NDC ASPECTS

Designing comprehensive policy packages for freight transport decarbonization: lessons from an international comparison (Deliverable 4.3b)

WP4 – Transformation Opportunities, Challenges and Policy Options

June 30th, 2023

Lauren Harry-Villain, Yann Briand, Henri Waisman, Harro van Asselt, Catherine Hall, Frederic Rudolph, Dipti Gupta, Marcio de Almeida D'Agosto, Ricardo Delgado Cadena, Jordi Tovilla, Thalia Hernandez, Nnaemeka Vincent Emodi, Alicia Zhao, Ryna Cui, Mark Gjerek, Rico Merkert, Maria Rosa Munoz, Sidsel Ahlmann Jensen, Amin Hassani

IDDRI, UEF, WI, IIML, UFRJ, UniAndes, TA, UQ, UMD, Mov3ment, USydney, T3, NCTR, SUT

Version: 1

Lauren Harry-Villain	IDDRI
lauren.harryvillain@iddri.org	https://www.iddri.org/en

Yann Briand	IDDRI
yann.briand@iddri.org	https://www.iddri.org/en

Henri Waisman	IDDRI
Henri.waisman@iddri.org	https://www.iddri.org/en

Dipti Gupta	Indian Institute of Management Lucknow
dipti.gupta@iiml.ac.in	https://www.iiml.ac.in/

Marcio de Almeida D'Agosto	Federal University of Rio de Janeiro
dagosto@pet.coppe.ufrj.br	https://ufrj.br/en/

Ricardo Delgado Cadena	University of the Andes
ricardo.delgado.ca@gmail.com	https://uniandes.edu.co/en

Jordi Tovilla	Tempus Analytica
jordi.tovilla@tempus-analitica.org	https://www.tempus-analitica.org/

Thalia Hernandez	Tempus Analytica
thalia.hernandez@tempus-analit-ica.org	https://www.tempus-analitica.org/

Nnaemeka Vincent Emodi	University of Queensland
nv.emodi@gmail.com	https://www.uq.edu.au/

Alicia Zhao	University of Maryland
aszhao@umd.edu	https://umd.edu/

Ryna Cui	University of Maryland
ycui10@umd.edu	https://umd.edu/

Mark Gjerek	Mov3ment
mark@mov3ment.com.au	https://mov3ment.com.au/

Rico Merkert	University of Sydney
rico.merkert@sydney.edu.au	https://www.sydney.edu.au/

Maria Rosa Munoz	Wuppertal Institute
maria.munoz@wupperinst.org	https://wupperinst.org/

Frederic Rudolph	Transportation Think Tank
frederic.rudolph@wupperinst.org	https://t3-forschung.de/der-think-tank/

Catherine Hall	University of Eastern Finland
catherine.hall@uef.fi	https://www.uef.fi/en

Harro van Asselt	University of Eastern Finland
harro.vanasselt@uef.fi	https://www.uef.fi/en

Sidsel Ahlmann Jensen	Norwegian Center for Transport Research
sidsel.ahlmannjensen@toi.no	https://www.toi.no/about-toi/category26.html

Amin Hassani	Sharif University of Technology
amin.hassani@outlook.com	https://en.sharif.edu/

Disclaimer

Copyright Message

NDC ASPECTS project has received funding from the European Union's Horizon 2020 Research and Innovation programme under grant agreement No 101003866

Preface

The NDC ASPECTS project will provide inputs to the Global Stocktake under the Paris Agreement (PA) and support the potential revision of existing Nationally Determined Contributions (NDCs) of the PA's parties, as well as development of new NDCs for the post 2030 period. The project will focus on four sectoral systems that are highly relevant in terms of the greenhouse gas emissions they produce yet have thus far made only limited progress in decarbonization. To advance these transformations will require to understand and leverage the Eigenlogic of those systems and take into account specific transformation challenges. These sectors are transport & mobility (land-based transport and international aviation & shipping), emission intensive industries, buildings, and agriculture, forestry & land-use, including their supply by and interaction with the energy conversion sector.

1. Changes with respect to the DoA

Within WP4 task 4.4 (Sectoral analysis of transport), a decision was made to focus the analysis solely on freight transport and to not study passenger transport. This was chosen for several reasons, detailed below.

First and foremost, while these two components of the transport sector are obviously connected through sharing some common infrastructure and sometimes vehicles, it has become apparent that they often have different stakes and challenges. For instance, zero-emission freight transport implies transforming existing production and consumption systems to reduce goods deliveries, shorten supply chains and facilitate modal shift and logistics optimization (Harry-Villain et al., 2021), which does not impact passenger transport. In addition, since the actors involved in each sub-sector (shippers, logistic service providers, freight carriers…) are quite different, organizing discussions specific to each-sector allows them to be more precise and come up with more relevant and implementable solutions.

Consequently, in order to be able to address one sub-sector adequately and in sufficient detail to be able to raise ambition, have specific policy and stakeholder-oriented analysis, it is necessary to focus specifically on it, and to put the other aside.

In that regard, it was decided to focus solely on freight transport, as it is often more overlooked than passenger transport, despite its important role in transport-related emissions. Indeed, freight represents 46% of transport emissions and this proportion is expected to keep growing, even if slowly (ITF, 2023). CO2-related emissions for this sub-sector are expected to double between by 2050 with current policies (ITF, 2023).

Furthermore, it is also less considered in NDCs. An analysis of NDCs carried out by GIZ in 2017 shows that only 16 non-annex 1 countries mentioned freight logistics in their NDCs by this date (GIZ & BMUB, 2017). According to the Slocat Partnership's NDCs Hall of Fame, two-thirds of second-generation NDCs do not include plans to reduce CO2 emissions related to freight, and most do not include comprehensive freight decarbonization solutions (Slocat, 2022). Even if some measures may be cross-cutting, their impact may not be as notable as if they were freight-specific measures, for the reasons cited above (ITF, 2021). Overall, no second-generation NDCs or LTS contain freight-related targets (Slocat, 2021a).

