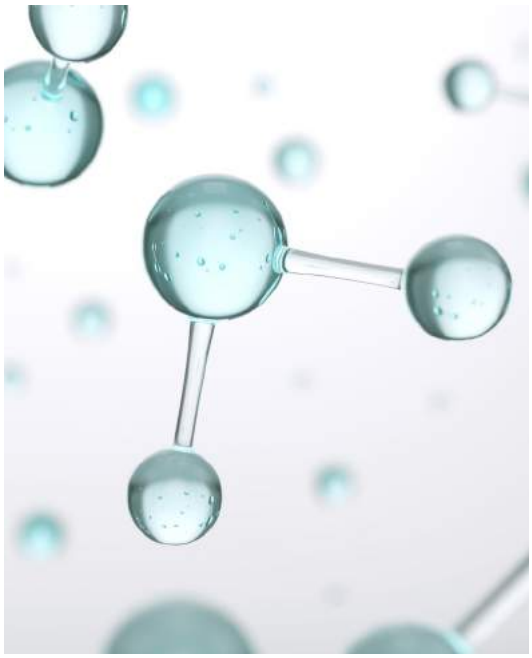
Decarbonising transport by 2050

A TDA manifesto on how to reach net zero emission mobility through uniting Countries, Cities / Regions and Companies

December 2018

TRANSPORT DECARBONISATION ALLIANCE


5G
NETWORK



Executive summary

Getting to net zero GHG emissions in the transport sector by 2050, as part of the global strategy to fight the global warming plague, requires strong and rapid action. This manifesto crafted by TDA is intended to serve as a call to action for Countries, Cities/Regions and Companies (the 3Cs) to join hands and kickstart the decarbonisation of the transport sector. The document proposes feasible solutions that the 3Cs can adopt to reach their objective. It seeks to act as the living backbone of TDA's action. It will be enriched further, progressively, in the months and years to come.

Levers and solutions to reach net zero emission-mobility

The document identifies solutions and levers to reach net zero emission-mobility by 2050, and showcases best practices that can foster the adoption of the right combinations of solutions through collaborative approaches. Such best practices rely on:

4 strategic imperatives for reaching GHG-neutral mobility, guiding all actions synergistically and leveraging ASI (avoid-shift-improve) initiatives:

Imperative 1 Move away from oil and other fossil fuels to focus on very-low-GHG energy
Imperative 2 Lower the energy intensity of our mobility patterns (global economy & individual lifestyles)
Imperative 3 Prepare the physical and IT infrastructure needed to accompany those changes
Imperative 4 Inform, educate and train populations to embrace the transformation

12 pillars of transformation to activate levers in synergy and create favourable economic, technical and social conditions for the transition:

Collaborating to create an enabling framework

1. Adapt economic rules to transformation
2. Accelerate energy mix transformation
3. Harmonise regulations related to charging or filling, and to emission standards
4. Develop new mobility and energy curricula in universities, with associated R&D and workforce training

Collaborating to organise territories and change behaviours

5. Position Cities/Regions at the forefront of transformation implementation
6. Upgrade services of mass transit and promote its use
7. Catalyse movement towards long-distance nonmotorised mobility (inter, intracity and regional)
8. Develop decentralised mobility and decentralised energy systems simultaneously

Collaborating to foster change and innovation as an impulse for GHG reduction

9. Innovate beyond state-of-the-art, and rapidly deploy innovation in mobility services and infrastructure
10. Impulse movement towards multimodal solutions for freight
11. Rely on digital tools to create shorter and smarter supply chains
12. Reorganise commuting habits

Proposed framework for the 3Cs to work together

The manifesto also proposes a framework for the 3Cs to create and maintain an unprecedented level of coordination, and enable large scale initiatives. This framework is built around:

4 enabling prerequisites that represent the actions and attitudes necessary to act quickly and overcome existing or future roadblocks, bearing in mind that getting there is no easy task:

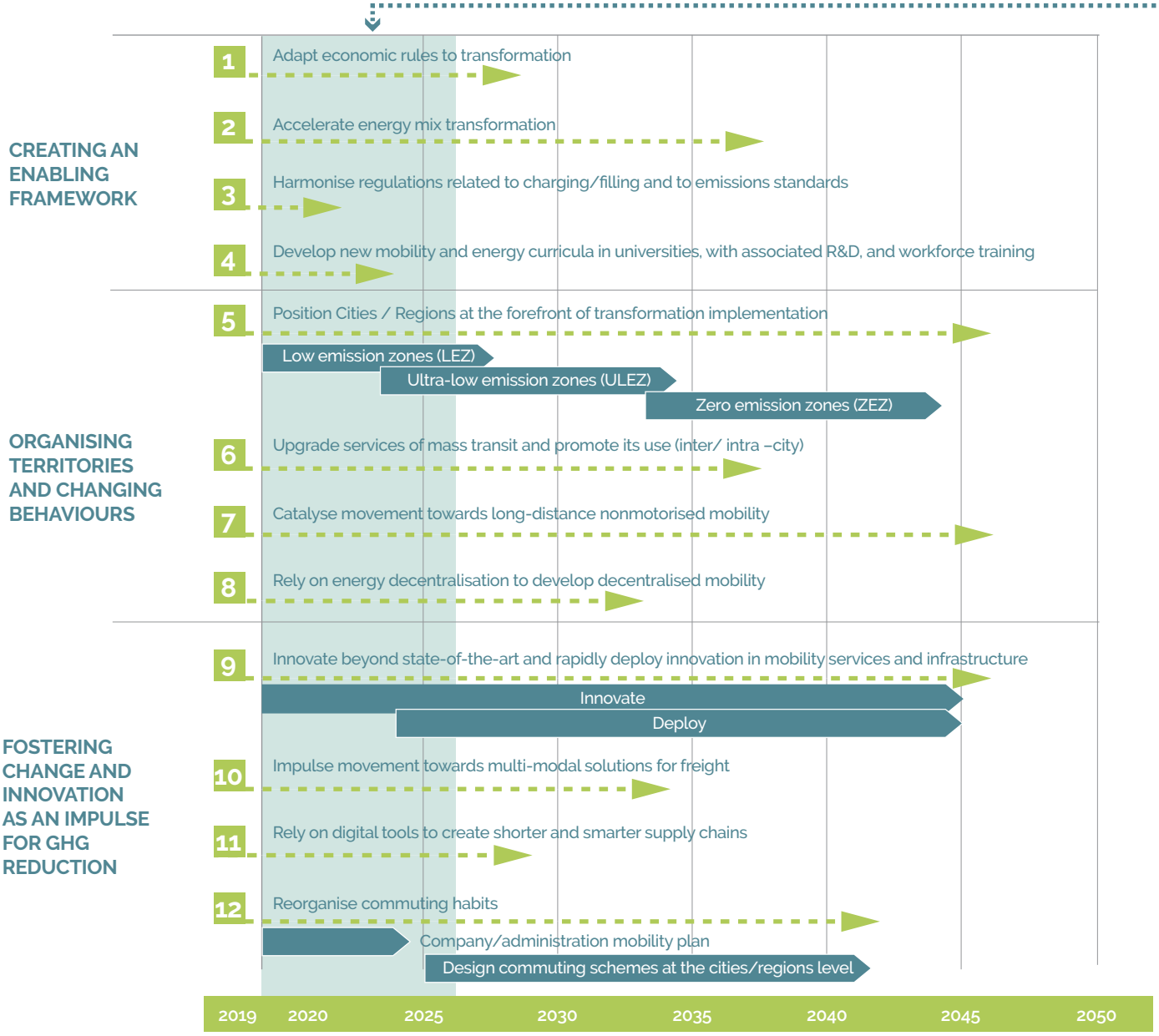
Prerequisite 1 Anticipate shifting effects
Prerequisite 2 Avoid inflexible approaches and make informed decisions
Prerequisite 3 Challenge all arguments for postponement
Prerequisite 4 Adapt the fiscal and regulatory environment to foster transformational investment

A five-step process to impulse change irreversibly, at the 3Cs level:

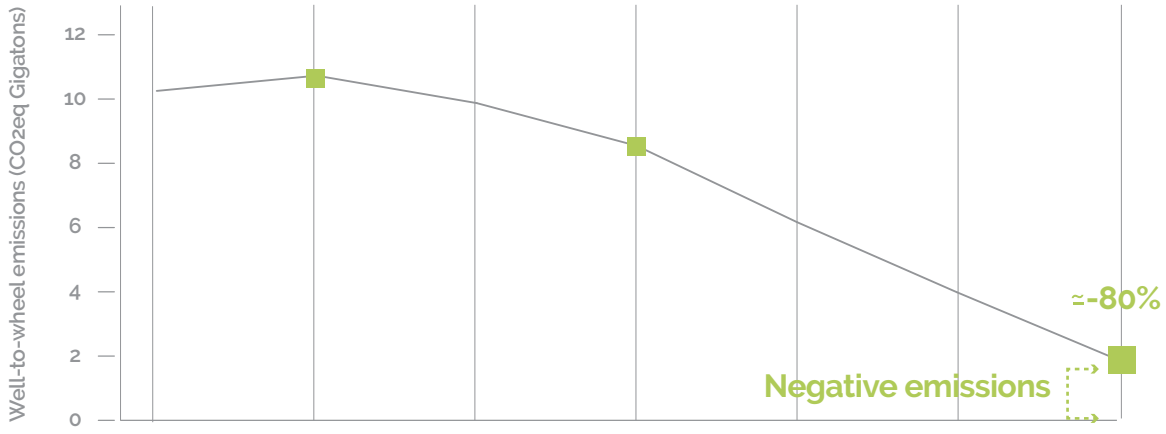
Step 1 Establish a firm "net zero emission-mobility" target involving all stakeholders in a spirit of irreversible commitment
Step 2 Develop 3C governance at the different scales to steer and monitor the transformation
Step 3 Spread homogeneous, effective tools to orchestrate the transition at the local, national and international levels
Step 4 Open up pro-business initiatives to foster new services and new products
Step 5 Promote international efforts to speed up the transition globally

