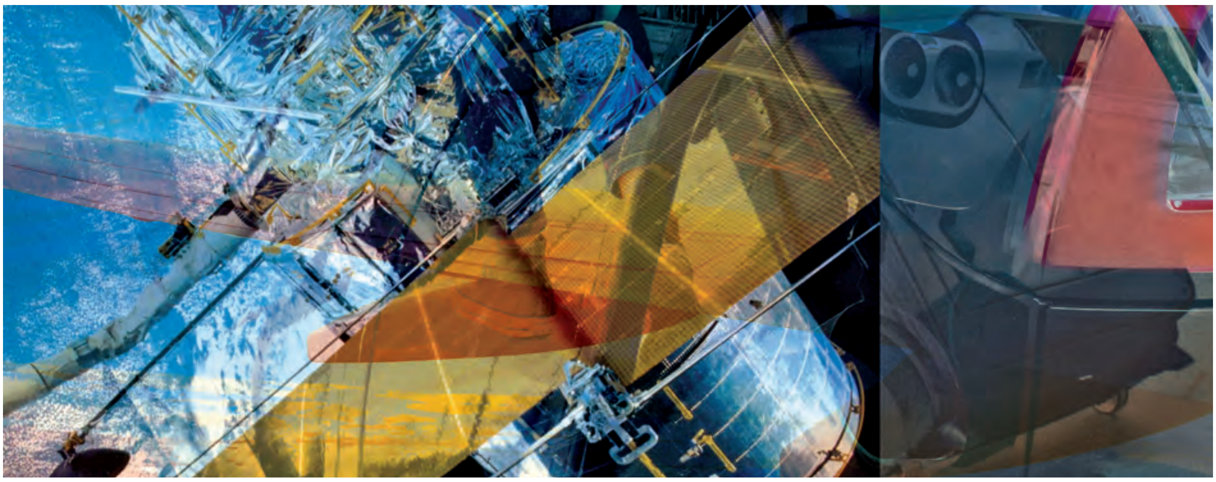
Of the different solutions, load consolidation and optimisation are considered to have the biggest potential in terms of impact and feasibility. These are followed by open warehouses and transport networks. This is no surprise as it is estimated that heavy goods vehicles are empty 30% of the time[25] and Europe as a whole averages 25% empty kms.[26]

In this regard, sharing available and idle capacity is key to overcoming the increase in freight transport fragmentation with smaller but much more frequent shipments (due to e-commerce for example). A significant reduction in empty running (for which algorithmic freight-matching engines are available) could reduce empty running by 15-40% overall.

The following *figure* gives an indication of the impact on emissions reduction of the solutions if implemented at scale as well as whether they can be implemented now or in the medium or long term.

		Timeframe		
		Short (today–2022)	Medium (2023–2030)	Long (2031–2050)
GHG Emissions Reduction Impact	High>20%		• Open warehouses and transport networks	
	Medium 10-20%	• Back-hauling	• Load consolidation • Load optimisation • Modular packaging and boxes	
	Low<10%			

Figure 11: **Impact and timeframe of solutions that share and use fleets and assets to the max *(indication only)***



25. UK Freight Transport Association (FTA 2019). FTA Logistics Report
26. Eurostat (2019). EU Transport in Figures, Statistical Pocketbook 2019

3.4

Fleets and assets are energy efficient

Solutions to improve the energy efficiency of vehicle and vessel fleets as well as fleets and equipment used in logistics sites are described in the table below. It is important to note that many of these solutions also contribute to a reduction in air pollutants.