Taking all of this into consideration, the ITF calls for additional efforts to be put into the decarbonization of freight transport (ITF, 2021).

Lastly, choosing the same focus helps favor synergies and knowledge-sharing between work packages: the analysis carried out as part of the WP4 transport sectoral analysis will indeed feed into the sectoral conversation (WP1), reinforcing its analytical background and making it more concrete and impactful.

Executive Summary

Reaching the Paris Agreement goal requires transformative systemic change in all main emitting sectors of the economy, including transport. Nonetheless, despite the fact that freight represents 8% of global greenhouse gas emissions, current strategies to diminish this sub-sector's emissions are far from being sufficient to meet this objective.

Existing research identifies the different transformations required to decarbonize the freight transport sector, but often addresses only some modes of transportation or aspects of the transition. Adopting such a segmented approach could lead to putting aside some of the systemic changes which should be implemented, such as the spatial reconfiguration of supply chains. Moreover, it could result in the identification of measures which may have a negative rebound effect on other necessary transformations. Consequently, it is challenging for policymakers to pinpoint the appropriate and efficient decisions that they must take to enable or accelerate the decarbonization of the freight sector.

In this paper, we present an integrated approach to analyze national freight decarbonization actions and attempt to show through a cross-country comparison that this comprehensive tool can be used to guide public policies. This approach uses different existing analytical frameworks: it is based on a pathway design framework which allows the consideration of all drivers of change, which is combined with an analysis of feasibility conditions and then of policy instruments. It has been applied and tested by in-country research teams in eleven countries: Brazil, Colombia, India, Mexico, Nigeria, the United States, South Africa, Australia, Ecuador, Norway and Iran.

Our results show that this method is helpful in guiding the development of policy packages made of various policy instruments. The analysis revealed that individual policies are not sufficient to reach some targeted decarbonization transformations.

Contents

1 Introduction

Reaching the Paris Agreement goal requires far-reaching and systemic transformations in all main emitting sectors of the economy, including transport as a crucial component to all aspects of our societies and economies (IPCC, 2022). Often viewed as hard-to-abate due to its heavy reliance on fossil fuels (IEA, 2022), this sector faces complex stakes and challenges when it comes to its decarbonization, but appropriate mitigation strategies could put transport back on track to alignment with the Paris Agreement goal (IPCC, 2022). Freight transport currently represents 8% of overall greenhouse gas emissions (IEA, 2018) and 46% of transport-related emissions (ITF, 2023) and according to the ITF's Current Ambition scenario, freight demand is expected to double by 2050 (ITF, 2023). However, despite these significant emissions and planned evolutions, freight policies are also often overlooked in national strategies and in transport decarbonization analyses (Slocat, 2021b).

In analyzing current policy research in this field, we found that two dimensions could contribute to explaining this gap.

Firstly, existing research on the decarbonization of freight has clearly identified the transformations necessary to reach the Paris Agreement in the sub-sector, but their analysis is often segmented. For instance, some only consider the transition of specific freight transport modes, independently of what could happen to the others, how this could impact the rest of the sector, or in the broader transformation of the production and consumption systems. Others focus on specific decarbonization options, like the electrification of vehicles, without integrating the interactions with other options such as those related to demand management (IPCC, 2022). Consequently, the policy solutions proposed may not produce the expected results and therefore may be detrimental or incompatible with the other transformations which need to occur and have an overall negative effect on the sector's decarbonization, because they consider freight sector transformations independently from one another. One example could be the suggestion to lower the cost of rail freight in order to support modal shift, not considering that road cost is also decreasing due to other reasons, including new regulations on the capacities of trucks, for instance. Another policy solution which may have unexpected effects if not addressed holistically is the adaptation of land use planning to transport decarbonization. While this may have a positive effect on modal shift, it could also increase transport demand, which would in turn increase transport-related emissions.

Second, policy analyses on the topic at hand often concentrate on single instruments as being blanket solutions, without necessarily considering other available policy instruments. Nevertheless, it seems that the systemic nature of the transformations necessary require complex policy interventions, in the form of comprehensive policy packages mixing different instruments. For instance, tax incentives to support the adoption of electric freight vehicles could be associated with adapted regulations on the manufacturing side, or facilitated access rules to city centers, for example.

Because of these two issues, the link between carbon neutrality and the broad spectrum of actions needed to fully decarbonize the sector is often unclear, which makes defining comprehensive policy packages necessary to reach this goal complex for policymakers.

As a solution, we propose an integrated approach to guide ambitious and more efficient sectoral public policies by better articulating the long-term decarbonization transformations necessary and short term policymaking. This approach consists in the articulation of relevant existing frameworks starting from a systemic analysis of the freight transformations and their feasibility conditions and concluding

with an analysis of policy instruments able to act on these conditions. We developed an articulated reporting template that we tested in both developed and developing economies with eleven in-country research teams from Brazil, Colombia, India, Mexico, Nigeria, the United States, South Africa, Australia, Ecuador, Norway and Iran. Using a bottom-up reporting method based on detailed knowledge of local circumstances and in-depth understanding of the challenges and implications of decisions made at national level makes the analysis robust and reliable (Waisman et al., 2021).

The deliverable is structured as follows: section 2 reviews the methodological challenges for designing comprehensive policy packages; section 3 briefly assesses freight transport's role in meeting SDG targets; section 4 introduces the integrated approach proposed to help design these comprehensive policy packages; section 5 presents an application of the framework proposed in section 3 using examples; section 6 concludes and discusses findings.