This approach to fast-track action in time for 2050 is summarised below:

Iconic measures to reach net zero emission mobility by 2050

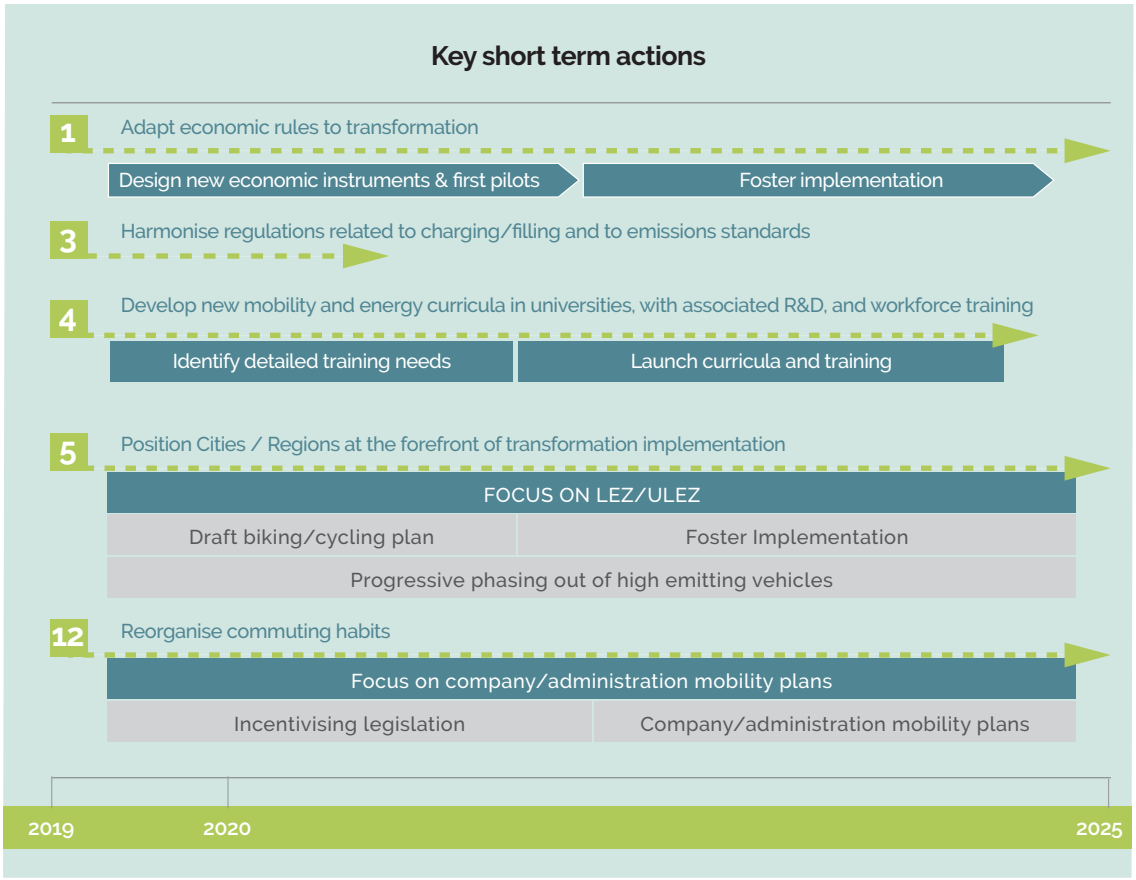


Aspirational track to reach net zero emission mobility by 2050*

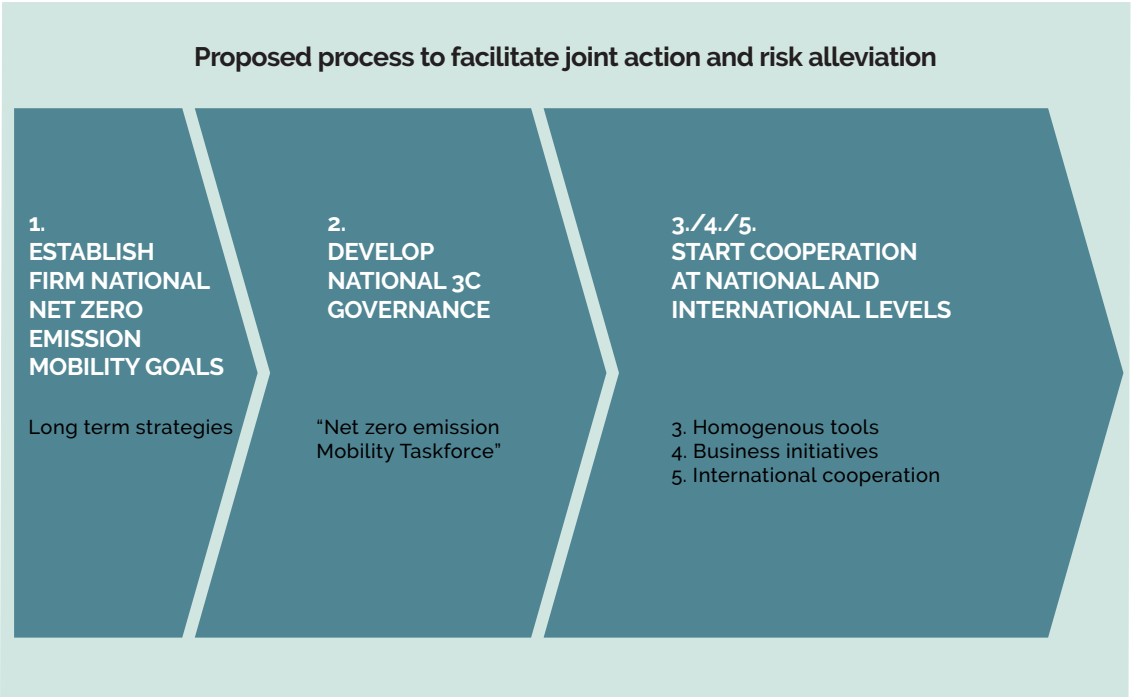


* This track represents an aspirational scenario to reach net zero emission mobility by 2050, taking into account the feasibility of the transformation, and the fact that negative emissions will be needed in addition to strong mitigation efforts. The trajectory reflects a probable increase of emissions until 2025, followed by a first decrease between 2025 and 2035, and a sharper decrease between 2035 and 2050, as more and more solutions become available and scalable. Approximately 20% of today's emissions will have to be compensated by negative emissions, close to the IEA scenarios that estimate that around 15% of the effort will rely on negative emissions.

Jump-starting the transition: **focus** on unmissable steps by 2025



NB: These unmissable steps by 2025 focus on how to reduce absolute emissions. As developed in the manifesto, complementary actions need to be taken regarding negative emissions in order to reach net zero emission mobility, and resilient infrastructure and mobility systems have to be developed concomitantly.



Foreword

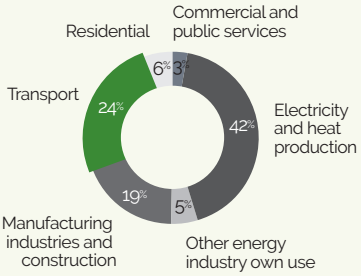
As the latest report of the Intergovernmental Panel on Climate Change (IPCC) clearly shows, time is of the essence: we should not only get to net zero Greenhouse Gas (GHG) emission to limit global warming below 1.5˚C or 2˚C, but also need to get there fast.

Achieving a resilient "net-zero-emission (NZE) economy" by 2050 requires us to collectively and successfully transform global mobility in a systemic manner over the next decades.

Current state of play and 2050 scenarios: The transport sector is a key player in achieving the <2˚C target

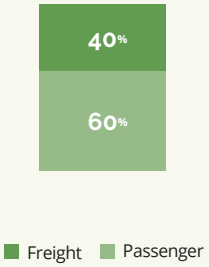
With 24% of the emissions stemming from fuel combustion worldwide, transport is a vital part of the solution to solve the puzzle of a net zero emission-economy. The distribution of final energy consumption between passenger mobility and freight is roughly 60-40%. Due to both their important share of passenger.km and ton.km and to their high carbon intensity, heavy and light road are the biggest contributing modes followed by air and shipping.

Global: Total CO_2 emissions from fuel combustion ($GtCO_2$)*



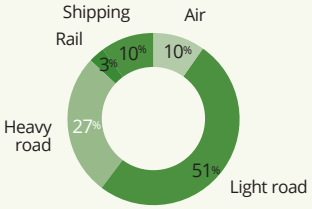
Total emissions (fuel combustion) : **32.3Gt** of which **7.9Gt** due to transport

Split between freight and passenger mobility**
(final energy consumption)



Freight Passenger

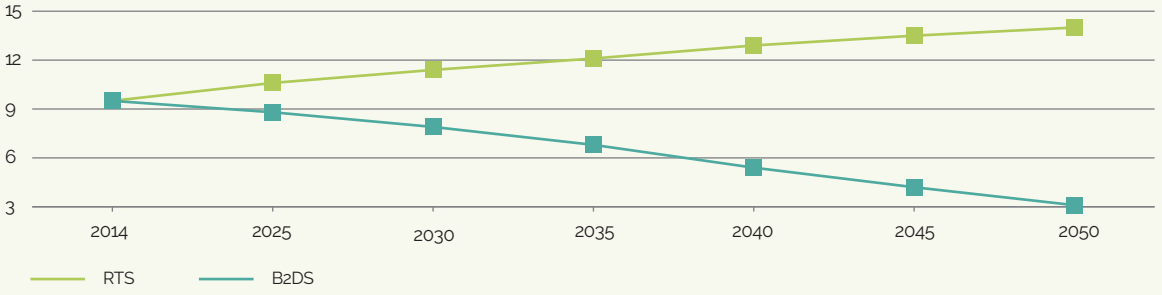
Well-to-wheel emissions by mode ($GtCO_2$)**



Total emissions due to transport : (well to whell) **9.5Gt**

Trends based on the engagements of countries to date in the Reference Technology Scenario (RTS) differ largely from the Below 2˚C scenarios (B2DS). This calls for strong and quick action on transport emissions. In the run-up to COP21, parties submitted their Nationally Determined Contributions (NDCs), specifying their national ambition to decarbonise their economy. More than 75% of the NDCs identify transport as a priority sector to mitigate national emissions. The measures proposed in NDCs are however deemed insufficient to achieve the "well below 2˚C" target.

