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Reconciliating urgent action and transformational changes: a pathway design framework for national freight decarbonization strategies applied in developing countries

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A pathway design framework for national freight transport decarbonization strategies

Yann Briand, Dipti Gupta, Marcio de Almeida D'Agosto, George Vasconcelos Goes, Daniel Neves Schmitz Gonçalves, Amit Garg, Saritha Sudharmma Vishwanathan, Fadiel Ahjum, Hilton Trollip, Bryce McCall, Ucok W. R. Siagan, Retno Gumilang Dewi, Steve Pye, François Combes & Martin Koning

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07/04/2025

SciencesPo

The Deep Decarbonization Pathways (DDP) initiative at a glance

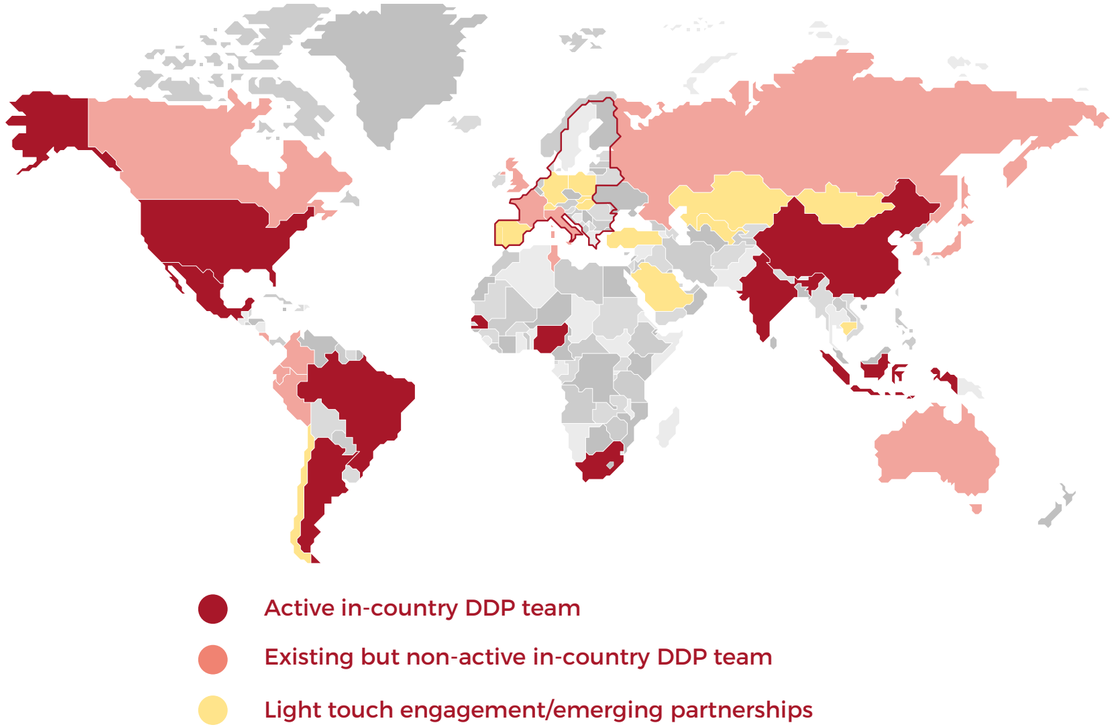
Who we are:

- an international network of in-country economists, climate and energy modelling experts
- a research-based initiative sharing a scientific methodology to develop country-specific, long-term, policy-relevant and economy-wide pathways to deep decarbonization (freight is just 1 out of 10 sectors) as a tool for policy dialogue

DEEP DECARBONIZATION PATHWAYS

What we do:

- developing country-driven national climate-compatible pathways
- structuring national and international engagement activities



> Aiming to strenghten independent research capacities in countries (a) and inform national and international decisions (b) about the enablers of the transition and the role of the different stakeholders

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Agenda

- Context and research question
- Method
- Modelling results
- Key lessons

Policy context

- Freight is overlooked in national mitigation policy strategies informing long-term and short-term goals compared to passenger-related strategies and measures

- When included, most actions are focused on the development of low-carbon fuels and vehicles, or technical solutions to improve fuel consumption

- Freight policy actors and socio-organizational systems are different from passenger

Research context:

Limitations in existing mitigation studies associated with modelling all decarbonization drivers and options

- Literature review highlights that freight transport decarbonization **requires the consideration of systemic changes related to demand management, supply chain reorganization and modal shifts,** in addition to technological changes focused on energy efficiency gains and low-emission vehicles and fuels.

- **In IPCC assessments, out of a total of more than 100 climate and energy models**, only four global transport models were included: the Mobility Model (Fulton et al., 2009), the Global Transportation Roadmap (International Council on Clean Transportation (ICCT, 2012), MESSAGE-Transport V.5 (Huppmann et al., 2019) and GCAM (Mishra et al., 2013).
  - While transport is the core focus of GTEMs, this is not the case for IAMs, where transport is only one economic sector within the whole economy. GTEMs lack the integration of the transport sector with other sectors of the economy, while IAMs provide less detail on national and sectoral transport transitions (Yeh et al., 2017).
  - Aspects such as drivers of demand generation and the spatial organization of logistics chains are poorly represented in all IAMs, and to some extent in GTEMs. This lack of sectoral detail means that models rely mostly on technological factors to reduce emissions, disconnected from the economic and spatial complexity of logistics chains and operations.
  - While models offer different interaction representations, no single model can produce a comprehensive picture accounting for all drivers of freight transport demand, modal choices, logistics efficiency and low-carbon technology shifts, and they thus represent a simplified and incomplete perspective of the reality.

The challenge in developing long-term DDPs is therefore to consider all of the existing research, models and analysis to enable a broader set of options to be examined, while at the same time ensuring the consistency of qualitative and quantitative pathway descriptions.

Research context

Limitations in accounting for stakeholder-oriented information relevant to policy decisions

- Rich literature is available on the relevance and value of scenario planning and the **need to involve stakeholders** to address profound, long-term transformations where information is incomplete and considerable uncertainties are present (Volkery & Ribeiro, 2009). The involvement of stakeholders is necessary for many reasons: they provide data that is otherwise largely unavailable; they contribute to generating ideas; they can prioritize trends and assess uncertainty levels; and they can assess scenario planning work. In addition, the **knowledge that stakeholders can derive from the scenario planning exercise is part of the expected outcome of the process (**Andersen et al., 2021).

- However, **current modelling approaches are often based on overly complex models and lack the flexibility to facilitate dialogues and** to adapt to discussions around the implementation conditions of the transition.

The challenge is therefore to provide a pathway design framework that sectoral stakeholders, such as shippers, carriers, infrastructure developers, vehicle manufacturers and energy providers can understand and use for expert interactions, based on a combined qualitative-quantitative method (Venturini et al., 2019).