2 Literature review: methodological challenges to the design comprehensive policy packages

This literature review highlights the limitations of current methods used to identify relevant policy options to decarbonize the freight sector at national level.

The key systemic transformations necessary to decarbonize the freight transport sector have been identified by the literature (IPCC, 2022; ITF, 2023; Slocat, 2021b), as being the following:

1. Reduce freight transport demand and distances through the reorganization of supply chains
2. Modal shift to the least emitting transport modes and enable intermodality
3. Limit the energy consumption of vehicles through technology and behavior
4. Switch to low-carbon fuels

However, long term sectoral pathways and more largely freight transport research often exclude some of the transformations identified by the literature, namely demand management. Freight-related literature has a heavy focus on transformations 3 and 4, usually putting a strong emphasis on technology-related solutions (IPCC, 2022). This results in analyses often also being segmented, which allows them to be more specific, but does not allow them to ensure their coherence with the rest of the sector. For instance, part of the literature takes a modal perspective, either focusing on one mode, such as (Meyer, 2020) and (Carrara et al., 2017) who only look at road freight, or at modal shift, in the manner of (Kaack et al., 2018) and (Jonkeren et al., 2019).

Moreover, existing research does not often link its findings to policy options and implementation, making it difficult for policymakers to define the concrete actions they must take. For example, the often-used ASIF (activity, modal structure, modal energy intensity, fuel-to-carbon ratio) framework as outlined in (Schipper et al., 2000) is an overarching methodology, which disaggregates the main factors of change in the transport sector. It allows both a breakdown of past shifts in emissions as well as an analysis of possible future evolutions. However, in order to enable the identification of solutions and public policies, it needs to be complemented by other operational methodologies.

Nevertheless, some freight-related research does make this link and suggests policy options, using different quantitative methods, namely (Nassar et al., 2023) who analyze modal shift policies to decarbonize the freight transport sector in Brazil through a system dynamics model and (Yan et al., 2021), who use a national-level model specific to freight transport to explore policy options & compare their effectiveness using the example of Ireland. Still, in order to analysis to communicate with stakeholders and facilitate real-world action, quantitative studies should be complemented with a qualitative or semi-quantitative analysis (Waisman et al., 2019).

Looking at the efficiency and relevance of the policies deduced from freight decarbonization-related research, it seems that some, though helpful to facilitate one transformation, may also be detrimental to other transformations. For example, charging infrastructure is largely identified as being one of the main levers to facilitate EV uptake and decarbonize road freight, with some articles attempting to identify optimal recharging station locations (Meyer, 2020). However, choosing these locations without considering the necessity to reorganize supply chains in order to reduce transport demand and distances will result in lock-ins and/ or stranded assets.

Lastly, the decarbonization of freight transport at the national level is widely addressed in the literature, with many articles focusing on one country or region, including (Pan et al., 2018) on China's

transport sector as a whole or (Yan et al., 2021) on freight decarbonization in Ireland. Some comparative literature exists, namely (Pietzcker et al., 2013), which combines a global approach with a national one (China and United States). Indeed, the analyses identified are very country-specific or global. However, no framework on the decarbonization of freight found was tested in a wide panel of both developed and developing countries, guaranteeing that it can be used in all national contexts.

Overall, it seems that an integrated qualitative approach applicable in different contexts to decarbonize the freight sector at national level combining the consideration of all necessary transformations and linking them with policy options and ensuring their relevance has not been developed.

3 Freight transport's role in meeting SDG targets

While there is no Sustainable Development Goal (SDG) specifically dedicated to freight transport (although 2 targets are transport-related (Sustainable Mobility For All Initiative, 2021)), this sector's role in meeting SDG targets is increasingly recognized. For instance, the 2nd United Nations Global Sustainable Transport Conference (UNGSTC) recognized that it is an "enabler and necessary condition for achieving many SDGs", in the "Beijing Statement"(UNGST, 2021). Moreover, the Sustainable Mobility for All (SuM4All) initiative highlights that a "clear correlation exists between the attainment of SDGs and the quality of a country's transport system" (Sustainable Mobility For All Initiative, 2021). Transport is being more and more recognized as a playing a key role in address global public challenges, including peace or climate change (Sustainable Mobility for All Initiative, 2019).

The table below is an extract from the IPCC's Working Group III Contribution to the Sixth Assessment Report which synthesizes the latest science on freight- sector specific synergies and trade-offs with the SDGs.

Table: Freight-related SDGs, based on AR6 Ch10 (pg.1054) (IPCC, 2022)

Freight-related topics	SDGs: Synergies & trade-offs				
	Basic human needs	Earth preconditions	Sustainable resource use	Social & economic development	Universal values
	SDG 1,2,3	SDGs 13, 14, 15	SDG 6,7 12	SDGs 8,9, 11	SDGs 4,5, 10, 17
	-Lower air pollution contributes to positive health outcomes -Access to healthcare -Diseases from air pollution	-Reduction of GHG emissions along the entire value chain, e.g. Well-to-Wheel (WTW) -Further development addressing minor GHG emissions and pollutants -Transport Oriented to Sustainable Development (TOD) -Circular economy principle applied to transport	-Share of renewable energy use -Energy efficiency of vehicles -Clean and affordable energy off-grid. -Reduce material consumption during production, life cycle analysis of vehicles and their operations including entire value chains -Close loop carbon and nutrient cycle linked to circular economy	-Role of transport for economic and human development -Transport Oriented to Sustainable Development (TOD) -Sustainable transport infrastructure and systems for cities and rural areas -Positive economic growth (employment) outcomes due to resource efficiency and lower productive energy cost -Transport manufacturers as key employers changing role of transport-related labor due to platform economy and innovations in autonomous vehicles	-Gender equality in transport -Reduced inequalities -Partnership for the goals
References	Grant et al. 2016; Haines et al. 2017; Cheng et al. 2018; Nieuwenhuijsen 2018; Smith et al. 2018; Sofiev et al. 2018; Peden and Puvanachandra 2019; King and Krizek 2020; Macmillan et al. 2020	Farzaneh et al. 2019	SLoCaT 2019	Bruun and Givoni 2015; Pojani and Stead 2015; Hensher 2017; ATAG 2018; Grzelakowski 2018; Weiss et al. 2018; Brussel et al. 2019; Gota et al. 2019; Mohammadi et al. 2019; Peden and Puvanachandra 2019; SLoCaT 2019; Xu et al. 2019	Hernandez 2018; Prati 2018; Levin and Faith-Ell 2019; Vecchio et al. 2020