2050 trajectory of well-to-wheel emissions ($GtCO_2$ eq): comparison of the Reference Technology Scenario (RTS) taking into account today's commitments and a Beyond 2˚C Scenario (B2DS)**



* Sources total emissions: IEA, CO2 emissions from fuel combustion 2018 -2016 data.

** Sources: IEA, Energy Technology Perspectives 2017 – 2014 data.
The difference between well-to-wheel emissions and fuel combustion emissions is explained by various factors including for instance the carbon impact of oil extraction.

With transport emissions set to possibly increase by around 50% between now and 2050 (RTS Scenario), while they should decrease by over two thirds in a below 2°C scenario, rapid and transformational action is needed, as well as strong coordination. To succeed in this epic endeavour, Countries, Cities/Regions and Companies have a unique role to play within a wider ecosystem comprising a diversity of actors such as citizens, international organisations and Non-Governmental Organisations (NGOs), as they are in a key position to ensure that international commitments get translated into concrete actions.

For this, it is critical that:

- Pioneering international companies, together with cities/regions spearhead the decarbonisation in the world, creating a network of front-runners and virally spreading good practices through their stakeholders
- Pioneering countries decide to be the early adopters of a fully decarbonised (net zero emission) economy, thus showing:
  - What it takes to conduct a full national strategy in connection with the private sector, sub-national governments and society as a whole in all domains of human activity
  - What existing tools and experiences can already be used to inform the definition of such strategies
  - What benefits can be derived from the transformation.

The Transport Decarbonisation Alliance (TDA) members have committed to implement decarbonisation (NZE) of transport by 2050, an objective recently endorsed also by the European Commission. This requires that in the next 30 years or so after the Paris Agreement has entered into force (4 November, 2016), they need to bring in and adhere to stringent and systematic transformational changes. This also requires working in radically innovative ways to go beyond existing strategies and, to start with, commit to more audacious NDCs in the Paris Climate Agreement process.

The resolve to win the climate change challenge and the conviction that this positive move is technologically feasible and will prove economically viable, with premiums benefiting both the planet and the front-runners, make decarbonisation of the transport sector the top agenda item for the TDA members.

This document is a unique co-creation by pioneer Countries, Cities/Regions and Companies. It is also a call addressed to all others seeking to tackle to the biggest challenge faced by transport in the 21st century. It aims at showing that concrete actions can lead to reaching GHG-neutrality and how the 3Cs can act together to scale up the transformations, with the support of existing initiatives and using common tools.

Arriving at GHG-neutrality in the transport sector calls for Countries, Cities/Regions and Companies working together, conscious that only the strongest coherence between the strategies of the 3Cs will secure ambitious NDCs on transport at the start and a resounding success at the end of the next three decades.

The clock is ticking.

José Mendes

TDA Chairman and Vice-Minister
for Mobility of Portugal

Patrick Oliva

Co-founder, Paris Process
for Mobility and Climate

Glossary

ADEME	Agence de l'Environnement et de la Maîtrise de l'Énergie - French Environment and Energy Management Agency
B2DS	Below 2°C Scenario
CDP	Carbon Disclosure Project
CDR	Carbon-dioxide removal
CO2eq	Equivalent carbon dioxide *(for any quantity and type of greenhouse gas, it signifies the amount of carbon dioxide (CO2) which would have the equivalent global warming impact. E.g. if 1kg of methane is emitted, this can be expressed as 25kg of CO2eq).*
COP	Conference of the Parties of the UNFCCC
EU	European Union
EV	Electric Vehicle
GHG	Greenhouse gases
ICAO	International Civil Aviation Organisation
ICE	Internal combustion engine
IDDRI	Institute for Sustainable Development and International Relations
IPCC	Intergovernmental Panel on Climate Change
IMO	International Maritime Organisation
IoT	Internet of Things
ITF	International Transport Forum
ITS	Intelligent transportation systems
LEZ	Low emission zone
NDC	Nationally Determined Contributions
NGO	Nongovernmental organisation
NZE	Net zero emission
NUMP	National Urban Mobility Policy
OCA	Open Charge Alliance
OCPP	Open Charge Point Protocol
OSCP	Open Smart Charging Protocol
PMD	Personal mobility devices
PPMC	Paris Process on Mobility and Climate
R&D	Research and development
RTS	Reference Technology Scenario.This IEA scenario takes into account today's commitments by countries to limit emissions and improve energy efficiency, including the NDCs pledged under the Paris Agreement
SBT	Science-based targets
SLoCaT	Partnership on Sustainable Low Carbon Transport
SUMP	Sustainable Urban Mobility Plan
TDA	Transport Decarbonisation Alliance
ULEZ	Ultra-low emission zone
UNFCCC	United nations framework convention on climate change
UNGC	United Nations Global Compact
VAT	Value Added Tax
WBCSD	World Business Council for Sustainable Development
WRI	World Resources Institute
WTO	World Trade Organisation
WWF	World Wildlife Fund
ZEZ	Zero emission zone

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NOTE TO THE READERS

The recommendations on possible actions and methods for getting to net zero emission-mobility provided in this document are the result of a process of collective discussions and reflections facilitated through the TDA. The recommendations are not binding and have not been endorsed individually by supporters of, or partners in the TDA. They result from a collaborative work that is still on-going, and might be adjusted and further enriched.

Solutions exist, others have to be enhanced - their implementation relies on strengthened collaboration between the 3Cs

Key levers for transport decarbonisation are the subject of numerous works identifying them and assessing their potential[1]. It is now urgent to go beyond scattered initiatives and to allow for the massification of solutions. For that, the 3Cs need to focus collectively on fundamental priorities. Transforming our mobility systems in a radical way is achievable, provided an unprecedented level of coordination is put in place.

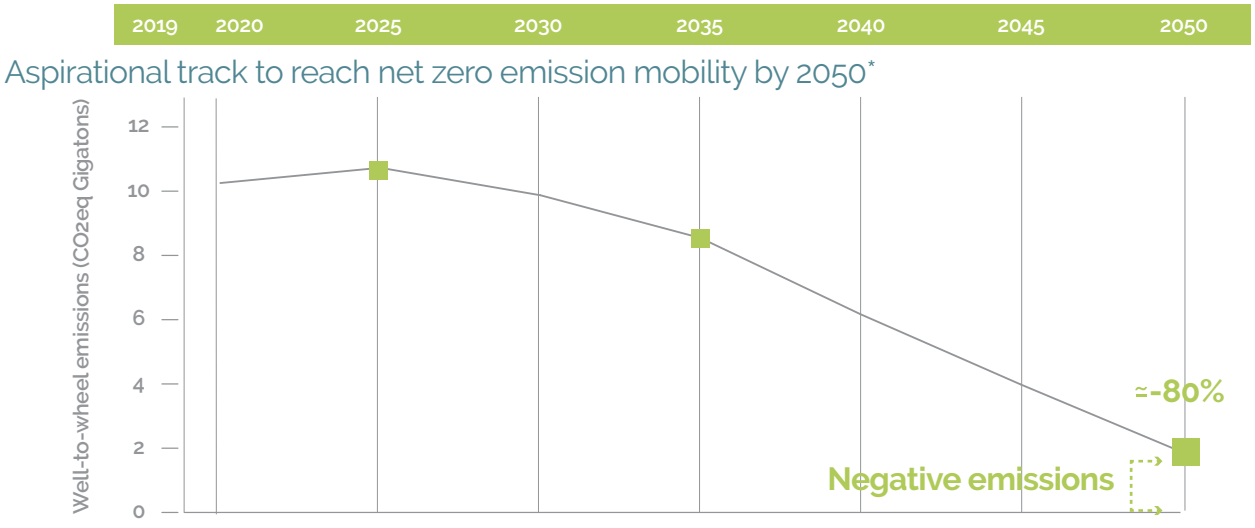
Creating synergy among the key levers identified by all actors through **four strategic imperatives**

Many solutions and techniques to reach a Greenhouse Gas (GHG) neutral transport sector by 2050 are identified, even if research is still ongoing and knowledge is constantly evolving. This manifesto aims **at showing the way for driving current knowledge into action, without delay, while continuing to improve collective know-how and advance research**. It extracts the very essence of what needs to be done to catalyse Avoid-Shift-Improve actions and create optimum synergism among them.

Four strategic imperatives for reaching GHG-neutral mobility by accelerating and catalysing the avoid-shift-improve levers **stand out:**

- Imperative 1 - Move away from oil and other fossil fuels to focus on very-low-GHG-content energy
- Imperative 2 - Lower the energy intensity of our mobility patterns (global economy & individual lifestyles)
- Imperative 3 - Prepare the physical and IT infrastructure needed to accompany those changes
- Imperative 4 - Inform, educate and train populations to embrace the transformation

The text below and the appendix illustrate key facets of actions and technologies to be promoted. It is important to note that while some solutions already exist, many are still to be developed or improved in order to reach the goal of net zero emission-transport. A comprehensive list of solutions is presented in the appendix. This list will be enriched as more knowledge becomes available.