Methodological challenges - conclusions

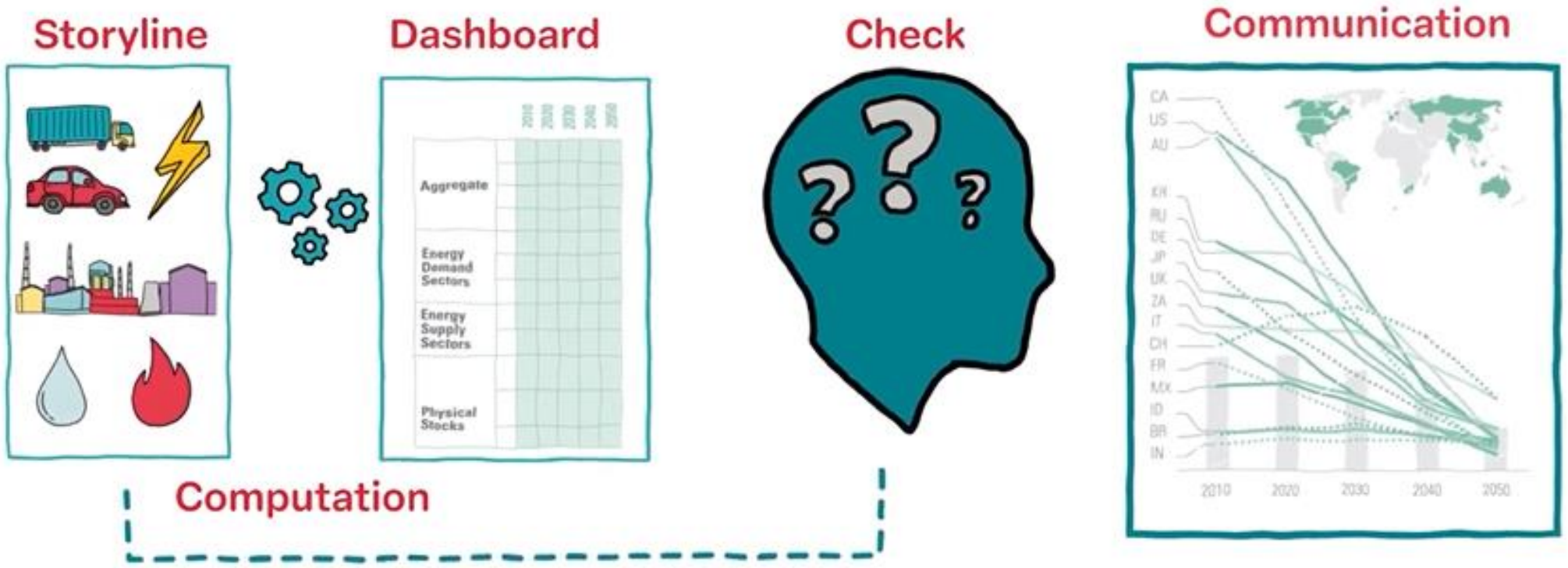
No pathway design frameworks have been developed to explore, consistently and simultaneously, all of the freight decarbonization drivers that will be required for carbon neutrality at the national level, to facilitate the decision-making processes of all public and private actors to inform the revision of future LTSs and NDCs.

Main research questions

How to design ambitious yet realistic long-term sectoral pathways able to inform national policy decisions?

How to better include and analyze systemic changes related to freight demand and logistics organisations?

Methods


Storyline
Dashboard
Check
Communication
Aggregate
Energy Demand Sectors
Energy Supply Sectors
Physical Stocks
CA
US
AU
CN
RU
DE
JP
UK
ZA
IT
CH
FR
MX
ID
BR
IN
2010
2020
2030
2040
2050
Computation

Proposed DDP research approach and key principles for designing ambitious and policy-relevant national pathways

1. **Bottom-up and country-led** analysis is required to build country-relevant pathways aligned with domestic development priorities

2. **Model- and tool-agnostic** analysis is required to build on the broad set of existing tools and build on their complementarities

3. **Articulating organizational and technological decarbonization drivers**, demand-side and supply-side measures, is required to take a systemic perspective and increase ambition

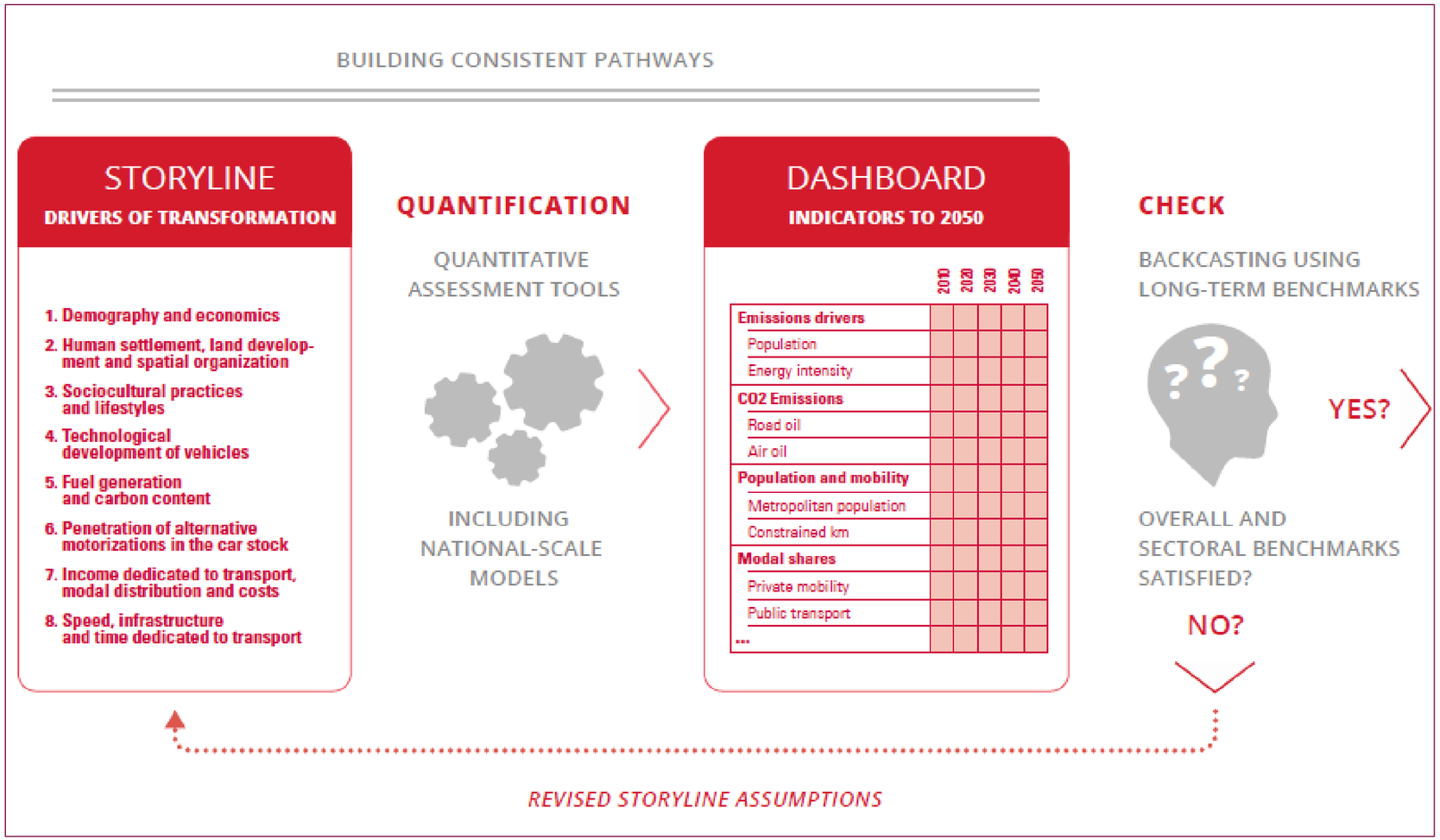
4. **Stakeholder-oriented, sectoral and qualitative analysis,** going beyond the usual quantitative energy and emissions trajectories, providing more granularity and sectoral details, providing international context elements and drivers, is required to complement quantitative modelling tools, be understood by national and international actors of the implementation, and provide concrete policy options

5. **Transparent** and inclusive processes are required to structure and facilitate dialogues with real-world actors.