4 Integrated approach to designing comprehensive policy packages

In this paper, we propose a novel integrated approach, which aims at counteracting the limits identified in the literature review, both in terms of analysis of the transport sector, identification and evaluation of policy options and of validity in different national contexts. The objective of the proposed approach is to enable the sector's alignment between long-term freight sector decarbonization objectives and short-term policymaking, as necessary to reach Paris Agreement objectives (Waisman et al., 2019) by making the articulation between the two explicit.

The approach first develops a holistic view of the sector's necessary transformations and associated feasibility conditions, before analyzing the available policy instruments and designing policy packages consistent with the different transformations. This methodology integrates existing separate frameworks into a novel structure: an analytical pathway design framework for freight transport deep decarbonization (see section 3.1.) and different policy instrument frameworks (see section 3.2.).

We describe this method as being an "integrated approach" for several reasons. Firstly, as mentioned previously, it facilitates the consideration of all the sectoral transformations needed at once, as well as their interactions. This ensures that none are put aside and enables the user to consider the implications that a given policy would have on the transition of the sector as a whole, therefore avoiding contradictions or unanticipated negative effects on the aspects of the sector not directly targeted by the policy. Furthermore, it helps the user envisage all existing policy instruments. Lastly, it is also integrated as it brings together all different aspects which need to be considered when addressing the decarbonization of the freight sector in a holistic manner: articulating the long-term transformations with the policy instruments available and ensuring that the policies chosen contribute to the objective of the freight sector reaching carbon neutrality.

4.1 Analyzing sectoral transformations and associated feasibility conditions through a pathway design framework

An analysis of feasibility conditions resulting in the identification of barriers and enablers in this method are spelt out in the IPCC's Sixth Assessment Report (IPCC, 2022). Indeed, they are helpful in providing evidence to be used to support policy decisions and actions as well as increase the efficiency of mitigation options (IPCC, 2022). As such, identifying these key aspects related to national or local circumstances helps policymakers specifically target policies which will strengthen enablers and reduce barriers, making them key to our analysis. Enablers resulting from this analysis can be defined as necessary conditions to implement a national transformation required to decarbonize (IPCC, 2022). On the other hand, barriers are conditions which slow down or block such a transformation (IPCC, 2022).

In order to ensure that a comprehensive overview of the main enablers and barriers to the decarbonization of freight is provided, we suggest carrying out this analysis through the transformational narrative framework of (Briand et al., 2023) :

1) Economic and social macrostructure: systems of production, consumption and trade of goods (e.g., economic growth, urbanization process, transformation of the agri-food sector, etc.)
2) Management and operation of transport and storage infrastructure (e.g., port infrastructure and connection to international transport, infrastructure access, etc.)

3) Logistics operations and delivery services (e.g., road and freight quality of service, digital innovations, driving conditions, etc.)
4) Supply and adoption of low-carbon vehicles (e.g., transformation of vehicle stock, technical efficiency gains of vehicles, etc.)
5) Supply and adoption of low carbon fuels (e.g., production of biofuels, competition between the different uses of biomass between different sectors, etc.)

(Briand et al., 2023)'s framework has been developed to ensure the consideration of all drivers of change and is therefore helpful in taking a holistic perspective to the sector's transition and consider the interactions between all its diverse aspects. It effectively supports the identification of the main national enablers and barriers of the past 5 to 10 years to achieve deep decarbonization transformations and when possible, the role of specific actors in the transition (including companies, NGOs, local governments, national governments, for example). This analysis is key to advise and steer an efficient definition and implementation of appropriate policies (Waisman et al., 2021).

4.2 Identifying and assessing public policies through policy instruments classifications

In order to ensure that all policy instruments are considered, we propose a classification based on existing and various typologies (Franco Vargas & Roldán Restrepo, 2019; IPCC, 2014; Lascoumes & Le Gales, 2007; Salamon, 2001):

1) Governance and planning instruments: policy targets, strategies and roadmaps, state organization and agencies…
2) Economic instruments: subsidy/tax; loans; direct investments and procurements; market-based and trading systems; …
3) Regulatory and "non-economic" instruments: standards and rules
4) Informational instruments: reporting, training, awareness campaign, private and voluntary agreements…

Based on each transformational narrative element and associated analysis of feasibility conditions, the related policies in place are listed following this framework. The result offers an overview of existing policy instruments and therefore of their gaps. This enables an adequacy check between the required transformations and feasibility conditions to activate and the current effort and policies in place.

In Section 4 of this paper, we display an extract of the application of the method by our research group made of national freight transport experts coming from Brazil, Colombia, India, Mexico, Nigeria, the United States, South Africa, Australia, Ecuador, Norway and Iran. In order to provide an adequate overview of how it functions while taking into account the quantity of collected data, the approach will be presented through only one of the categories of the transformative narrative framework. This will nevertheless allow us to show how the approach can be concretely applied, demonstrating how the analysis of the feasibility conditions helps define and assess the public policies which should be implemented.