Table 5. Logistics decarbonisation solutions that focus on energy efficiency of fleets and assets

SOLUTIONS	DESCRIPTION	MORE INFO
Cleaner and efficient technologies	• **Tyres.** Low rolling-resistance tyres can be designed with various specifications, including dual tyres or wide-base single tyres. It is noted that wear and tear of tyres also generate PM emissions.[27] • **Aluminium wheels**. These wheels replace common steel wheels and are intended to reduce vehicle weight and heat dissipation while improving fuel efficiency. • **Idling-reduction technologies**. These include auxiliary power units and generator sets, battery air conditioning systems, plug-in parking spots at truck stops and thermal storage systems. • **Automatic transmission**. Moving from manual to automatic/automated manual transmission can greatly improve efficiency. Adding gears, reducing transmission friction and using shift optimisation in manual automated or fully automated transmissions can also improve drivetrain efficiency. • **Low-viscosity lubricants**. Oils with less internal resistance to flow that decrease engine mechanical losses, thereby reducing fuel use. • **Oil by-pass filtration system**. Secondary filtration unit with the purpose of super-cleaning engine oil, extending lifetime. It has high contaminant-holding capacity and filters out the smallest particles to include sludge and soot in special cases.	IEA 2017 IRU 2017 ITF 2018
Efficient vehicles and vessels	• **Fleet renewal**. Effectiveness and cost-effectiveness of early replacement of old vehicles to improve air quality, reduce dependence on oil, CO_2 emissions and increase road safety. • **Light-weighting**. Broadly, all HDV vehicle types except utility trucks could cost-effectively reduce weight by upwards of 7% within the next ten years. Weight advantage offers a greater degree of freedom in vehicle design and performance. • **High-capacity vehicles**. Refers to an increase in a truck´s size with heavier payloads, leading to a smaller proportionate increase in fuel consumption. Hence, leading to less fuel than smaller trucks per each unit of freight. The European Modular Concept (EMS) and duo-trailers are specific types. • **Use mega-vessels and freight trains**. The frequency of shipments can be reduced by increasing the volume transported per shipment. There is a trend towards mega vessels able to hold 20.000+ Twenty-Foot Equivalent Unit (TEUs) combined with freight trains that go beyond the common 600 750 metre lengths. • **Autonomous trucks**. Driverless vehicles which are fully automated and are operated remotely. Managing fleets of autonomous trucks may bring important economic benefits that should and could be translated into low emission energy sources. • **Autonomous rail services**. Driverless trains which are fully automated and are operated remotely.	WEF, 2009 IEA, 2017 IRU, 2017 ITF, 2018 ACEA, 2018 ERTRAC, 2019/1[28] ERTRAC, 2019/2[29]

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27. Kole et al (2014). Wear and Tear of Tyres: A Stealthy Source of Microplastics in the Environment
28. ERTRAC (2019)/1 Long Distance Freight Transport. A roadmap for system integration of Road Transport. www.ertrac.org
29. ERTRAC (2019)/2 Connected Automated Driving Roadmap. www.ertrac.org

SOLUTIONS	DESCRIPTION	MORE INFO
Driving behaviour / Eco-driving	Practice of eco-driving in such a way as to minimise fuel consumption (i.e. coasting before engine breaking, limit harsh breaking and acceleration), the emission of carbon dioxide and vehicles wear and tear.	IEA 2017 IRU 2017
Fleet operation	• **Platooning**. Refers to the practice of driving heavy-duty trucks (primarily tractor-trailers or rigid trucks) in a single line with small gaps between them to reduce drag and thereby save fuel during highway operations. • **Routing**. Optimising delivery routes through the deployment of GPS and GIS to assist drivers in finding the shortest route or avoiding traffic congestion. • **Retiming**. Refers to shift to off-hour (or night-time) logistics operations and deliveries. • **Slow steaming**. The practice of operating transoceanic cargo ships, especially container ships, at significantly less than their maximum speed. • **De-speeding**. The practice of operating trucks, especially long-distance trucks, at significantly less than their maximum speed. • **Planning of use**. Reducing the non-productive operations of trucks, trains and ships (e.g. train coupling, truck maintenance, ship cleaning) through better planning. • **Maintenance.** Moving from preventative to predictive maintenance that optimises the use of vehicles and vessels and improves planning of their use.	IEA, 2017 IRU, 2017 McKinnon, 2018 WEF, 2009 ITF, 2018
Telematics / TMS	Telematics is technology that combines telecommunications and global positioning system (GPS) information (i.e., time and location) to monitor driver and vehicle performance from the central authority or dispatching unit. Truck fleets can improve operational efficiency, boost driver safety, and reduce high-cost vehicle repairs by implementing these communication systems. Telematics is often combined with boarder Transport Management Systems (TMS).	IEA 2017 IRU 2017
Logistics centres and warehouses	• **Energy efficiency measures**. Examples are renewal of equipment for material handling and yard logistics, LED lights, smart-sensors, high frequency battery chargers and lithium batteries, and thermal insulation. Additionally, to increase storage density by improving pallet stacking, automated systems and use of small(er) shuttles and redesign of roll cages.	WEF, 2009