6. **Multi-scenario and exploratory** analysis is required when looking at mid-century transitions given all global and country-specific uncertainties possible in order to inform on possible futures and consequences, and help adapt dynamically

7. **Iterative and backcasting from 2050-70** analysis is required to identify the compatible short-term actions **AND** consider some systemic changes with profound inertia to reach mid-century development objectives and emissions neutrality starting from the present

The DDP framework for designing pathways



<u>2 main modes of representations of the pathway:</u>

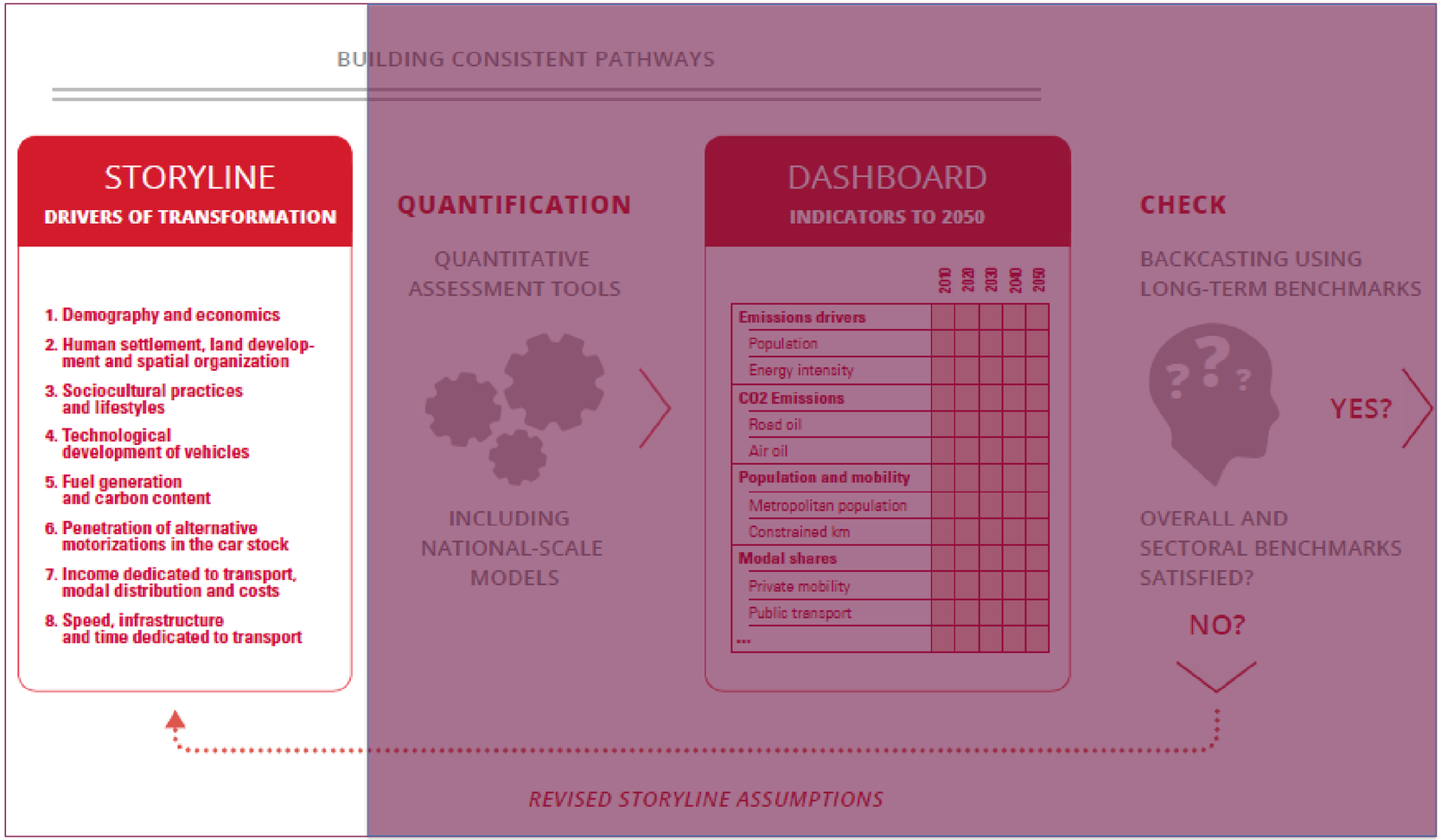
1. The Storyline
2. The Dashboard

<u>3 main steps to build consistent pathways:</u>

1. The Storyline definition
2. The Quantification
3. The analytical Check and iterative process

Note: The readable elements in the storyline and dashboard boxes are not general an related to examples from the passenger transport sub sector.

Mode 1 – The Storyline



Objective:

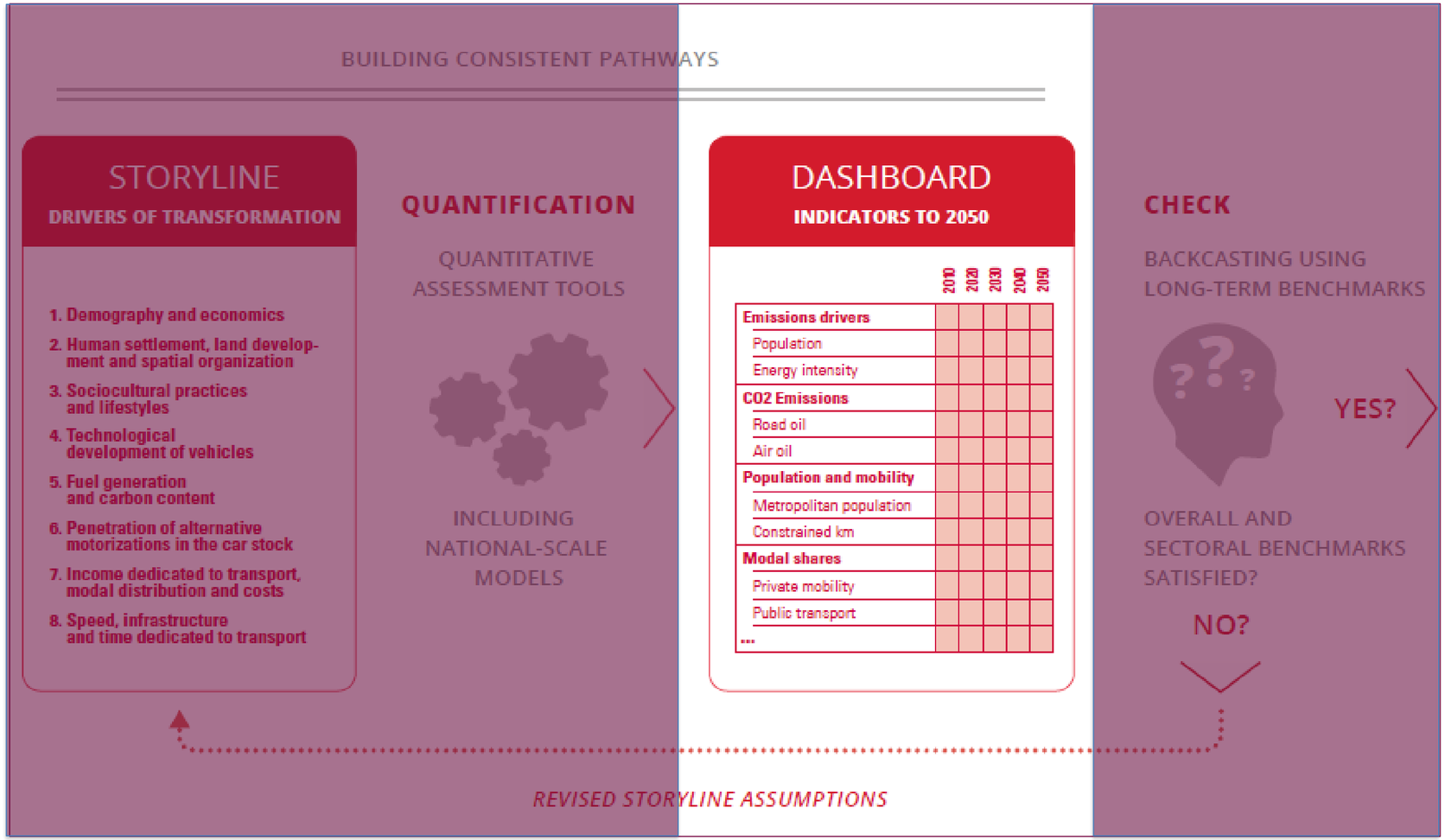
- Structure the systemic description of the pathway around all categories of drivers covering the economic, demographic, technical, organisational, and behavioural dimensions that influence the emission trajectories and other development trajectories

- Provide a litteral and comprehensive representation of these underlying transformations which concerns the future actions of the different sectoral stakeholders and national stakeholders

Key words: Drivers description, detailed, qualitative, semi-quantitative

Note: The readable elements in the storyline and dashboard boxes are not general an related to examples from the passenger transport sub sector.

Mode 2 – The Dashboard



Objective:

- Structure a synthetic representation of the pathway each 10 years from 2010 to 2050-70 showing its main components and effects through national and sectoral selected indicators

- Provide a quantitative only representation of specific low-carbon transformations enabling policy discussions and control of long-term objectives and transition effects

Key words: Synthetic, quantitative only, Indicators selection

Note: The readable elements in the storyline and dashboard boxes are not general an related to examples from the passenger transport sub sector.

The “DDP Design and Reporting Template” structures the presentation of the description of national scenarios

National and international overview picture	**Global Context (Storyline only)**
	National Overview
	Macro- demographic and economic picture
National sectoral transitions	Transport - Passenger sector
	Transport - Freight sector
	Industry - Energy Intensive Industries (e.g. Iron and steel, Aluminium, Cement, Lime, Glass, Brick, Ceramics, Pulp paper and board, and Chemicals not related to fuel production)
	Industry - Light Industries (e.g. all other industries not included in EII and the 3 energy generation industries)
	Buildings - Residential
	Buildings - Commercial
	Agriculture, Forestry and Land Use
	Waste
	Industry - Power production
	Industry - Extractive energy industries
	Industry - Other energy industries (e.g. refineries, energy conversion industries, synthetic liquid and gaseous fuel production…)

Freight storyline: 5 key areas of transformations to capture all drivers of emissions and stakeholder's point of view

1) The future demographic, economic, spatial and socio-cultural structure of consumption, production and trades **-> Cargo owners/industrials, Consumers**

2) The development and management of transport and logistics infrastructures **-> Infrastructure developers and operators**

3) The development of vehicles, trucks technologies and penetration in the stock **-> Vehicle manufacturers, carriers**

4) The organisation of logistics operations (supply and delivery), modal and vehicle choices **-> Cargo owners, logistics service providers**

5) The production and distribution of fuels -> **Energy providers**

Freight storyline: examples of guiding questions

1) The future demographic, economic, spatial and socio-cultural structure of consumption, production and trades

- **Consumption patterns of the population affecting freight demand:**
  - population features (size, revenues/expenditures, household size, urbanization process),
  - new patterns (e-commerce, sharing, local/regional/national priority, fashion…)

- **Consumption & production patterns of agriculture, industry and service** businesses affecting freight demand and supply chain length:
  - futures of key macro-industries (agro-food sector, construction sector, manufacturing sector of low-added value and high added value products),
  - future industrial strategies (sourcing strategy and localization, marketing strategy, distribution and stock strategy…),
  - new production patterns (relocation/nearshoring, circular economy (reduce, reuse, recycle), 3D printing, JIT…)

- **Changes in urbanisation process and localisation of consumption sites, and changes in economic situation and geographical distribution of industrial production affecting trip distances of goods**

- **Changes in trade and commercial rules (social, fiscal, environmental norms in LAM regions, trade agreements evolution, temporal condition on exchanges/transport), changes in industrial policies and relative share of national production versus international import/export**

Goods features and relations with modes: Heavy versus light; Dangerous products; Fresh food; Fragile versus bulk delivery; Low versus high added values…

Freight - Dashboard

- Demand indicators:
  - Aggregated: GDP, tons transported, tkm
  - tons, tkm disaggregated by 6 categories of goods
  - tkm disaggregated by distances: <150km, >150km and nature of transport (national, imp/exp, transit) + by road/rail/IWWC/Air

- Supply indicators:
  - tkm, vkm disaggregated by HGV vs LCV
  - vkm by HGV/LCV and distances
  - HGV/LCV: empty running factor, stock, sales by 5 categories of energy tech

- Energy consumption and emission indicators
  - by modes, by type of fuels, by vehicles/type of fuels