5 Application of the integrated approach

The category of the transformational narrative framework chosen as an example to display the application of the framework is “Transport and storage infrastructure and its management” as improving and increasing the capacity and management of transport infrastructure has been identified as a key enabler in most of the countries analyzed in this paper.

Indeed, looking at freight-related infrastructure and its management is key for mitigation in several aspects. It offers access to production and consumption locations, enables the development of transport services and favors a certain spatial organization of the supply chain (ITF, 2023). It influences modal choices and could facilitate modal shift towards more rail and inland waterways transport.

This category focuses on the future of transport infrastructure such as the linear land transport infrastructure (rail, road, inland waterways), the multimodal hubs and ports, but also includes the goods storage facilities. It includes description around the number of facilities, their localization, their costs, but also their organization, access, interconnections such as speed regulations, access tariffs, booking systems, etc. However, it does not include energy-related infrastructure for the supply of low-carbon fuels, notably charging or fueling infrastructure for electric vehicles, biofuels or hydrogen. This type of energy-related infrastructure is considered to fit into category 5: “Supply and adoption of low-carbon fuels”.

The national feasibility conditions related to this category and obtained through the framework are detailed below, before the related policy measures identified are considered.

5.1 Analyzing the feasibility conditions associated to sectoral transformations described within “transport and storage infrastructure and management”

The analysis carried out on infrastructure and its management considers all transport modes, with rail and road freight being the most considered.

Looking at rail in more detail, upgrades in infrastructure should respond to different needs depending on the country. For some countries, the overall rail transport network should be modernized and/or developed (South Africa, Mexico, Nigeria, Iran, India, Brazil). In other contexts, it is more a question of improving the efficiency and reliability (Norway, Brazil), or of cost (India) or access (Brazil).

Moreover, road infrastructure is also key in many countries as it is usually the most used transport mode. Modernization and rehabilitation of roads is required in some countries due a lack of maintenance and the excess weight of vehicles (South Africa, Nigeria) but also for carbon efficiency gains (Colombia). Building new roads is also necessary to limit over-congestion (South Africa) and reduce distances (Norway) or facilitate the uptake of other transport modes (Ecuador).

In addition, port infrastructure is also a priority in some countries namely its expansion (Brazil) and improvement of operational efficiency (Norway and Brazil).

Lastly, some countries have also identified facilitating intermodality as being key, more specifically concerning last mile connectivity and development of waterways for India, and in intermodal facilities in South Africa. In India, uniformity in rules and regulations across different modes will be required to optimize the modal mix as well.

This transformational narrative framework category also encompasses infrastructure used to manage stock and ensure delivery and time reliability. Furthermore, it also addresses infrastructure access: rules and regulations (speed, cost, booking systems, etc.). This was also identified as an enabler by some countries (South Africa, Ecuador). In Ecuador, this more specifically refers to specialized logistics infrastructure that supports production chains, commercial networks and add value to logistics service (CAF, 2016). In South Africa, this revolves mostly around increasing storage infrastructure itself.

Considering all of these inputs, it seems that most of the information collected revolves around building new or improving existing rail and road infrastructure. Indeed, port and multimodal infrastructure are mentioned to an extent for some countries and not necessarily land multimodal platforms for mode interconnections as well as inland waterways. Furthermore, there is little mention of storage infrastructure and almost no mention of infrastructure management and regulation. Yet, these two aspects are key to ensure that infrastructure does contribute adequately to the decarbonization of freight transport. Indeed, storage infrastructure is essential to increase the flexibility and the ability for freight forwarders to choose the lesser emitting transport methods and facilitate intermodality. This is summarized in the table 1 below.

Table 1: Summary of national feasibility conditions addressed as part of the category "transport and storage infrastructure and its management"

Sub-category	Level of importance in the national analyses from 0 (no coverage) to 3 (very covered)
1. Investments in construction and upgrade of infrastructure	
Road	3
Rail	3
Port	2
Inland waterways	0
Multimodal platforms	1
Storage and logistics infrastructure	1
2. Management and maintenance and regulation access to infrastructure	
Speed rules	0
Toll charges and cost rules	0
Other access rules (weight…)	0
Maintenance	1

Looking at elements less addressed in national policies, the management and regulation of infrastructure will be essential to ensure its longevity as well as to maximize the worth of the investment and must be addressed at the same time as its development. Indeed, some of the improvements highlighted by the country experts are necessary due to lack of oversight. These two aspects should therefore be incorporated in the strategies and policies chosen by decisionmakers at national level, in order to ensure that these policies are comprehensive and efficient.

Furthermore, it is useful to mention that choosing what infrastructure to invest in is a lock-in and can be a barrier in some national contexts. For instance, one of the main barriers acknowledged in Colombia to the development of rail freight is the fact that newly built roads have to be paid for, which not only limits the investments made in rail freight, but also may increase the enthusiasm to use roads instead. Indeed, this must also be considered by policymakers when choosing what infrastructure to specifically promote in their policies.

Lastly, in the countries considered, transport-related infrastructure improvements and management is not specific to decarbonization but is also very strongly linked to other objectives, mainly development and improvements in quality of life. For instance, in India, infrastructure improvement is a national government focus.

The national feasibility conditions analyzed above, and the conclusions made on the ones missing should now enable us to appraise the public policies currently in place.

5.2 Identifying and assessing public policies

Consistently with the national feasibility conditions identified, economic instruments are by far the most used in the countries analyzed when it comes to infrastructure, as most of the focus is on financing. What is more, most of these policies' overarching aim is not necessarily the decarbonization of the sector, but still contribute to this goal.

In practice, policies related to building as well as improving transport and storage infrastructure are usually direct governmental investments at the national level.