Of all listed solutions in this table, the adoption of high-capacity vehicles and duo-trailers are considered to have the highest potential. Indeed, this is a ready-to-use solution that requires little or no additional investment in the existing road infrastructure but may require changes in regulation to be implemented extensively in Europe and elsewhere. If intelligently implemented, it could also favour other solutions such as multimodal optimisation and create an economic value.

The following *figure* gives an indication of the impact on emissions-reduction of the solutions if implemented at scale. It also shows whether they can be implemented now or in the medium or long term. It is noted that individual companies could implement solutions in a shorter timeframe and achieve higher emissions reductions if implementation is optimised (e.g. driver training).

GHG Emissions Reduction Impact	Timeframe: Short (today–2022)	Timeframe: Medium (2023–2030)	Timeframe: Long (2031–2050)
High>20%	• High-capacity vehicles and Duo-trailers		
Medium 10-20%	• Telematics / transport management systems • Slow steaming ships • De-speeding trucks	• Fleet renewal	
Low<10%	• Tyres • Aluminium wheels • Idling reduction technologies • Automatic transmission • Low-viscosity lubricants • Oil by-pass filtration system • Light-weighting • Fuel management • Fleet maintenance • Routing • Re-timing • Driving behaviour / eco-driving • Planning of use • Maintenance • Energy efficiency in warehouses and logistics centres	• Autonomous trucks non-public roads • Platooning • Autonomous trains	• Autonomous trucks public roads

Figure 12: **Impact and timeframe of solutions that improve fleet and asset energy efficiency *(indication only)***

3.5

Fleets and assets use the lowest energy source feasible

Solutions to reduce the carbon content of energy are described in the table below.

Table 6. Logistics decarbonisation solutions through use of the lowest energy source feasible

SOLUTIONS	DESCRIPTION & EVOLUTION	MORE INFO
Optimising diesel systems	New cleaner diesel system that includes an efficient engine and optimised combustion system with the most advanced fuel-injection, turbocharging and engine management strategies. Usually coupled with advanced emissions controls and after-treatment technologies, including particulate filters and selective catalytic reduction (SCR) systems, all running on ultra-low sulphur diesel fuel.	IEA 2017 IRU 2017
CNG/LNG	By using positive ignition systems, medium and heavy-duty compression-ignition engines can be designed to run solely on methane, in form of compressed natural gas (CNG) for larger vehicles or liquefied natural gas (LNG) for smaller trucks.	IEA 2017 IRU 2017
Biofuels	A range of biofuel options (biodiesel, HVO and biomethane) has the potential to partially replace petroleum product consumption in heavy-duty road transport, ocean vessels and barges, and airplanes.	IEA 2017 IRU 2017 ITF, 2018 IATA, 2009
Hydrogen	Trucks using fuel cells and hydrogen are essentially electric vehicles using hydrogen stored in a pressurised tank and equipped with a fuel cell for on-board power generation.	IEA 2017 IRU 2017 ECF, 2018
Electric/ hybrids	Parallel hydraulic hybridisation may be the most cost-effective near-term technology option for municipal utility vehicles, while electric hybridisation tends to be the best hybridisation option for most other mission profiles. Electric road systems (ERS) consist of infrastructure (e.g. catenary) which supplies electrical energy to trucks while they move. Trucks maintain their operational flexibility as they can operate outside the ETS with a hybrid drive train or by having enough battery.	IEA 2017 IRU 2017 ECF, 2018 ERTRAC, 2017[30]
Logistics centres and warehouses	The roof of the warehouses could be used to produce renewable energy. Equipment used in logistics sites and warehouses can use renewable energy or electricity.	WEF, 2009