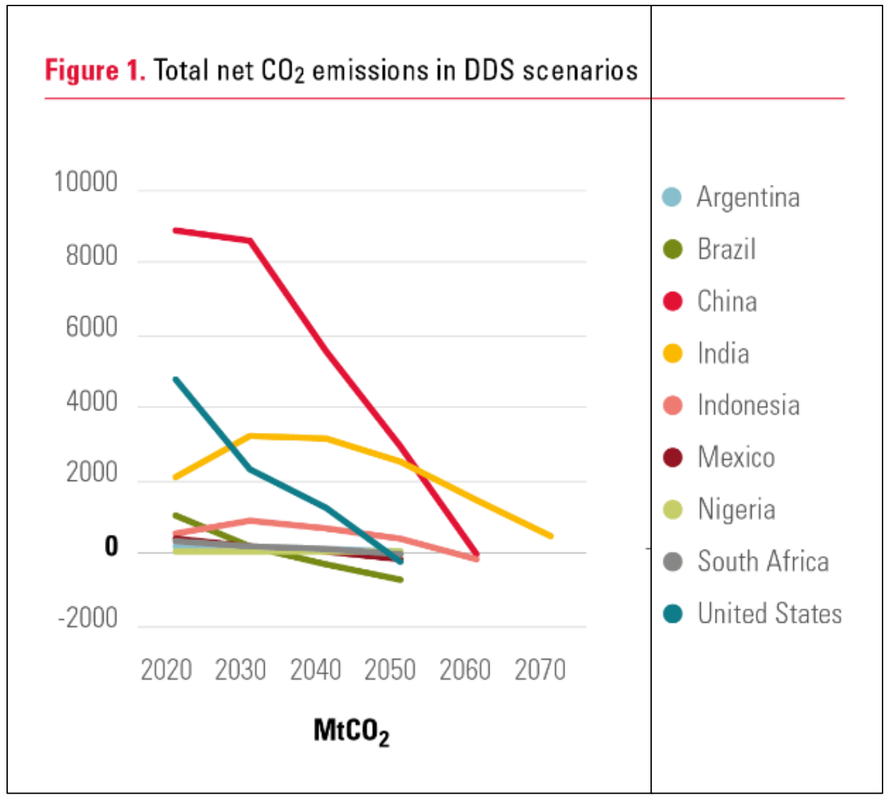
Research teams and modeling tools

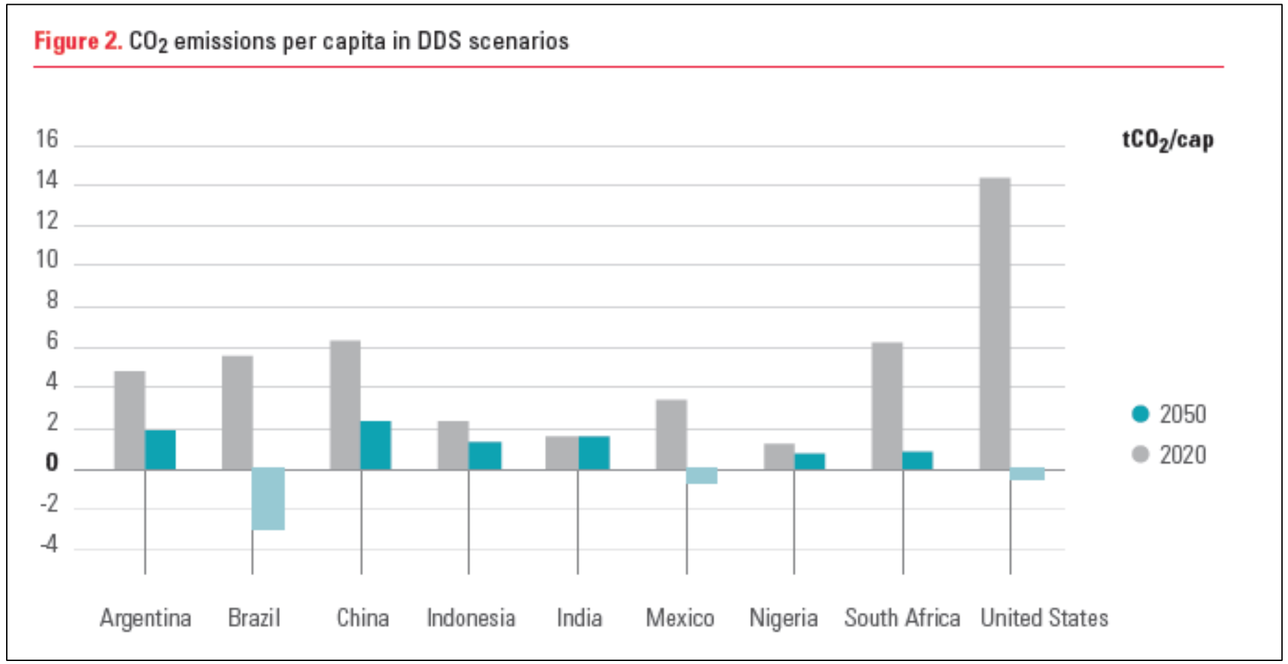
Research partners	Macro-economic modeling	Transport sector modeling
UFRJ	IMACLIM-BR	TEMA
IIMA/IMML	IMACLIM-IND	AIM/Enduse
UCT	SAGE	SATIM

Soft-coupling of a bottom-up sectoral model with a macro-economic and integrated assessment model

Modelling Results - Illustration of key dashboard indicators

Country-driven analysis are important to understand the role of freight compared to other sectors in reaching net-zero





(DDP, 2024). Making it happen: national pathways to net-zero. DDP IDDRI. Paris.
https://ddpinitiative.org/ddp-annual-report-2024/