Larger governmental investments plans, include the Infrastructure Investment and Jobs Act in the United States, which provides funding not only for transport related infrastructure priorities (including, roads, bridges, rail, transit, ports, airports) but for also for other core US infrastructure priorities (117th Congress, 2021). In India, transport infrastructure improvements in the different modes have therefore been one of the major components of the overall budget in the last few years. As an example, the Indian government has provided significant funding to electrify railway lines through the "Mission 100% Railways Electrification" policy (Ministry of Railways Government of India, 2021). Nevertheless, mode specific plans or development programs evidently also exist, such as the National Logistics Plan in Colombia, a dedicated package for investment in railways for terminals and longer passing loops and connecting lines in Norway or the White Paper on National Rail Policy in South Africa (Department of Transport. South Africa, 2022). In the United States, the Port Infrastructure Development Program provides discretionary grant funding to strengthen, modernize, and improve the U.S. maritime systems and gateway ports (US Department of Transportation Maritime Administration, 2021).

Other tools rather than national governmental investments have also been used in some countries. Public-private partnerships are also sometimes considered, such as in Brazil with the Investment Partnership Program for instance. In Nigeria, the Federal Government has issued Green Bonds to raise

capital for many different priorities, including afforestation and renewable energy but also transport. Furthermore, international financing of low-carbon infrastructure has been identified as being a global enabling condition, meaning one which is dependent on actions from multiple other countries and international actors, as opposed to domestic enablers (Svensson, 2023), in several countries such as Colombia and Nigeria.

Some governance and planning instruments are used in some countries, mostly in the form of policy targets. For instance, some countries have general objectives linked to infrastructure, such the National Logistic Policy (2022) in India, which aims to optimize modal mix and develop inland and coastal waterways to leverage the existing potential of water transport. Furthermore, some countries have objectives which do not clearly mention development and management of infrastructure, but which will only be achieved thanks to feasibility conditions linked to it. For example, increasing the share of rail freight is an objective in five of the countries analyzed (India, Nigeria, Norway, Colombia, Iran). However, more precise strategies and roadmaps related to infrastructure have not been identified.

Regulatory and non-economic instruments (standards and rules) as well as informational instruments have not been highlighted as being key concerning infrastructure and its management in the countries analyzed.

The level of implementation of the different types of policy instruments in place in the countries studied are summarized in Table 2.

Table 2: Summary of policy instruments covering transport and storage infrastructure and its management in the countries studied

Type of policy instruments	Level of importance in the national analyses from 0 (little to no coverage) to 3 (very covered)
Governance and planning instruments	1
Economic instruments	3
Regulatory and “non-economic” instruments	0
Informational instruments	0

Even if these policies are coherent with the fact that the main feasibility condition identified is financing, it is mostly unclear whether these policies meet the exact needs of the countries identified in the previous section (access to infrastructure for example). It would therefore be useful to define precise strategies and roadmaps, or other governance and planning instruments to ensure that the investments are used where they should be. Consequently, the adequacy of the public policies implemented is not always clear. (ITF, 2023) namely recommends that government use a “vision-led way” in their investments in infrastructure and avoid only responding to current demand.

Furthermore, the management and maintenance of existing or new infrastructure was not mentioned directly in the analyses carried out, but must be considered at the same time as the financing of infrastructure. Indeed, other useful tools may include:

- State organization & agencies to handle this management, maintenance and enforcing the

rules
- A source of revenue to be able to finance these institutions and their operations, in the form of an economic instrument such as a tax or toll fee
- Regulations and rules to organize access and limit the damage to the infrastructure (including speed regulations, access tariffs, booking systems, etc.)
- Informational instruments to spread good practices & inform users about the above regulations

Overall, the analysis shows that building and upgrading infrastructure is identified as a key aspect to decarbonize the freight sector at the national level, but that needs vary depending on the context. However, management and maintenance will also be crucial and must be considered more thoroughly. These two key takeaways from the national feasibility conditions help define and characterize the public policies necessary to ensure that this transformation occurs. Our analysis therefore helped show that economic instruments alone are insufficient to cover policy needs when it comes to infrastructure. Indeed, in addition to financing, this aspect of freight transport decarbonization also necessitates governance and planning instruments to ensure that the financing is used in accordance with national context needs, but also to organize management and maintenance, which also requires regular revenues. Moreover, non-economic and regulatory policies could offer a large set of options to regulate the infrastructure access and are also under-represented, as policy levers for decarbonization.

6 Conclusions and Discussion

The approach proposed in this paper seeks to contribute to improving the relevance of public policies to decarbonize the freight transport sector. It relies mostly on a consistent articulation between the feasibility conditions linked to the transformations of the freight sector and the different public policy instruments available to play on these feasibility conditions.

This proposed approach and its application are useful in showing that such a method is helpful in drafting policy packages that are coherent within categories of the freight transformational narrative. Indeed, the example used showed that by laying out all the different feasibility conditions that relate to the category at hand, not only does the relevance of the policy instruments implemented become more apparent, but also highlights what instruments are missing. This therefore helps building efficient and consistent policy packages with policies that can reinforce one another. Indeed, the strategies built to answer to the national needs identified in the first section of the approach can be executed using economic instruments with specific objectives (with precise projects and uses in mind, for instance) and/ or regulatory instruments to reinforce them.

Looking at the transformational narrative as a whole, we have also found that the two categories which were the most populated are: (2) ‘’Transport and storage infrastructure and its management” and (4) “Goods transport vehicles”. This can be interpreted as a reflection of the current political framing of decarbonization. Indeed, systemic transformations, namely reduce freight transport demand and distances through the reorganization of supply chains, is considered only to a limited extent. Yet, these are essential to ensure a real and effective transition towards carbon neutrality (IPCC, 2022). It is therefore necessary that more emphasis is put on these transformations by policymakers. Furthermore, analyzing all the categories of the pathway framework could also help to clarify which feasibility conditions and policy packages could be detrimental to another and therefore avoid contradictory policies.