30. ERTRAC (2017). European Roadmap Electrification of Road Transport. www.ertrac.org

Of all solutions in this area, the adoption of electric/hybrid and hydrogen vehicles are considered to have the highest potential. The main limitation to leverage the potential of these solutions is the investment in infrastructure required that may delay the implementation. Technology barriers currently exist for all transport modes. The Energy Transition Commission found that multiple energy sources will be used for aviation, maritime shipping and long-haul trucking. For example, for long-haul trucks a combination could include LNG and biofuels as transition fuels until 2035 and hydrogen fuel cell vehicles and battery electric vehicles in the longer term.[31]

The following *figure* gives an indication of the impact on emissions reduction of the solutions if implemented at scale as well as whether they can be implemented now or in the medium or long term.

GHG Emissions Reduction Impact	Timeframe: Short (today–2022)	Medium (2023–2030)	Long (2031–2050)
High>20%	• Electric/hybrids urban		• Hydrogen and Hydrogen related fuels
Medium 10-20%		• Electric/hybrids long-haul	• Ammonia (maritime shipping)
Low<10%	• Cleaner diesel • CNG/bioLNG • Biofuels (vehicles) • Solar power (logistics sites)	• Biofuels (planes/ships)	

Figure 13: **Impact and timeframe of solutions that focus on using the lowest energy source feasible *(indication only)***

31. Energy Transition Commission (2018). Mission Possible: Reaching net-zero carbon emissions from harder-to-abate sectors by mid-century

4. ROLES OF STAKEHOLDERS

This chapter describes the main roles that the different stakeholders – companies, government, R&D institutes and civil society - can play to facilitate the uptake of logistics decarbonisation solutions.

4.1 Companies

Private and public companies include shippers, LSPs, carriers, operators, but also OEMs, technology suppliers, port, Enterprise Resource Planning (ERP) and Transport Management Systems (TMS) suppliers, energy suppliers and financial institutions, consultancies, associations and others. The table below gives examples for mostly shippers/LSPs/carriers as the key actors in implementing the solutions described previously.

Table 7. Role of companies in each solutions area

SOLUTIONS AREA	ACTIVITY DESCRIPTION	ACTORS
Freight transport demand growth is managed	• Factor logistics into the company's strategy and planning, e.g. supply chain restructuring, dematerialisation, localisation and nearshoring. • Consider the potential of 3D printing of products or product parts in product design.	Shippers
	• Consider the potential of 3D printing of products or product parts in product design.	Shipper
	• Offer services to analyse the supply network design to shippers and LSPs including these solutions.	Consultancies
	• Be transparent about the emissions impact of goods delivery by providing information to customers when they make their orders (e.g. emissions footprint, type of vehicle or fuel used).	Retailers / LSPs
	• Develop strategies to enable positioning inventory closer to the consumers (demand forecasting, decentralise inventory, etc).	Shippers/ Retailers