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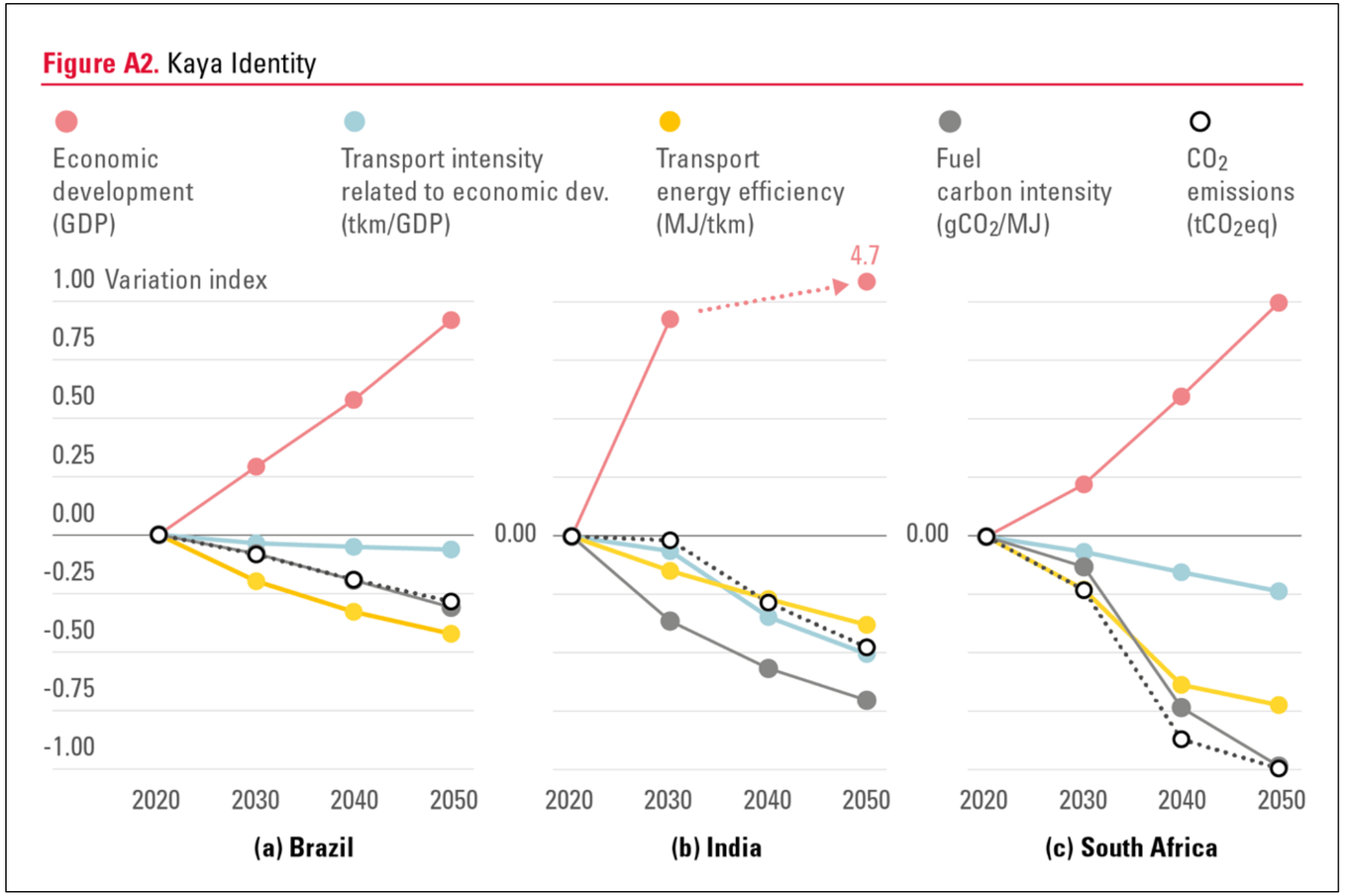
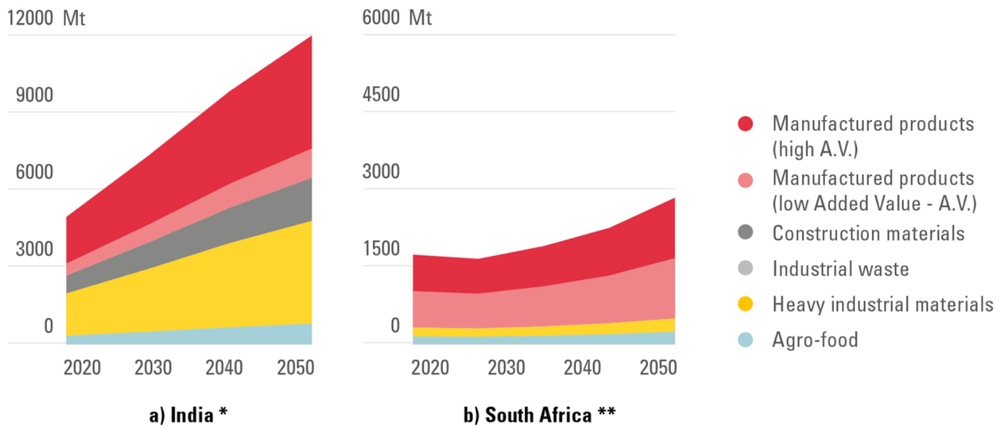


(Briand et al., 2024). A pathway design framework for national freight transport decarbonization strategies, Climate Policy. https://www.tandfonline.com/doi/full/10.1080/14693062.2024.2412709?mi=n22u6n

Examples of energy-demand related indicators: modal shift (and demand management)

Figure A1. India and South Africa - Nature of goods transported (Mt), 2020-2050



*Note: * Industrial waste not available. ** Industrial waste not available. Construction materials not assessed.*

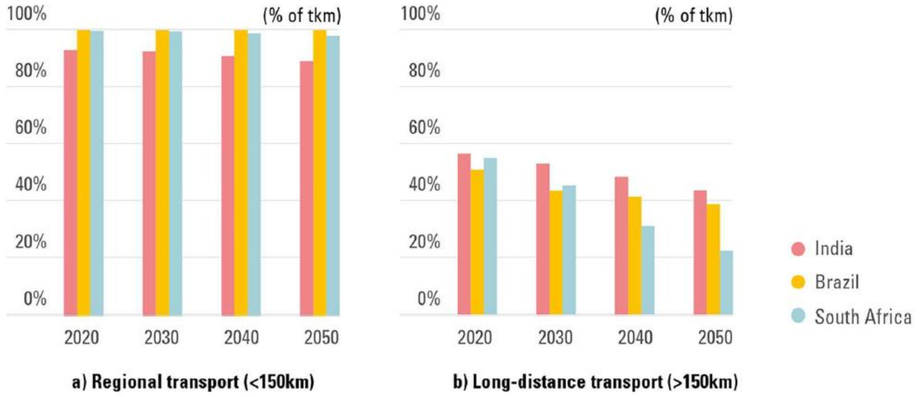


Figure 4. Share of road transport in (a) regional transport and (b) long-distance transport, 2020–2050.

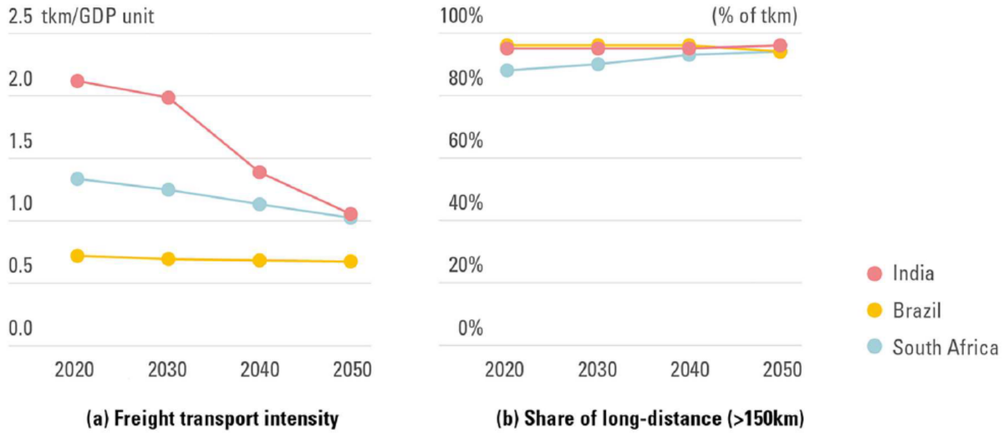


Figure 2. Freight transport intensity (a) and share of long-distance (>150 km) transport demand (b), 2020–2050.

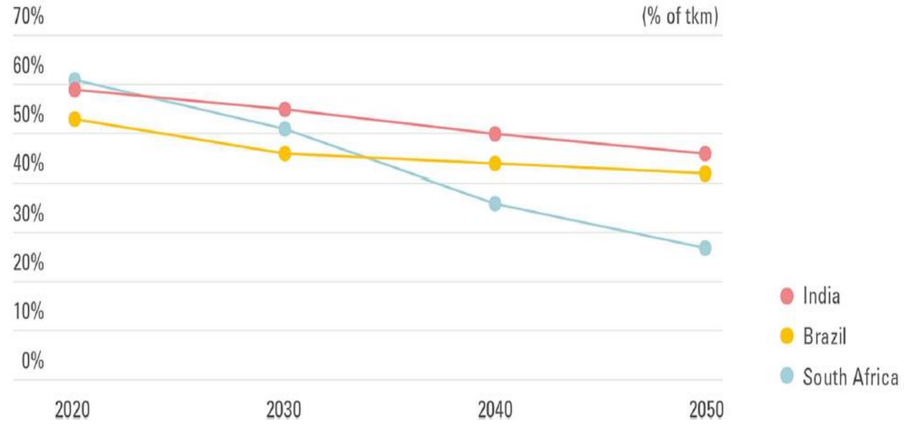


Figure 3. Share of road transport in total transport in total mobility (%tkm), 2020–2050.