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Strategic imperative 1

Move away from oil and other fossil fuels to focus on very-low-GHG-content energies

Avoid locking in alternatives with limited or unconfirmed GHG benefits

With a little more than 30 years to reach the net zero emission objective, there is a high risk that "transitory" solutions — with only limited GHG emissions benefits — might eventually do more harm than good by delaying the implementation of the more effective solutions. This would, for example, be the case for the massive replacement of oil derivatives by natural gas in internal combustion engines (ICEs), advocated by some, to save a mere <15% CO2 emissions only[2]. Switching from oil to gas can take years, if not decades, of investments, at the expense of the development of more effective solutions and should not be done without careful anticipation (or be limited to sub-sectors where no better solution is within reach). Cost-benefit analysis, taking all the impacts into account, will be critical to avoid such potential dead-ends.

Shift to radically lower emitting energies

Transport is the least diversified energy end-use sector, relying almost exclusively on oil. Shifting to radically lower emitting alternative energies, including, in particular, low-GHG electricity, electrolysis-produced hydrogen, second and third generation biofuels and sustainable synthetic fuels, is key. The precise GHG impact of a massive shift to electric mobility is directly linked to the evolution of the electricity mix. In any event, this shift is one of the levers with the highest impact and seems unavoidable in all existing <2C° scenarios. Emission standards as well as economic incentives (such as bonus-malus systems, GHG pricing or fiscal incentives) will be essential to drive this change.

An overwhelming reliance on oil:

- Transport represent **65%** of the global oil final demand
- Oil represents **92%** of the transport final energy demand

Source : International Energy Agency, Energy Technology Perspectives 2017

Improve alternative low-carbon energies

Current technologies are not up to the level of GHG efficiency needed to reach the objective, at a competitive cost. This is why research and development (R&D) is necessary to overcome current limits in reducing the GHG intensity of electricity, improving battery efficiency, recyclability and cost, increasing fuel cell yield, and lowering clean hydrogen cost.

Strategic imperative 2

Lower the energy intensity of our mobility patterns (global economy and individual lifestyles)

Avoid unnecessary motorised trips and foster active mobility, mass transit and shared mobility (demand management)

A conscious decision to avoid motorised trips to the extent possible can go a long way in reducing energy consumption in our daily life. In order to reduce the energy intensity of our lifestyle, unnecessary motorised trips should be avoided. Key examples of actions include i) reducing unnecessary trips for people, by limiting urban sprawl and encouraging teleworking; ii) empowering public transport, active modes and shared services, for instance; iii) and also for freight, by de-fragmenting and shortening supply, and production and distribution chains. Public and private actors should promote, whenever possible, nonmotorised trips (e.g. cycling, walking and sailing).

Shift to lower energy-consuming motorised modes

Another option is to switch to transport modes that use less energy. Key examples include shifting logistics from high energy intensity modes such as air or road travel, to lower intensity modes such as rail and boat, whenever possible. Similarly, for the transport of people, mass transit systems are typically more energy-efficient than individual transport modes. Such switches often entail wide-scale changes in the infrastructure of Cities/Regions and Countries, and come at a high upfront cost. However, their impact is significant in terms of curtailing emissions.

Improve the energy-efficiency of all transport modes and vehicles

Additional energy benefits will come from the systematic technical upgrading of transport modes. In all sectors, including cars and heavy-duty trucks, lower energy-consuming vehicles (lighter, possibly with less power, sometimes slower) should be developed, leveraging dedicated R&D. While ICEs will never reach the energy performance of electricity-powered vehicles, their performance could and should, nevertheless, be rapidly improved.

Note: These four "strategic imperatives" aim at reducing absolute emissions. As detailed on page 19, complementary actions need to be taken regarding negative emissions in order to reach net zero emission-transport. Resilient infrastructure and mobility systems will also contribute to making this strategy effective.

Strategic imperative 3

Prepare the physical and IT infrastructure needed to accompany those changes

Infrastructure development is fundamental to achieving zero emission-mobility by 2050. Key examples include a timely development of infrastructures for electric vehicles (EVs) (electric charging and hydrogen refilling networks) associated with matching distribution grids for e-mobility to grow at the speed needed. Similarly, important investments in physical infrastructure are required to support the development of hydrogen mobility, biogas, and alternative sustainable liquid fuels.

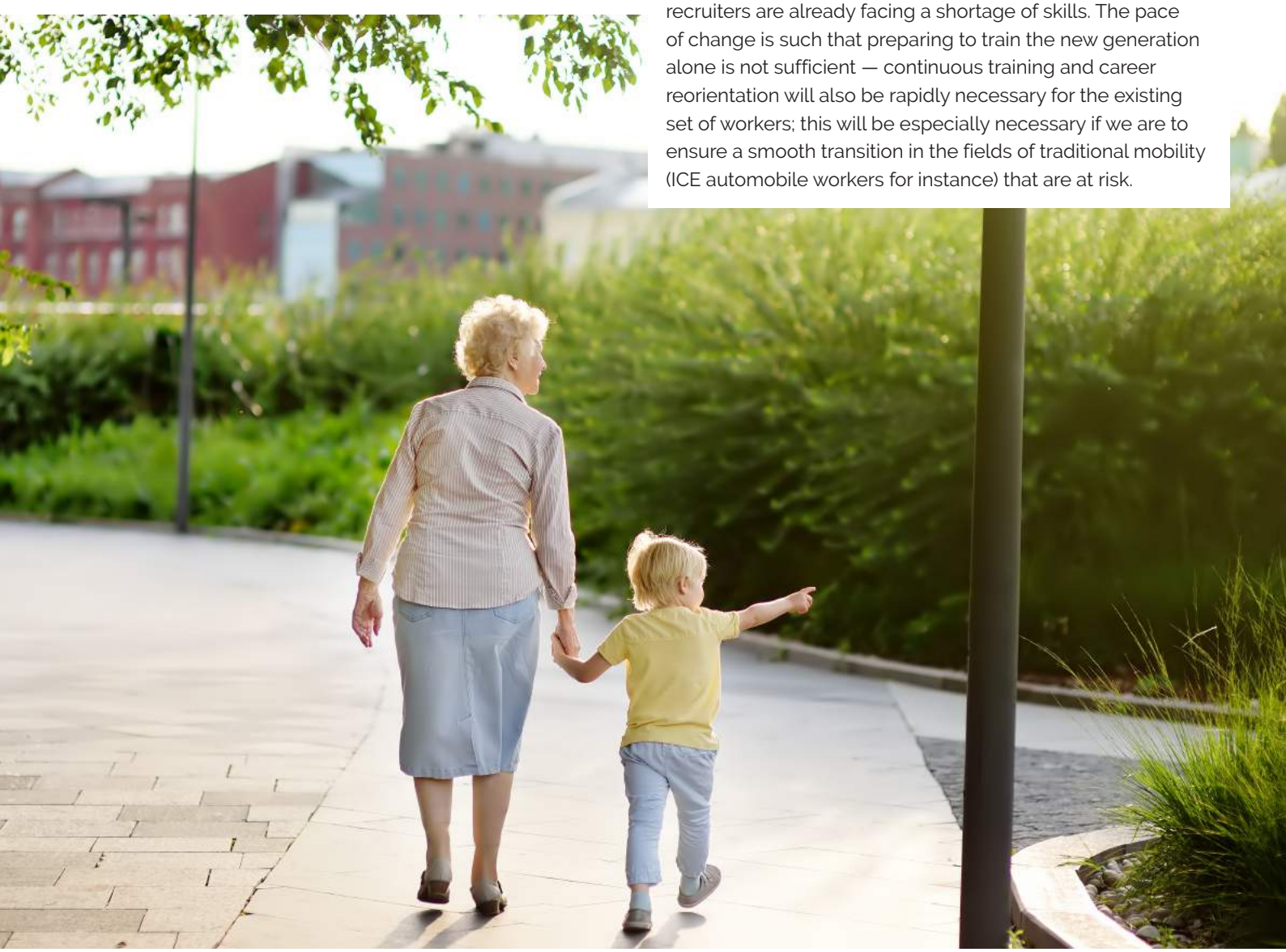
The development of an adequate IT infrastructure, including 5G services, Internet of Things (IoT) and secured sharing of mobility data, is also a strong lever to support intelligent transportation systems (ITS) and unlock a reduction in GHG emissions.

Strategic imperative 4

Inform, educate and train populations to embrace the transformation

The many behavioural changes induced by the transition (limiting trips when needed, shifting to other transport modes, switching from decades-old technologies to emerging ones, coordinating new actors, etc.) will require an almost complete change of mind-set for all. Strong communication will, therefore, be needed.

Beyond behavioural aspects, the shift in paradigm will generate radical economic and social change, and needs to be reflected in academic curricula. In order to build an entire economic sector dedicated to low GHG and sustainable mobility, and invent the necessary technological breakthroughs, new training programs have to be designed for both existing and future generations. In some cases, recruiters are already facing a shortage of skills. The pace of change is such that preparing to train the new generation alone is not sufficient — continuous training and career reorientation will also be rapidly necessary for the existing set of workers; this will be especially necessary if we are to ensure a smooth transition in the fields of traditional mobility (ICE automobile workers for instance) that are at risk.