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SOLUTIONS AREA	ACTIVITY DESCRIPTION	ACTORS
Transport modes are smartly used and combined	• Choose lower emissions modal solutions where possible as a core part of the company's logistics purchasing policy, e.g. by requesting logistics partners to provide the GHG footprint of alternative routes alongside the price.	Shippers
	• Give consumers and customers alternative choices in their online purchasing to reduce adverse impacts of freight transportation (e.g. flexible delivery window).	Retailers / LSPs
	• Choose lower emissions modal solutions where possible as a core part of the company's service to customers, e.g. by providing the GHG footprint of alternative routes alongside the price or offering zero-emissions urban freight services.	LSPs
	• Adopt KPIs that stimulate the use of lower emissions modal solutions.	Shippers / LSPs
	• Develop ERPs and TMS systems that can easily accommodate flexible transit times between two points (enabling Synchromodality and or slow speed transport).	ERPs suppliers
	• Expand investment portfolio to infrastructure that improves the connectivity and complementarity of freight transport modes and logistics sites.	Banks / Financiers
Fleets and assets are shared and used to the max	• Make collaboration with other shippers part of the corporate strategy, e.g. through joint-contracting with other shippers, implementing CO3[32] horizontal collaboration models or by requesting LSPs for opportunities to combine services with other shippers (massive pooling).	Shippers
	• Give more freedom to LSPs in terms of where to hold the inventory of shippers and retailers to make use of the full network of warehouses and maximise pooling	
	• Explore what standardised modular packaging and boxes can be applied to facilitate co-loading with goods from other shippers	Shippers / LSPs
	• Conduct a systematic analysis of product origins across suppliers to identify opportunities for combined transport to logistics sites	Retailers / LSPs
	• Invest in freight exchange platforms combined with open warehouses	Financiers
Fleets and assets are energy efficient	• Include fleet efficiency criteria in logistics procurement processes.	Shippers / LSPs
	• Adjust purchasing policies giving preference to fuel efficient vehicles/vessels and other equipment. • Make training of fleet managers and drivers part of a company's policy. • Adapt the TMS to optimise energy efficient fleet operation.	LSPs / Carriers
	• Make training of fleet managers and eco-driving training of drivers part of a company's policy.	LSPs / Carriers
	• Adapt the TMS to optimise energy efficient fleet operation.	LSPs / Carriers
	• Co-invest in fleet efficiency options to help carriers overcome the investment barrier, e.g. through negotiating bulk purchasing.	Shippers
	• Develop loans for energy efficient equipment/vehicles/vessels tailored to the situation of carriers.	Financiers
	• Offer the standard installation of energy-efficient technologies in new vehicles/vessels to help avoid retro-fitting costs by customers.	OEMs
	• Develop a plan for energy efficiency in warehouses. • Adapt the WMS to optimise energy efficient warehouse operation.	Warehouse managers / LSPs

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32. Collaboration Concepts for Comodality. EU funded project. http://www.co3-project.eu/

SOLUTIONS AREA	ACTIVITY DESCRIPTION	ACTORS
Fleets and assets use low emissions energy sources feasible	• Include alternative/cleaner fuels criteria in logistics procurement processes.	Shippers / LSPs
	• Invest in infrastructure for charging electric vehicles at logistics sites, e.g. electrical fast chargers. • Invest in equipment for material handling and yard logistics using alternative fuels. • Invest in renewable energy production in logistics sites.	Operators of logistics sites

4.2

Government

The table below gives examples of the roles of government. A further distinction can be made between city, national and EC government levels.

Table 8. Role of government in each solution area

SOLUTIONS AREA	ACTIVITY DESCRIPTION	ACTORS
Freight transport demand growth is managed	• Marketing campaign showing consumer behaviour effects for "next day e-delivery" and long-distance fulfilment centres.	Cities
	• Include sustainability awareness and life-cycle analyses thinking in educational programs.	National, EC
Transport modes are smartly used and combined	• Keep and maintain rail tracks that could be used for future autonomous rail services. • Advance in the creation of a European truly interconnected transport system allowing seamless cross-border transport end to end throughout the whole of Europe. • Enable the wider use of high capacity vehicles for national and international multimodal and road freight transport.	National, EC
Fleets assets are shared and used to the max	• Incentives to optimise load optimisation/restrict low load factors vehicles access to certain infrastructures. • Create/facilitate the infrastructure needed for bundling (hubs). • Facilitate sharing of public and private assets, incentives to asset owners. • Reusable standard packaging/boxes adoption incentives.	National, EC