Examples of energy supply – related indicators: shift to EVs and biofuels

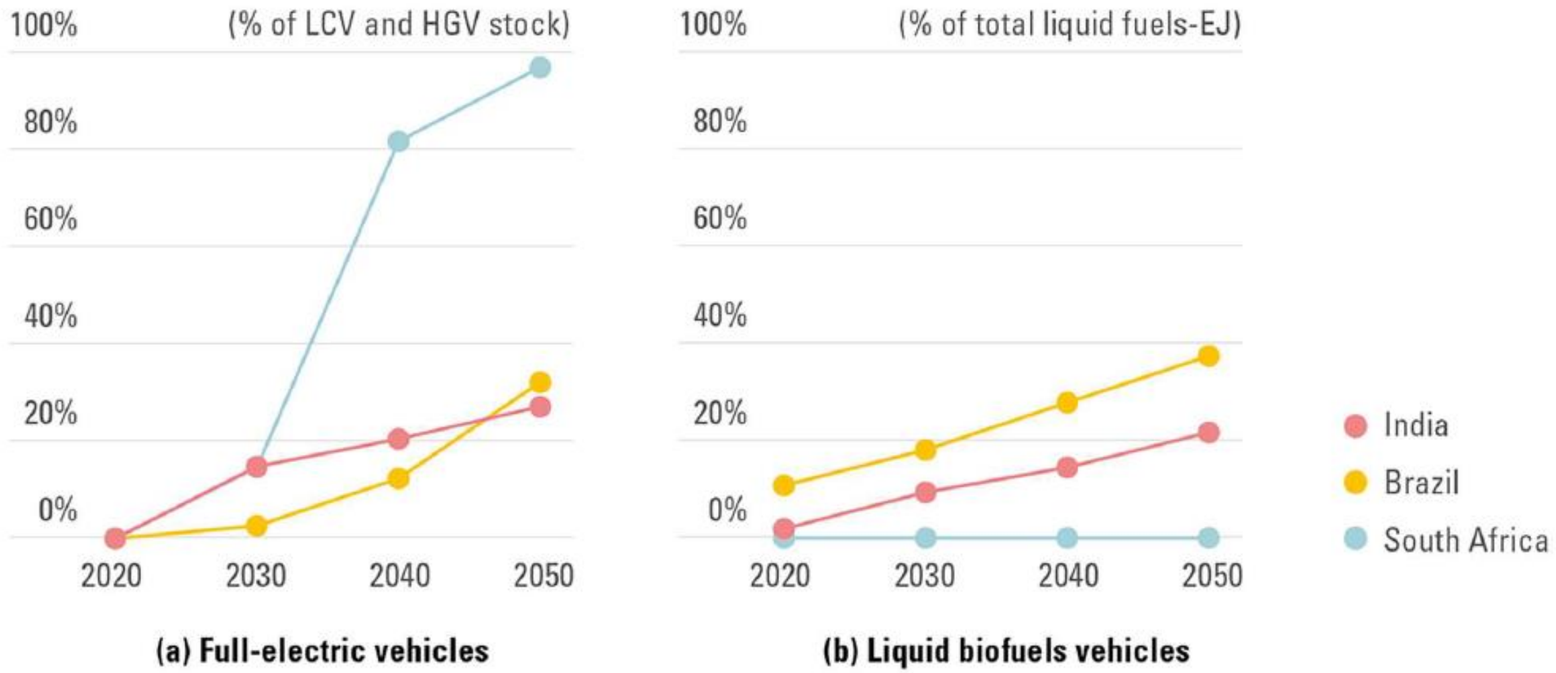


Figure 7. Share of full-electric road freight vehicles stock (a) and liquid biofuels vehicles (b).

Key lessons

About the use of the framework:
- Supported discussions between teams on indicators and conditions
- Helped push energy and climate modelers to go more in depth into some freight-specific questions

About the results:
- Level of freight decarbonization by 2050 from an integrated carbon neutrality perspective in a developing context. National mitigation strategies currently overlook the reduction of national freight transport emissions, so it should become a higher priority in future revisions.
- Role of action levers: Demand, modal shift, load improvement, fuel switch -> Decarbonization requires systemic changes in logistical and industrial organizations consistently linked with the necessary technological changes towards zero-emission vehicles.
- Policy-relevant strategies should be adapted to national development, industrial and logistics contexts

About the consideration of systemic changes:
- Difficulty to assess tons of goods and distance related indicators
- Difficulty to approach the question and represent the effect of consumption/production paradigm changes to reduce tons, to approach changes in supply chain length
- In addition to road hauliers, road vehicle manufacturers and energy providers (usual suspect), national strategies must not forget to drive changes among freight owners and shippers, customers, infrastructure developers and operators, as well as logistics service providers.

Other research

What consequences for national « short-term actions »?

(DDP, 2024). Making it happen: national pathways to net-zero. DDP IDDRI. Paris.
https://ddpinitiative.org/ddp-annual-report-2024/

Main challenge for the sector – how to mobilize actors for longer term emission reductions!

- National emission reductions by 2030-35 are never essentially due to the freight sector and in some countries, freight-related emissions could even increase due to socio-economic development.
- Nevertheless, by the horizon of carbon neutrality, sectoral emission mitigation is critical to reach net-zero.

So, this does not mean that no short-term actions should be implemented!

Short-term actions targeting (1) short-term impact are necessary to manage/moderate emissions in the short-term

(1) Measures related to driving conditions, to electrifying light duty vehicle fleets in urban freight, to off peak delivery time priorities… can deliver short-term impact on emission, **while avoiding future lock-ins** (like for example measures supporting the development of natural gas-based network and vehicles)

Short-term actions targeting (2) long-term impact are critical.

(2) Measures tackling the sources of inertias related to the infrastructure planning and investment, governance and institutional organization and changing lifestyles and behaviors (see previous slide). They are needed now to lay the foundation for deeper emission reduction by 2050

The drivers of non-technological/organisational changes are often characterized by significant inertia and resistance to change

Table 1. Four organizational shifts and related examples of enabling conditions

Organizational shifts	Enabling conditions	Country examples
Producing and consuming sustainably	• New governance to allow cross-cutting measures between energy, transport, and industrial systems • Consumer information about repairability and product lifetimes • Involvement of large private industries to allow effective policies on logistics	France
Producing goods closer to consumers	• Adapted production tax;	Brazil
Developing more and better railway infrastructure, integrated into the logistics organizations	• Shifting road infrastructure finance to rail infrastructure • Multimodal logistics reforms to standardize transport regulations across national regions • Rail governance reforms centralizing infrastructure planning decisions and opening infrastructure finance to private and foreign investors • Involving large private industries to allow effective policies on logistics • Involving indigenous peoples to allow appropriation and adapted infrastructure development	India Nigeria
Reinforcing the competitiveness of rail services in terms of costs, time and quality compared to road services	• Revised road taxation systems; • Rail governance reforms opening access to railway infrastructure to private rail freight service operators	Brazil South Africa

(DDP, 2023). ***Innovative International Cooperation for Climate : Reconciling urgent action and transformational change*****. DDP IDDRI. Paris.**
https://ddpinitiative.org/ddp-annual-report-2023/

What role for international cooperation?