Collaboration among the 3Cs on **twelve pillars of transformation** to set levers in motion

The TDA identifies major areas where strong collaboration between Countries, Cities/Regions and Companies is highly desirable, even essential, to translate the four strategic imperatives into tangible achievements. The **twelve pillars of transformation** below appear as the most critical, yet other common priorities may arise from future collaborative reflections. Each of those twelve pillars can already be illustrated through successful cases of cooperation, as shown by the few examples below taken from TDA members and other initiatives. These practical examples are only a first step – it is now time to scale-up practical solutions around these twelve pillars of transformation.

Collaborating to create an enabling framework

1. Adapt economic rules to transformation
2. Accelerate energy mix transformation
3. Harmonise regulations related to charging or filling, and to emission standards
4. Develop new mobility and energy curricula in universities, with associated R&D and workforce training

Collaborating to organise territories and change behaviours

5. Position Cities/Regions at the forefront of transformation implementation
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Collaborating to foster change and innovation as an impulse for GHG reduction

9. Innovate beyond state-of-the-art and rapidly deploy innovation in mobility services and infrastructure
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11. Rely on digital tools to create shorter and smarter supply chains
12. Reorganise commuting habits

LEGEND

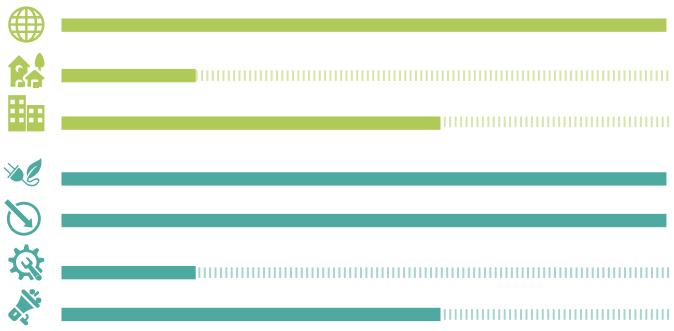
Indicative level of involvement of each C

- Countries
- Cities/Regions
- Companies

Indicative level of impact on each strategic imperative

- Move away from oil and other fossil fuels to focus on very-low-carbon-content energies
- Lower the energy intensity of our mobile lifestyle
- Prepare the physical and IT infrastructure needed to accompany those changes
- Inform, educate and train cities, countries, companies and citizens

1 ADAPT ECONOMIC RULES TO TRANSFORMATION



Why?

In spite of their will to change, the combined efforts of Countries, Cities/Regions and Companies have been insufficient overall to shift transport towards a fully sustainable path in the last few decades. In many respects, the trends regarding modes of transport and types of vehicles used haven't undergone major upheavals. Furthermore the efforts made by the 3Cs have not led to significant market change. This situation is not going to change unless strong decisions are made to alter the rules by which those markets operate. The implementation of new economic instruments can help foster the change of behaviour and the development of long-term investment in low-carbon technology, both in infrastructure and R&D.

How?

The introduction of a revamped economic system and the development of specific new tools can help the shift to a low-carbon economy. In particular, tools that assign a monetary value to GHG emissions need to be developed. For instance, countries and companies can work hand-in-hand to establish carbon cap-and-trade mechanisms. Simpler carbon tax schemes also prove to be effective and their implementation across all sectors and fuels put all actors on an equal footing. Around 40 Countries, and more than 20 Cities/Regions, already use carbon pricing mechanisms, already covering about 13% of the annual global GHG emissions, with more planning to implement them in the future[4]. Furthermore, large geographic scopes can avoid environmental dumping. Besides carbon pricing, it is also important to correct other distortions on energy pricing, in order to better align prices with all other externalities. In addition, as electricity will become more prevalent in the energy sector, attention will have to be paid to ensure that this sector does not bear most of the decarbonisation costs (transition to renewables and offsetting of the remaining CO_2), while other energy sources might not have to contribute to the same extent.

Carbon pricing is not the only way of incentivising low-carbon decisions. Greenbonds and sustainable funds, measures on the reduction of amortisation periods, and many other options are among the instruments that can leverage massive transformations.

In practice

Fiscal incentives for mobility sharing and clean transport modes in Portugal

Portugal has decided to create a regulatory environment, friendly to the development of new mobility models, based on sharing concepts. For this, legal acts on Uber-like transport, car sharing, and bike-sharing, as well as flexible transport for low-density areas, were passed in 2016, 2017 and 2018. As a result, Portuguese cities became vibrant test beds for innovative solutions.

In addition, Portugal offers a strong fiscal package to support the adoption of electric mobility by individuals and companies, becoming a leading country with EV sales already exceeding 5% of the overall car sales. The clean vehicles initiative, with public funding, supports one of the larger fleet renewal programs in Europe, introducing 715 new electric and GNC buses, 10 new vessels and 1200 new cars in public administration over the next three years.

Innovation related to carbon pricing instruments

An acceleration of carbon pricing policy implementation is underway. This acceleration has an impact on the increase in associated revenues, and international experience points to very different uses for these revenues: investment in low-carbon projects, allocation to the general budget, reduction of other taxes, and direct payment of premiums or subsidies. Two different approaches are illustrated below.

Sweden introduced a carbon tax nearly 30 years ago, while reducing its tax burden

The Swedish carbon tax was introduced as part of broad tax reforms in the early 1990s, in parallel with a reduction in income and labor taxes. Subsequently, as the carbon tax rate increased, employers' social contributions were reduced and the most vulnerable households benefited from income tax exemptions[5]. The carbon tax was introduced in 1991 at a rate corresponding to €26 per ton of CO_2, and has gradually been increased to €120 per ton of CO_2 in 2018.

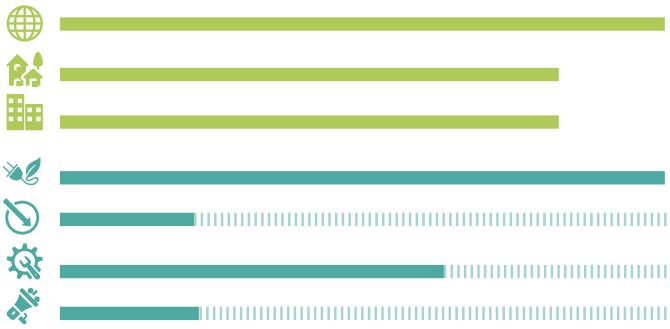
France has introduced a replacement premium on old vehicles in place to mitigate social side-effects of carbon pricing

The Carbon component of the Domestic Consumption Tax on Energy Products (Taxe Intérieure de Consommation sur les Produits Energétiques) was established in 2014. It is planned to steadily increase this tax, targeting €86 per ton of CO_2 by 2022. A convergence between diesel and gasoline taxes is also expected to be implemented by 2022. Measures have been introduced in order to support households and companies in the transition, such as subsidies to buy Zero emission vehicles, or to replace old cars with more recent ones; opportunities for companies to help employees to use bikes; support in the implementation of EV charging points; and measures promoting carsharing. The goal is to reach 1 million premiums by 2022 (250 000 applications registered in 2018).

Collaborating to create an enabling framework

2

ACCELERATE ENERGY MIX TRANSFORMATION



Why?

E-mobility is recognised as a key technology to decarbonise transport. Only a clean electricity mix can ensure that the switch to e-mobility translates into GHG reductions up to the level needed. Alternative fuels (hydrogen, synthetic fuels, and potentially biofuels) will also contribute to reducing oil consumption.

How?

Classical approaches to energy policies often put national governments at the center. However, Companies and Cities/Regions are playing a growing role, enabled in particular by the increased decentralisation and privatisation of energy production. To date, over 100 cities worldwide are sourcing the majority of their electricity (at least 70%) from renewables[6]. As for alternative fuels, local clusters, sometimes headed by Cities/Regions can play a major role. Short term goals could be to reach 200gCO2eq/kWh for electricity mix at the national level, as a first step towards energy mix decarbonisation and tend to 25 gCO2eq/kWh in the long run. By 2030, hydrogen and sustainable liquid fuels industries must have been developed.

In practice

Development of the renewable energy in Lisbon and Portugal

Lisbon committed to a 20% reduction in GHG emissions by 2020 (Covenant of Mayors), but in 2014, it was already 50%. This was due to local strategies, but also to the ambitious policies for renewables at the national level. Indeed, the Portuguese Government launched in 2001 strong energy policies consisting of a set of diversified measures that aimed at promoting a consistent and integrated approach to energy supply and demand. Today, the national energy mix accounts for 28.5% of the renewables, mostly due to their weight in the electricity production (54% renewables in 2016). Furthermore, there were already periods with high renewable generation, where the country was running on 100% renewable power.

3

HARMONISE REGULATIONS RELATED TO CHARGING OR FILLING, AND TO EMISSION STANDARDS

Why?

Battery electric and fuel cell vehicles have takers only if users have the opportunity to easily access charging or filling stations and seamlessly switch from one provider to another the way they currently do with their ICE vehicles. To create momentum, harmonised emission standards also need to be implemented.

How?

Connection and charging systems cannot be specific to each manufacturer and have to be standardised. To facilitate cross-border transport, such standards need to be at least compatible between countries. The nature of the charging infrastructure grid (types of chargers and average distance between charging parts) should also be broadly similar. Tools providing live information about the localisation and availability of charging stations are critical to facilitate consumer use too.

Regarding emissions standards, the ongoing works related to the harmonisation and implementation of emissions measurement tests should be pursued for all types of vehicles (cars, trucks, two-wheelers, planes, ships, etc.).

In practice

Harmonisation of charging regulation and infrastructure

The Open Charge Alliance (OCA) demonstrates how companies and public authorities can work together on the harmonisation of regulations to build a functional and structured framework. OCA is a global consortium brought together to promote open standards and make EV networks open and accessible. Since 2009, Open Charge Point Protocol (OCPP) has become the de facto protocol in 50 countries with over 10,000 charging stations. 25 cities and several companies.