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SOLUTIONS AREA	ACTIVITY DESCRIPTION	ACTORS
Fleets and assets are energy efficient	• Technology verification programs and impact assurance. Example: Low rolling resistance tyres. • Phase out schemes for inefficient and polluting technologies. Example: scrappage of older trucks and ships.	National, EC
	• Performance-based standards and regulations for trucks' weights and dimensions (i.e. security, emissions, infrastructure limitations, etc.). Example: Truck size/dimension regulations adjustment instead of purely weight and dimensions. • Encourage and incentivise eco driving.	National, EC
Fleets use low emissions energy sources feasible	• Introduce ecolabels showing the actual costs & GHG emissions. • Use a carrot-and-stick policy (subsidy and pricing) to reduce carbon content of energy. • Increased investment in (renewable) energy. • Create the infrastructure needed for logistics decarbonisation (electric vehicles, hydrogen, biofuels etc.).	National, EC

4.3

Research and development

R&D applies to any organisation or individual involved in R&D, thus also including universities, consultancies, laboratories, companies and others. R&D is generally performed by or in close cooperation with companies to realise specific industry requirements as well as facilitate easy transfer into practice.

Table 9. Role of research & development and research needs in each solution area

SOLUTIONS AREA	ACTIVITY DESCRIPTION
Freight transport demand growth is managed	• Improve strategic and tactical supply-chain planning capabilities. Develop explanatory models of market behaviour, complexity and dynamics (applying a systems perspective). • Develop sustainable logistics and network design concepts to match demand for next day or even next-hour delivery, while reducing the carbon footprint of the end-to-end operation. • Explore what incentives would prompt consumers to resist same-day delivery in order for suppliers to increase filling rates and use lower emissions transport options. • Network redesign modelling, taking into consideration CO_2e and costs. • Support industry research initiatives fostering the introduction of sustainable consumer behaviour choices in e-commerce. (Sciences with and for society programme).

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SOLUTIONS AREA	ACTIVITY DESCRIPTION
Transport modes are smartly used and combined	• Integrated approaches for supply chain driven combinations of transport modes. Develop new models for rail freight collaboration, network and services sharing among rail freight operators. • Optimise and develop transhipment technology and capabilities, increase flexibility of multimodal hubs to facilitate multimodality and autonomous loading and unloading systems. • Algorithmic decision support (Machine learning/AI) and optimisation models for synchronisation of various modes in multimodal transport networks. • Develop capabilities to provide visibility of multimodal services and enable multimodal booking on demand. • Deep analysis of the potential of soft modes in urban (parcel) distribution: cargo bikes, etc. • Segmentation is necessary according to sensitivity/elasticity of transport cost and perceived value of time.[33]
Fleets and assets are shared and used to the max	• Develop framework conditions, metrics and solutions to get comprehensive information about weight & cubic fill (i.e. understanding of effective saturations/load factors of vehicles). • Warehousing/transhipment nodes energy consumption/emission benchmarking. • Develop and test standard protocols for data sharing and flow optimisation. • Analyse consolidation requirements for various types of flows/cargo types. • Evaluating and assessing efficiency and effectiveness of solutions and industry practices. • Further deployment and evolution of standard modular load units from transport to handling containers and boxes. • Development of novel freight flows bundling strategies and tools. • Develop software, operative and business models capable to provide collaborative tactical and operational and dynamic transport planning to arrange multi-party transport flows and inventory management via hubs, cost sharing and allocation.
Fleets and assets are energy efficient	• Increase the understanding of impact of new technologies. • Studies on market barriers for fleet energy management.
Fleets use lowest emissions energy source feasible	• R&D in alternative fuels: Transition cost, investment and impact of hydrogen related fuels deployment. • Assess in which scenarios and scopes the different alternatives are more advantageous for society (i.e. electrification for last mile and city logistics and hydrogen, biofuels, others for long distance?). • Battery technology development with regard to life cycle and capacity. • Smart grid and smart charging infrastructure. • Full life-cycle analysis of energy sources (i.e. not shifting from emission at point of energy use to point of energy production, system analysis of EVs (fleets vs vehicles, charging structures). • Optimisation models determining the electric fleet requirements, locating charging infrastructure and determining their capacity needs.