Table 2. Four organizational shifts and related examples of cooperation tools

Organizational shifts	Experience sharing on policies	Technical assistance	Financing	Trade requirements
Producing and consuming sustainably	• producer responsibility for the longevity and repairability of products, • consumer information	• planning and adaptation of sustainable production processes	• more sustainable industrial manufacturing processes	• repairability, longevity and recyclability of products
Producing goods closer to consumers	• local sourcing mandates, • tax incentives based on local content of products	*	• industries enabling local supply of semi-finished goods and alternative raw materials	• local content of production • social and economic conditions for workers to favour social development • taxes on production to avoid fiscal competition
Developing more and better railway infrastructure, integrated into the logistics organizations	• planning and public consensus	*	• rail, multimodal and logistics infrastructures	• regional rail interconnection and interoperability associated to regional trade
Reinforcing the competitiveness of rail services in terms of costs, time and quality compared to road services	• rail privatization and concessioning	• rail operations and system optimization	*	• technology transfer of innovative technologies reducing operation time and costs

*Blank squares are not an indication that relevant tools do not exist, just that no example has been provided.

(DDP, 2023). *Innovative International Cooperation for Climate : Reconciling urgent action and transformational change*. DDP IDDRI. Paris. https://ddpinitiative.org/ddp-annual-report-2023/

Under which conditions, international cooperation tools could support such changes?

KNOWLEDGE SHARING ON POLICIES

- structured around industrial organization
- allow entering into country-specific details of possible solutions, by opposition to skimming at the surface

FINANCE

- analyse infrastructure changes in the industrial and transport sectors
- discuss country-specific and infrastructure-specific financing barriers and solutions, by opposition to an overall perspective of financing flows

TECHNICAL ASSISTANCE

- focused on technical gaps for national organizational changes
- demand-driven, by opposition to being triggered by technical assistance offers

TRADE

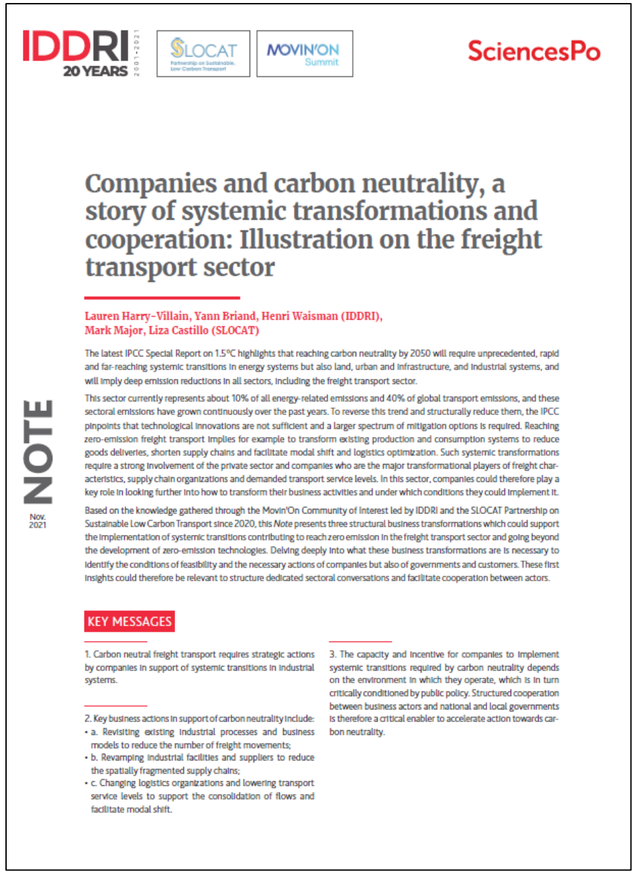
- consider the impact on freight transport emissions
- discuss requirements to ensure a development of regional, continental and sustainable industrial value chains, and associated logistics

The role of shippers in shaping new production and consumption patterns

1. Carbon neutral freight transport requires strategic actions by companies in support of systemic transitions in industrial systems.

2. Key business actions in support of carbon neutrality include:
   a. Revisiting existing industrial processes and business models to reduce the number of freight movements;
   b. Revamping industrial facilities and suppliers to reduce the spatially fragmented supply chains;
   c. Changing logistics organizations and lowering transport service levels to support the consolidation of flows and facilitate modal shift.

3. The capacity and incentive for companies to implement systemic transitions required by carbon neutrality depends on the environment in which they operate, which is in turn critically conditioned by public policy. Structured cooperation between business actors and national and local governments is therefore a critical enabler to accelerate action towards carbon neutrality.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NOTE
Nov. 2021

Companies and carbon neutrality, a story of systemic transformations and cooperation: Illustration on the freight transport sector

Lauren Harry-Villain, Yann Briand, Henri Waisman (IDDRI), Mark Major, Liza Castillo (SLOCAT)

The latest IPCC Special Report on 1.5°C highlights that reaching carbon neutrality by 2050 will require unprecedented, rapid and far-reaching systemic transitions in energy systems but also land, urban and infrastructure, and industrial systems, and will imply deep emission reductions in all sectors, including the freight transport sector.

This sector currently represents about 10% of all energy-related emissions and 40% of global transport emissions, and these sectoral emissions have grown continuously over the past years. To reverse this trend and structurally reduce them, the IPCC pinpoints that technological innovations are not sufficient and a larger spectrum of mitigation options is required. Reaching zero-emission freight transport implies for example to transform existing production and consumption systems to reduce goods deliveries, shorten supply chains and facilitate modal shift and logistics optimization. Such systemic transformations require a strong involvement of the private sector and companies who are the major transformational players of freight characteristics, supply chain organizations and demanded transport service levels. In this sector, companies could therefore play a key role in looking further into how to transform their business activities and under which conditions they could implement it.

Based on the knowledge gathered through the Movin'On Community of Interest led by IDDRI and the SLOCAT Partnership on Sustainable Low Carbon Transport since 2020, this Note presents three structural business transformations which could support the implementation of systemic transitions contributing to reach zero emission in the freight transport sector and going beyond the development of zero-emission technologies. Delving deeply into what these business transformations are is necessary to identify the conditions of feasibility and the necessary actions of companies but also of governments and customers. These first insights could therefore be relevant to structure dedicated sectoral conversations and facilitate cooperation between actors.

KEY MESSAGES

1. Carbon neutral freight transport requires strategic actions by companies in support of systemic transitions in industrial systems.

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(IDDRI, 2021). Companies and carbon neutrality, a story of systemic transformations and cooperation: illustration on the freight transport sector
https://www.iddri.org/sites/default/files/PDF/Publications/Catalogue%20Iddri/Autre%20Publication/202111-Note%20transport.pdf

2021-24 work with dedicated research on freight

DEEP DECARBONIZATION PATHWAYS

CLIMATE AMBITION
BEYOND EMISSION NUMBERS

Taking stock of progress by looking inside countries and sectors

DDP ANNUAL REPORT 2023

Innovative International Cooperation for Climate

Reconciling urgent action and transformational change

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Thank you!

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