MOBI.E is an electric mobility network management system that integrates all charging systems for electro-mobility in a universal and open access platform. The system allows that any EV customer has a seamless access to all the public charging network, regardless of the infrastructure manager and with only one energy service provider (one card fits all, ATM like roaming system). The Portuguese Government led the project hand-in-hand with CEiiA and other innovative private companies. In 2019, the public access MOBI.E charging network will comprise 1800+ charging points, targeting 1 Fast Charger/80 EV and 1 Semi-Fast Charger/15 EV by 2022.

4

DEVELOP NEW MOBILITY AND ENERGY CURRICULA IN UNIVERSITIES, WITH ASSOCIATED R&D AND WORKFORCE TRAINING

Why?

The academic world has to adapt to the new challenges of the 21st century, and be part of the first movers to bring change in the fields of digitalisation, ecology and environment, etc. Transitioning towards net zero emission is already creating new job positions that need to be filled by professionals with adapted skills. This need for new skills and job competencies will strongly increase. Specialised trainings to qualify workforce on mobility and energy are of paramount importance. Public servants will also be required to acquire new skills to plan and manage the transition.

How?

Cooperation between universities and companies is a key element to develop the appropriate skills. It is a way to take into account the real needs of the industry, which will also help determine the content of the delivered courses (energy management, digital tools, social aspects and industry process). Depending on national set-ups, Countries and/or Cities/Regions can play an important role to facilitate those exchanges. Multidisciplinary vision and work with public research can also foster new synergies. The development of local curricula or courses on the specificities of certain territories will involve local actors who will have a main role in gathering local experts and knowledge.

In practice

Transition campus (“Campus de la transition”) in France

The transition campus is an academic institution that offers multidisciplinary teaching programs dedicated to environmental issues. It provides an interesting example of an academic institution focusing on climate change. This kind of initiative with a growing involvement of the 3Cs has a promising future. Overall, in France and elsewhere, there is still a huge gap between training needs on the issue of green mobility and the current offer. Massive and rapid action is needed to develop wider scale initiatives.

Collaborating to organise territories and change behaviours

5

POSITION CITIES/REGIONS AT THE FOREFRONT OF TRANSFORMATION IMPLEMENTATION

Why?

Cities represent around 70% of the global GHG emissions, in large part due to road transport. They definitely represent a fertile ground for testing, since they totalise the major part of the population, with associated means for investment, and are the place where alternative solutions are already flourishing, including on last-mile delivery. They also face the issue of air pollution related to increasing motorised trips, and have to tackle the resultant health and environmental problems. Besides, they can have a powerful incentive on citizens' mobile lifestyles and prompt them to adopt more sustainable transport modes – such as active mobility (walking, cycling, etc.) and mobility-sharing.

How?

Provided adequate regulations exist at the national level, Cities/Regions can leverage their knowledge and experience of the local context to implement tailored measures. For instance, cities have the necessary knowledge to establish adapted low emission zones (LEZ) or define cycling plans to modify the transport habits of citizens. Successive goals can be to implement LEZ by 2025, ULEZ (Ultra-low emission zones) by 2030-35 and ZEZ (Zero emission zones) by 2035-40. This includes, among other steps, progressively banning the most emitting vehicles. Cooperation with private companies such as personal mobility devices (PMD) operators, or with public transport companies, is also crucial.

In practice

Dutch biking culture and infrastructure

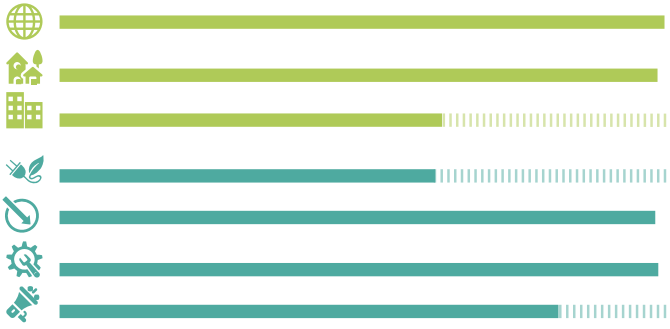
The Netherlands are globally known as leaders in the use of cycling as a transportation mode. Among the Dutch people population, 36% list the bicycle as their most frequent mode of transport as compared to the cars (45%) and public transport (11%)[7]. The infrastructure is geared to cyclists with many roads withseparate dedicated cycle lanes for exclusive use by cyclists. The public policy is bike-friendly as well, with an adapted urban planning.

LEZ and ULEZ

The concept of LEZ was born in Tokyo in 2003. Since then, various cities worldwide have developed LEZ or ULEZ. In London, a LEZ established in 2008 has plans to become a ULEZ as early as 2019. Other examples include Copenhagen's goal to become a ZEZ in 2025 and the creation of LEZs in 15 French cities by 2020.

6

UPGRADE SERVICES OF MASS TRANSIT AND PROMOTE ITS USE



Why?

Public transport is key to reducing GHG emissions by avoiding the use of personal cars, for short and long journeys (an average passenger car produces 205 gCO2eq/passenger.km while a tram emits only 6,6 gCO2eq/passenger.km)[8]. Its use has to be encouraged and renewed, with solutions allowing seamless mobility and the development of door-to-door services.

How?

Mass transit services must be upgraded by developing networks and fostering cooperation between territories to help them interconnect. In parallel with fixed lines, informal mass transit must also be included in local transport schemes. Cities/Regions with strong and growing urbanisation, in developing countries for instance, are particularly concerned. At a national level, Cities/Regions must be given the means to conduct changes (long-term planning competencies, specific budget, etc.) and foster ITS. Alongside building adapted infrastructure, promoting the use of mass transit is essential.

In practice

Tramways are back !

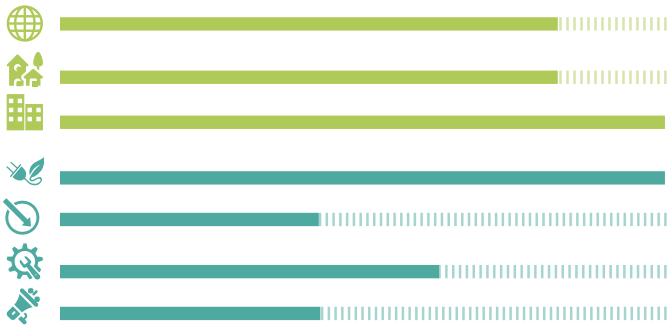
The first tramways in the world opened in New York (1832) and New Orleans (1835). Trams offer speed and reliability, are cheaper and easier to install than rail and offer side benefits such as no local emissions. Yet, the electric tram was killed off by the rise of the automobile in the 20th century. Over the past 25 years, however, the tram has undergone a stuttering revival. Across Europe, there are examples of existing tram networks' renovation, which are then put back into service for passenger and freight. For instance in Saint-Étienne, France, the TramFret project uses tramway lines to transport cargo on the city's network. It is built on a partnership between Casino, the local authority and the tramway operator.

Urban Public Transport Policy in Colombia

Colombia's Urban Public Transport Policy, launched in 2003, features a good example of cooperation, whereby a National Urban Mobility Policy (NUMP) is used to harmonise and impulse Sustainable Urban Mobility Plans (SUMP). Local authorities apply for national funding and are required to meet several requirements to get funding, namely, having a mobility master plan integrated with land use, advance technical preparation of the projects, and providing local funding. Since its launch, the program has contributed to significant improvements in Colombia's transport systems (e.g., expanding mass transit systems from two to eight cities, building 487 km of bus corridors, and modernising public transport in medium-sized cities)[9].

7

CATALYSE MOVEMENT TOWARDS LONG-DISTANCE NONMOTORISED MOBILITY (INTER, INTRACITY AND REGIONAL)



Why?

Long-distance travel, whether between cities in a given country or between different countries, represents a high share of citizens and companies' carbon footprint. They are dominated by emissive transport modes such as car or plane. In Denmark, for example, international travel represents 31% of the Danes' CO2eq emissions from passenger travel[10]. Similarly, international freight represents 30% of all CO2eq emissions from fuel combustion, and more than 7% of the global emissions[11].

How?

Due to its large geographical and variable scope, long-distance travel is seldom the focus of policies at the national, or city and regional levels. The role of companies and international fora is therefore key, especially for cross-border travel. Regular dialog between Cities/Regions with major transport hubs can also create a breeding ground for initiatives to flourish and for new innovations to emerge. Examples of potential solutions – many of which consist of very simple, cost-effective and well-known techniques, include floating freight, wind sails, cables, waterways, and air balloons (Flying Whales), or even animal traction. More established technologies such as shore-to-ship should also be spread to lower GHG emissions of long-distance freight[12]. Hybrid techniques between motorised and nonmotorised solutions also have to be investigated (e.g. sailing boats with auxiliary motors for freight).

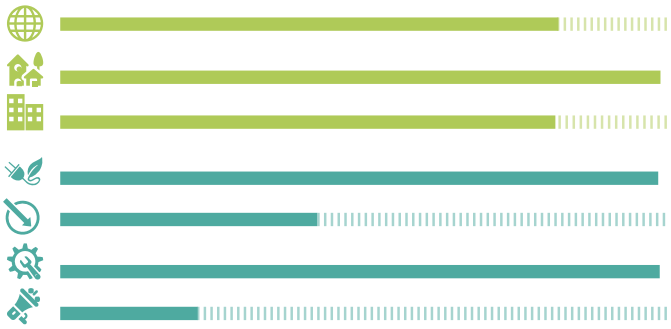
In practice

SeaWing - Cargo ship kites

Among the different technologies that harness renewable energy sources to improve the carbon impact of cargo shipping, kites could allow fuel reductions of up to 20%, with the possibility to retrofit entire fleets easily. The project SeaWing, supported by the French Agency for Environment and Energy (ADEME) and coordinated by the company AirSeas, aims at bringing this technology to maturity. In September 2018, the company registered its first firm order, thus proving its economical relevance.