33. A good start would be this segmentation: https://www.supplychainquarterly.com/topics/Strategy/20130306-supply-chain-strategies-which-one-hits-the-mark/

4.4

Civil society

Table 10. Role of civil society in each solution area

SOLUTIONS AREA	ACTIVITY DESCRIPTION
Freight transport demand growth is managed	• Campaigns to share the impact of consumer behaviour on freight transport demand. • Promote near sourcing and repairing items.
Transport modes are smartly used and combined	• Set up programs or processes to mobilise collaboration between players operating different modes.
Fleets and assets are shared and used to the max	• Campaigns to disseminate how to ensure compliance of antitrust regulations in horizontal collaboration schemes between shippers and LSPs.
Fleets and assets are energy efficient	• Advocate for fuel economy standards for vehicles and vessels. • Campaigns to raise awareness of fleet efficiency among businesses.
Fleets use lowest emissions energy source feasible	• Ensuring neutral assessment of the potential of different energy alternatives with a full life-cycle analysis.

5. MANAGING THE TRANSITION AND SHORT-TERM ACTIONS

The table below lists key activities across the three leadership behaviours described earlier. The timeline for transition-management activities is the short-term initially (i.e. until 2022) as the window of opportunity to stay within 2ºC is closing. Activities can be updated in time and will increasingly focus on the medium- and long-term.

1 Report
credible emissions and set science-based reduction targets

2 Reduce
emissions by developing and implementing action plans

3 Collaborate
and advocate for sector-wide uptake

Figure 14: **Smart Freight Leadership to drive the transition towards zero logistics emissions**

It is expected that industry will start leading the transition towards decarbonisation by example. In this framework, government and policy should support and boost transition with specific regulation and incentives that would reinforce those more sustainable strategies adopted by industry players. The objective is that there is a shift towards a clearer correlation between environment-friendly solutions and the competitiveness of the industry and logistics sector. Alternatively, if industry is not in the lead, governments and cities will need to push for restrictive regulation to ensure sustainable development and quality of life.

In particular, SME engagements in the process should be facilitated to reach massive impact and governments may need to incentivise sustainable solutions adoption within this stakeholder group.

As a priority to speed up transition, a solid commitment towards decarbonisation needs to be made by all stakeholders. In particular, more focus and resources are needed in order to facilitate agreement on sectorial objectives, access to knowledge and solutions for individual companies to set realistic targets and setting the path supported by enforcement.

Strengthening current efforts on standardisation and accountability of emissions measurement is key so that a common framework is agreed shortly by industry enabling the benchmarking and best practices definition.