Considering further research to be carried out based on this work, some elements required additional focus. First, while it was crucial for this analysis to use first-hand data from a variety of different countries to ensure its relevance, the next step would be to use this common reporting approach to carry out a comparison between countries. Indeed, this would enable us to counteract the heterogeneity of the national analyses and build more robust policy packages based on the experience of other countries. These cross-country messages would also be valuable in international fora, to be able to have more precise discussion on these issues (Gunfaus & Waisman, 2021). Moreover, defining policy packages also requires taking into account other fundamental policy dimensions, such as policy acceptance by real-world actors. This can be a significant obstacle to its approval by legislative bodies, as joint instruments can conflict with the interests of traditional sectors or actors with high powers of influence. Therefore, the necessary effort to articulate with different interest groups could be considered, aiming at the effective implementation of the policy package, minimizing the amount of changes in its composition (that may be requested) or even its refutation.

7 References

Briand, Y., Waisman, H., Gupta, D., De Almeida D'Agosto, M., Vasconcelos Goes, G., Neves Schmitz Gonçalves, D., Garg, A., Sudharmma Vishwanathan, S., Ahjum, F., Trollip, H., McCall, B., W.R. Siagan, U., Gumilang Dewi, R., Pye, S., Combes, F., & Koning, M. (2023). A pathway design framework for sectoral deep decarbonisation: the case of freight transportation. *Climate Policy*, *Submitted April 2023*.

CAF. (2016). *Pefil Logistico de America Latina (Perlog) Ecuador*. https://scioteca.caf.com/bitstream/handle/123456789/1023/CAF_PERLOG%20ECUADOR.pdf?sequence=64&isAllowed=y

Carrara, S., Longden, T., Eni, F., & Mattei, E. (2017). Freight Futures: The Potential Impact of Road Freight on Climate Policy. *Transportation Research Part D: Transport and Environment*, *55*, 359–372. https://doi.org/10.1016/j.trd.2016.10.007

Department of Transport. South Africa. (2022). *National Land Transport Act: White Paper on the National Rail Policy March 2022*. www.gpwonline.co.za

Franco Vargas, M. H., & Roldán Restrepo, D. (2019). The instruments of public policy. A transdisciplinary look. *Cuadernos de Administración*, *35*(63), 101–113. https://doi.org/10.25100/cdea.v35i63.6893

GIZ, & BMUB. (2017). *Transport in Nationally Determined Contributions (NDCs): Lessons learnt from case studies of rapidly motorising countries*. https://changing-transport.org/wp-content/uploads/2017_Transport-in-NDCs.pdf

Gunfaus, M. T., & Waisman, H. (2021). Assessing the adequacy of the global response to the Paris Agreement: Toward a full appraisal of climate ambition and action. *Earth System Governance*, *8*. https://doi.org/10.1016/j.esg.2021.100102

Harry-Villain, L., Briand, Y., Waisman, H., Major, M., & Castillo, L. (2021). *Companies and carbon neutrality, a story of systemic transformations and cooperation: Illustration on the freight transport sector* (ITF Transport Outlook). OECD. https://www.iddri.org/sites/default/files/PDF/Publications/Catalogue%20Iddri/Autre%20Publication/202111-Note%20transport.pdf

IEA. (2018). *Fuel share of CO2 emissions from fuel combustion, 2018*. IEA, Paris. https://www.iea.org/data-and-statistics/charts/fuel-share-of-co2-emissions-from-fuel-combustion-2018

IEA. (2022). *World Energy Outlook 2022*. https://www.iea.org/reports/world-energy-outlook-2022

IPCC. (2014). *IPCC, 2014: Climate Change 2014 : Mitigation of Climate Change. Contribution tof Working Group III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change* (O. Edenhofer, R. Pichs-Madruga, Y. Sokona, E. Farahani, S. Kadner, K. Seyboth, A. Adler, I. Baum, S. Brunner, P. Eickemeier, B. Kriemann, J. Savolainen, S. Schlömer, C. von Stechow, T. Zwickel, & J. C. Minx, Eds.).

IPCC. (2022). *IPCC, 2022: Climate Change 2022: Mitigation of Climate Change. Contribution of Working Group III to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change* (P. R. Shukla, J. Skea, R. Slade, A. Al Khourdajie, R. van Diemen, D. McCollum, M. Pathak, S. Some, P. Vyas, R. Fradera, M. Belkacemi, A. Hasija, G. Lisboa, S. Luz, & J. Malley, Eds.). Cambridge University Press. https://doi.org/10.1017/9781009157926

ITF. (2021). *ITF Transport Outlook 2021* (ITF Transport Outlook). OECD. https://doi.org/10.1787/16826a30-en

ITF. (2023). *ITF Transport Outlook 2023*. OECD Publishing. https://doi.org/10.1787/b6cc9ad5-en

Jonkeren, O., Francke, J., & Visser, J. (2019). A shift-share based tool for assessing the contribution of a modal shift to the decarbonisation of inland freight transport. *European Transport Research Review*, *11*(1). https://doi.org/10.1186/s12544-019-0344-x

Kaack, L. H., Vaishnav, P., Morgan, M. G., Azevedo, I. L., & Rai, S. (2018). Decarbonizing intraregional freight systems with a focus on modal shift. In *Environmental Research Letters* (Vol. 13, Issue 8). Institute of Physics Publishing. https://doi.org/10.1088/1748-9326/aad56c

Lascoumes, P., & Le Gales, P. (2007). Introduction: Understanding Public Policy through Its Instruments-From the Nature of Instruments to the Sociology of Public Policy Instrumentation. *Governance: An International Journal of Policy, Administration, and Institutions, 20*(1), 1–21.