8

DEVELOP DECENTRALISED MOBILITY AND DECENTRALISED ENERGY SYSTEMS SIMULTANEOUSLY



Why?

The ongoing decentralisation of electricity systems offers an unprecedented chance to develop decentralised mobility systems. This is an occasion to ensure that peri-urban and rural territories benefit from the transition to net zero emission-transport and to secure a high share of renewables for the transport sector. In addition to power generation, non-urban areas represent a favourable field for local generation and use of hydrogen and biogas/biofuels.

How?

Provided adequate regulations are in place, Cities/Regions, as well as Companies, can work together to develop local renewable energy sources (wind, solar, biogas, etc.). In parallel with this development, local transport ecosystems can be built. For example, locally generated surplus electricity can be used to produce hydrogen or synthetic fuels that respond to local demand. This requires strong coordination to ensure that those two parallel development are coherent. Rural territories will primarily act as suppliers to cities where most of the fuel needs are concentrated. Cooperation will therefore be needed at the regional level. National coordination should ensure the harmonisation of decentralised innovative approaches.

In practice

TSO2020 project in Northern Netherlands on hydrogen

TSO2020 is an initiative of the Dutch Ministry of Infrastructure and Transport, and several public and private actors. Together, they are working on the development of a hydrogen hub with an underground gas storage, in the Northern Netherlands. This HyStock pilot project focuses on the conversion of water into hydrogen using solar energy, a way to respond to the fluctuations between supply and demand for green power.

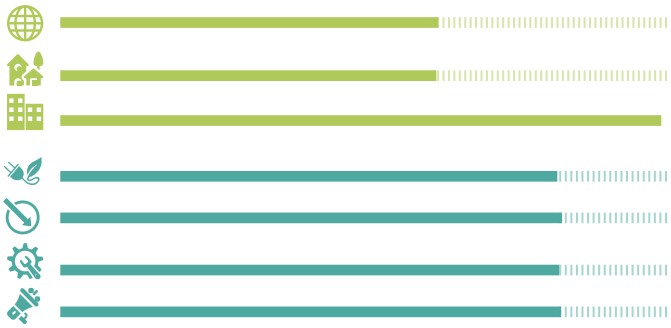
Innovative legislation in Portugal

Portugal has recently passed an innovative legislation that allows for electricity production from renewables to be used by public transport vehicles at different times and locations. In addition, the City of Lisbon is projecting a large photovoltaic power plant to produce electricity for the municipal bus operator CARRIS.

Collaborating to foster change and innovation as an impulse for GHG reduction

9

INNOVATE BEYOND STATE-OF-THE-ART, AND RAPIDLY DEPLOY INNOVATION IN MOBILITY SERVICES AND INFRASTRUCTURE



Why?

Many technological innovations needed for GHG-neutrality in the transport sector do not exist yet and have to be developed (including batteries with sufficient autonomy to satisfy heavy uses, technologies to ensure that the GHG goals of the aviation sector are reached, or innovation in the field of maritime transport). Other technologies exist but are for now insufficiently deployed. Innovation also embraces the implementation of new business models to scale up existing technologies and the development of solutions for behavioural changes, taking account of the disruptive trends that will affects mobility behaviours (e.g. automated vehicles, shared mobility services).

How?

Companies lead innovation in most cases; however, public support is important. In addition to adequate regulations, such as norms with sufficient flexibility to allow experiments by first movers, public authorities can subsidise innovative projects and bring investors long-term visibility. For many projects, either on the emergence of new solutions or on the deployment of existing ones, local innovation clusters are essential; hence the key role of Cities/Regions, that provide favourable conditions for experimentation.

In practice

Green Deals in the Netherlands

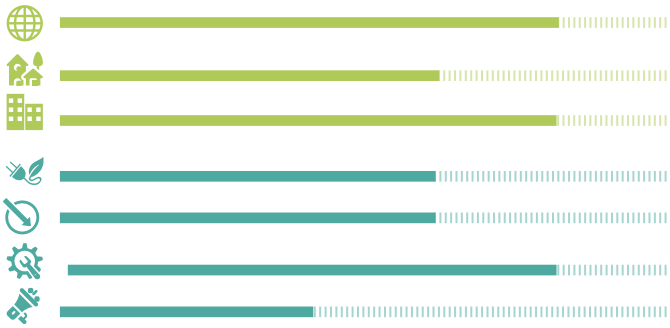
The Green Deal approach is a way for companies, local and regional government to work with the Dutch Government to help sustainable initiatives grow and to accelerate their implementation. Many projects are under development such as those on Zero Emission public transport buses or car-sharing solutions. Between 2011 and 2014, 176 Green Deals were closed in the Netherlands, involving a total of 1,090 private and public participants.

Hydrogen train in Germany

Alstom, in 2016, launched a zero-emission train powered by hydrogen, the Coradia iLint. Growing customer demand for innovative ecological solutions, the unlimited amount of hydrogen available, and its price make this technology economically sustainable. Moreover, Alstom's cooperation with and support from the region of Saxony, the German Ministry of Economy and Mobility, and the German Government, has led to two pre-series trains running in the region of Saxony since September 2018.

10

IMPULSE MOVEMENT TOWARDS MULTIMODAL SOLUTIONS FOR FREIGHT



Why?

Heavy- and medium-duty trucks are in many cases the default solution for freight and alone emit 1,5GtCO2eq, around 23% of the total transport emissions from fuel combustion[13]. Switching traffic to other, less GHG-intensive modes, and in first place to rail, is essential. This relies on multimodal solutions offering better environmental performance and flexibility when taken as a whole and when including the best combinations of available techniques in a given context (ranging from nonmotorised modes, to digital solutions, or to disruptive solutions like hyperloop). Freight relying mostly on maritime transport, strengthened efforts are required to optimise the use of maritime infrastructure and improve its coordination.

How?

The priority is to enable multimodality by developing multimodal logistic platforms, building new ones, or upgrading or even displacing older ones. Cities/Regions play a major role in planning the development of such platforms, and more globally, in designing multimodal freight schemes and allow for the best rail-road equilibrium at a territory level. Such schemes have to be integrated at a national and even international level, and cannot be developed without the input of companies that are the main shippers of goods.

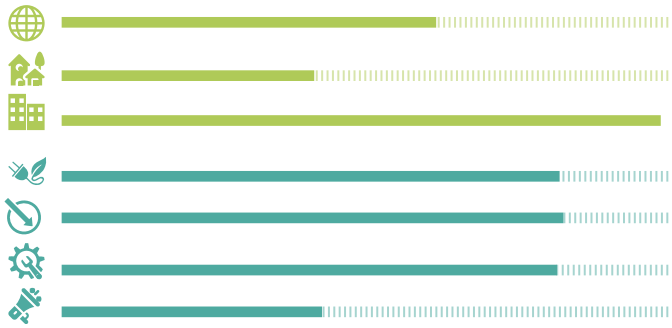
In practice

Intermodal transit hubs in India

India has the ambitious goal to triple gross freight traffic by 2030 (increasing the railway's share in overall goods movement to 50% from the current 35%). A pilot program for intermodal transit hubs is also ongoing, with the strong support of Indian Railways. The hubs aim to be one-stop locations for various transportation systems (railways, buses, mass transit, water transit, taxis and auto rickshaws) to enable seamless flow from one system to another. Nagpur and Varanasi have been selected out of 15 contending cities, as part of this program.

11

RELY ON DIGITAL TOOLS TO CREATE SHORTER AND SMARTER SUPPLY CHAINS



Why?

The tremendous scale of digital sharing platforms and crowd-based access to already existing assets is redefining the concept of 'sharing' and reshaping the future of logistics, bringing great financial and productivity benefits. For example, according to research, one in four trucks on US and European Union (EU) roads drives empty or only half-loaded. In the meantime, new digital tools can help construct shorter and smarter supply chains that can contribute to the reduction of the climate impact of transport in the industrial sector. This optimisation of supply chains is at the heart of industry 4.0.

How?

The reorganisation of supply chains can rely on several digital tools such as systems for more accurate production data to improve load sharing, thus lowering both transport costs and GHG emissions. Digital platforms provide an instant snapshot of availability and the ability to access spare capacity in almost any truck, including smaller delivery vehicles, on a day-to-day basis. While the innovators will be companies, these applications should be supported at the national and local levels, so that solutions can be deployed broadly and can feed the entire ecosystem. Technologies like 3D-printing will also have a significant impact on industrial activies and lead to a recomposition of industrial production. The 3Cs can actively collaborate to rethink logistics in synergy with such technological evolutions.

In practice

Deutsche Post DHL Group

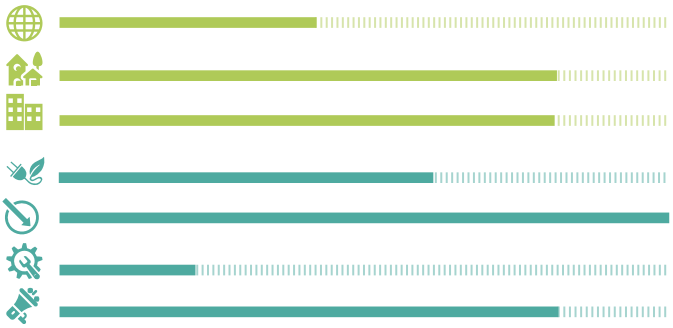
DHL as one of the leaders in the logistics sector, works on the optimisation of its logistics networks at different levels, from capacity optimisation, to adjustment to customer-specific volumes and deliveries, or by planning pick-up and delivery at night time, when traffic is low. New IT tools are crucial for many of these changes, and help both companies and cities to shape more efficient logistics processes. By the year 2025, DHL wants to increase its carbon efficiency by 50%, compared with 2007 levels[14].