Table 11. Roles of different stakeholder groups working together

C = companies; GVT = government; R&D = R&D institutes; CS = civil society

	ACTIVITY DESCRIPTION	LEAD	SUPPORT	TIMELINE
Reporting	• Report corporate logistics emissions annually across modes and transhipment centres annually that are calculated using the GLEC Framework as universal reference method.	c	CS, GVT	Annually
	• Report national logistics emissions annually across modes and transhipment centres annually. It is noted that the current existing international scheme for national GHG inventories does not cover a separate category for logistics.	GVT	R&D, CS	Annually
	• Develop a simplified GLEC Framework for SMEs.	C	CS	<2022
	• Conduct research on the recommended topics under the EU Horizon 2020-funded LEARN project:[34] - Further harmonisation of existing approaches. - Standardisation of data exchange. - Extension of the calculation scope. - Support of ex-ante calculation. - Implementation of the GLEC Declaration.	R&D	GVT	<2022
	• Support methodology development[35] - Back GLEC Framework and support ISO development & EN16258 update. - Back single global set of fuel emission factors, including alternative fuels. - Support awareness and information campaigns for industry.	GVT	R&D, CS, C	<2022
	• Support data collection and exchang[17] - Back IMO/IATA protocols & alignment. - Support development of global (or EU) data exchange protocol(s). - Explore development of neutral platform and IT architecture with TMS link. • Take more central role in data exchange.	GVT	R&D, CS, C	<2022
	• Support improved assurance[17] - Give companies incentives to collect high quality data and obtain assurance. - Explore assurance needs in case of mandatory reporting or carbon pricing. - Support standardised assurance guidance and reporting template.	GVT	R&D, CS, C	<2022

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34. Ehrler V., Dobers K., Lewis A., Smith C., Davydenko I., Rojo B., Bäckström S, Lischke A. (2018) Research and Development Agenda Towards Eco-labelling for Transport Chains. Conducted as part of the EU Horizon 2020-funded LEARN project. www.learnproject.net

35. Smart Freight Centre (2019). Policy Recommendations for Logistics Emissions Accounting and Reporting. Conducted as part of the EU Horizon 2020-funded LEARN project. www.learnproject.net

	ACTIVITY DESCRIPTION	LEAD	SUPPORT	TIMELINE
Setting targets	• Develop national/EU targets for logistics emissions.	GVT	R&D, CS	<2022
	• Develop sectoral targets for logistics emissions, coherent with Science Based Targets.	C	GVT R&D, CS	<2022
	• Develop corporate targets for logistics emissions, coherent with Science Based Targets.	C	CS, R&D	<2022
	• Develop national KPIs consistent with corporate KPIs.	GVT/C	CS, R&D	<2022
	• Incentivise improved performance through KPIs and targets for the organisation as a whole and key positions that influence logistics decisions.	C	CS, R&D	<2022
Reducing emissions through action plans	• Update NDCs to incorporate freight and logistics.	GVT	CS	<2022
	• Develop national action plans for the logistics sector covering infrastructure, vehicles, vessels and their operation.	GVT/C	CS, R&D	<2022
	• Develop corporate action plans.	C	C, CS, R&D	<2022
	• Policies seriously enforced (clean air zones, incentives to avoid on empty capacity etc.).	GVT	C, R&D	<2022
	• Disseminate examples on strategies combined with concrete action plans to gear up the results on local/company/pilot level to a system level: (corridor, chain, region, cross-border etc).	CS	GVT	<2022
Collaboration	• Develop benchmarking at European/national/sector level.	C	R&D	<2022
	• Incentivise horizontal collaboration and other solutions for increased efficiency and productivity such as pooling, opening transport networks and access to idle capacity of assets and vehicles through carbon credit schemes.	GVT	C	<2022
	• Incorporate low-emissions considerations in logistics procurement processes with subcontractors.	C	CS, R&D	<2022
	• Establish national Green Freight Programs[35]	GVT	C	<2022
	• Support multi-stakeholder collaboration approaches: - acting based on local potentialities --> implies collaboration at the local level. - acting sectorial --> collaboration required “vertically” along the chain.	GVT	C, R&D, CS	<2022

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	ACTIVITY DESCRIPTION	LEAD	SUPPORT	TIMELINE
Advocacy	• Develop an integrated set of decarbonisation solutions based on existing roadmaps and other evidence: Technology is ready but take-up is slow.	R&D	GVT, CS, C	<2022
	• Integrate the true costs of GHG emissions into policies.	GVT	R&D, CS	<2022
	• Integrate the true costs of GHG emissions into pricing.	C	R&D, CS	<2022
	• Support industry surveys and recognition.	GVT	C, R&D, CS	<2022

TOWARDS

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