Meyer, T. (2020). Decarbonizing road freight transportation – A bibliometric and network analysis. *Transportation Research Part D: Transport and Environment*, *89*. https://doi.org/10.1016/j.trd.2020.102619

Nassar, R. F., Ghisolfi, V., Annema, J. A., van Binsbergen, A., & Tavasszy, L. A. (2023). A system dynamics model for analyzing modal shift policies towards decarbonization in freight transportation. *Research in Transportation Business and Management*. https://doi.org/10.1016/j.rtbm.2023.100966

Pan, X., Wang, H., Wang, L., & Chen, W. (2018). Decarbonization of China's transportation sector: In light of national mitigation toward the Paris Agreement goals. *Energy*, *155*, 853–864. https://doi.org/10.1016/j.energy.2018.04.144

Pietzcker, R., Kriegler, E., Luderer, G., Longden, T., Wenying, C., Fu, S., & Kyle, P. (2013). *Long-term Transport Energy Demand and Climate Policy: Alternative Visions on Transport Decarbonization in Energy Economy Models*.

Salamon, L. M. (2001). The New Governance and the Tools of Public Action: An Introduction. In *Fordham Urban Law Journal* (Vol. 28). https://ir.lawnet.fordham.edu/uljAvailableat:https://ir.lawnet.fordham.edu/ulj/vol28/iss5/4

Schipper, L., Marie-Lilliu, C., & Gorham, R. (2000). *Flexing the Link between Transport and Greenhouse Gas Emissions A Path for the World Bank*.

Slocat. (2021a). *Climate Strategies for Transport: An Analysis of Nationally Determined Contributions and Long-Term Strategies*. www.slocat.net/ndcs

Slocat. (2021b). *Tracking Trends in a Time of Change: The Need for Radical Action Towards Sustainable Transport Decarbonisation*. www.tcc-gsr.com

Slocat. (2022). *The NDCs Hall of Fame*. https://slocat.net/ndcs-hall-of-fame/

Sustainable Mobility for All Initiative. (2019). *Global Roadmap of Action : Toward Sustainable Mobility*. The World Bank, Sustainable Mobility for All Initiative. https://www.sum4all.org/data/files/gra-globalroadmapofaction-press.pdf

Sustainable Mobility For All Initiative. (2021). *Implementing the SDGs*. https://www.sum4all.org/implementing-sdgs

Svensson, J. (2023). *IDDRI submission to the GST on behalf of the IMAGINE project Using the Global Stocktake to identify and design opportunities for enhanced global collaboration that accelerates national climate and development action: the case of international finance*.

UNGST. (2021). *Report of the Second United Nations Global Sustainable Transport Conference (Beijing)*.

US Department of Transportation Maritime Administration. (2021, April 22). *Port Infrastructure Development Program Grant Information*. https://www.maritime.dot.gov/ports/port-infrastructure-development-program

Waisman, H., Bataille, C., Winkler, H., Jotzo, F., Shukla, P., Colombier, M., Buira, D., Criqui, P., Fischedick, M., Kainuma, M., La Rovere, E., Pye, S., Safonov, G., Siagian, U., Teng, F., Virdis, M. R., Williams, J., Young, S., Anandarajah, G., … Trollip, H. (2019). A pathway design framework for national low greenhouse gas emission development strategies. In *Nature Climate Change* (Vol. 9, Issue 4, pp. 261–268). Nature Publishing Group. https://doi.org/10.1038/s41558-019-0442-8

Waisman, H., Torres Gunfaus, M., Pérez Català, A., Svensson, J., Bataille, C., Briand, Y., Aldana, R., Anggreni, L., Angulo-Paniagua, J., Argyriou, M., Benavides, C., Bergamaschi, L., Berghmans, N., Boer, R., Buira, D., Bukowski, M., Calderón, W., D'Agosto, M., De León, M., … Zevallos, J. (2021). *Climate ambition beyond emission numbers: taking stock of progress by looking inside countries and sectors*. https://www.iddri.org/en/publications-and-events/report/climate-ambition-beyond-emission-numbers-taking-

Yan, S., de Bruin, K., Dennehy, E., & Curtis, J. (2021). Climate policies for freight transport: Energy and emission projections through 2050. *Transport Policy*, *107*, 11–23. https://doi.org/10.1016/j.tranpol.2021.04.005

Text - H.R.3684 - 117th Congress (2021-2022): Infrastructure Investment and Jobs Act. (2021, novembre 15). https://www.congress.gov/bill/117th-congress/house-bill/3684/text

PARTICIPANTS

Wuppertal Institut

VUB BRUSSELS SCHOOL OF GOVERNANCE

IDDRI

DLR Deutsches Zentrum für Luft- und Raumfahrt German Aerospace Center

E3Modelling Energy Economy Environment

bc3 BASQUE CENTRE FOR CLIMATE CHANGE Klima Aldaketa Ikergai Sustainability, that's it!

UNIVERSITY OF EASTERN FINLAND

IIM AHMEDABAD

UNIVERSITY OF CAPE TOWN IYUNIVESITHI YASEKAPA • UNIVERSITEIT VAN KAAPSTAD

清華大學 Tsinghua University

IPB University Bogor Indonesia

SCHOOL OF PUBLIC POLICY CENTER FOR GLOBAL SUSTAINABILITY

HOLISTIC

NDC ASPECTS project has received funding from the European Union's Horizon 2020 Research and Innovation programme under grant agreement No 101003866

NDC ASPECTS

www.ndc-aspects.eu

@ndcaspects

@ndcaspects