Collaboration of Cities and Companies on digital solutions

Companies specialised in smart software for transport, such as PTV in Germany, develop the IT tools needed for increased cooperation between urban planners and transport planners. In Strasbourg (France), for example, the company developed a tool that allows the traffic management center to have access to real time information on congestion. This information is used to smoothen traffic, and to feed into the dedicated Cityapp, Strasmap.

12

REORGANISE COMMUTING HABITS



Why?

Business travels represent the main source of GHG emissions related to office activities. Furthermore, business trips and home-to-office trips represent 50% of companies' CO2eq emissions[15].

How?

Companies and administrations have the ability to reduce the climate impact of employees and civil servants' traveling, by raising awareness, drafting company or administration transport plans that encourage them to use "clean" transport (public transport, cycling, carpooling, car sharing), or even by rethinking work organisation to structurally reduce business travel and real estate footprints (remote collaboration tools, promotion of teleworking[16]) . City and regional support is essential for net zero emission-commuting at a local level, for instance, with revisions in city planning. The implementation of local mobility plans can be done hand-in-hand with national governments to ensure country-wide harmonisation.

In practice

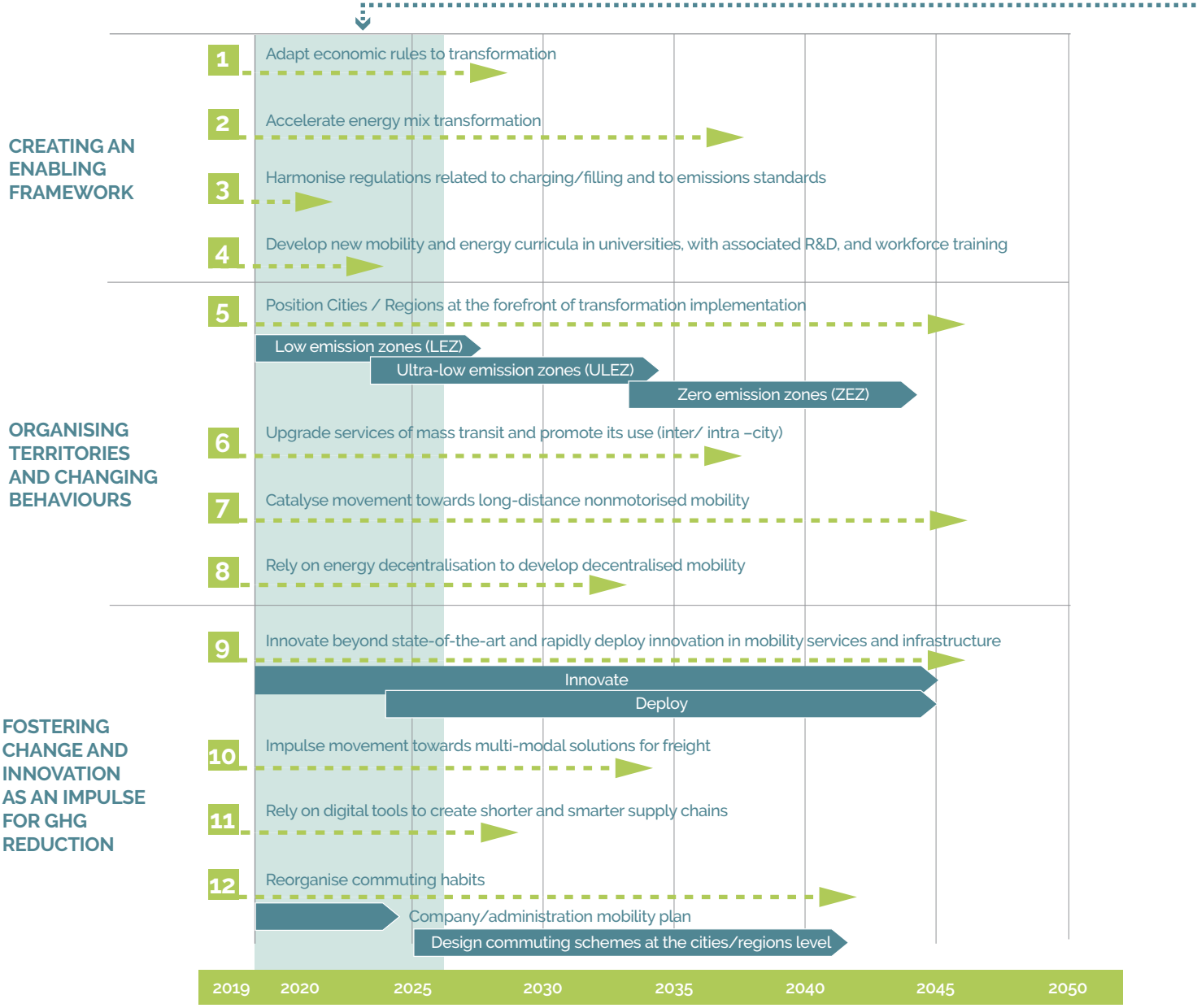
Encouraging other work patterns in Northern Europe

Teleworking is a strong lever to reduce GHG emissions related to commuting. Northern European countries such as Denmark, the Netherlands, Sweden and Luxembourg seem to be more open to telework than other European countries, with more than 20% of the Swedish population and nearly 35% of the Danish working population being teleworkers (compared to 3.5% on an average in Europe). This is made possible by flexible regulations, and by evolutions in the working world: enabling information and communication technologies, factors associated with managers' trust and control, the character of jobs, and work-life balance issues. In Denmark, for instance, occasional distance work is not regulated by law; it is regulated by framework agreements concluded between trade unions and the state, regions and municipalities, depending on the case. Another inspiring example comes from the Netherlands, where 50 front-running businesses have launched the initiative "Anders reizen" to reduce work-related mobility.

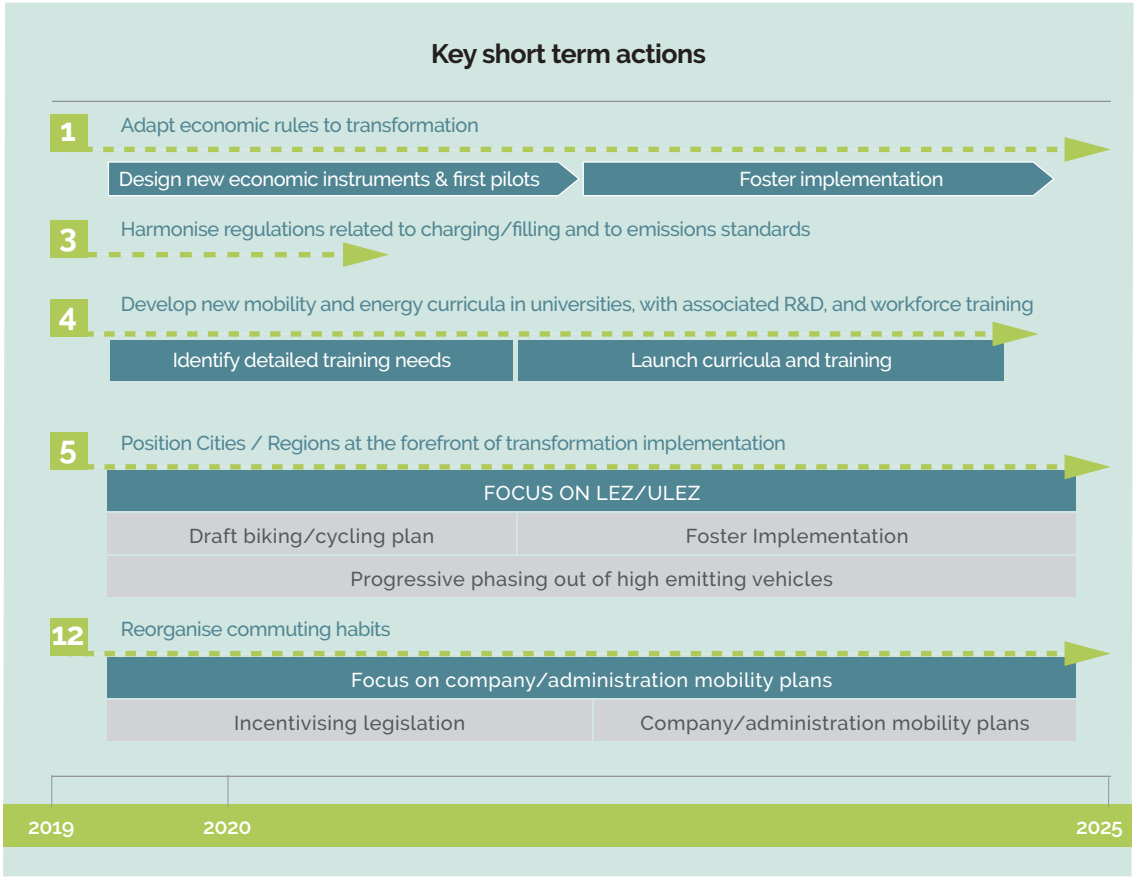
Collaboration among the 3Cs on **twelve pillars of transformation** to set levers in motion

Those twelve pillars of transformation have to be phased in order to reach net zero emission-mobility. The illustration below highlights the key actions to be taken in the next decades by the 3Cs, and key short-term actions to kick-off the transformation:

Iconic measures to reach net zero emission mobility by 2050

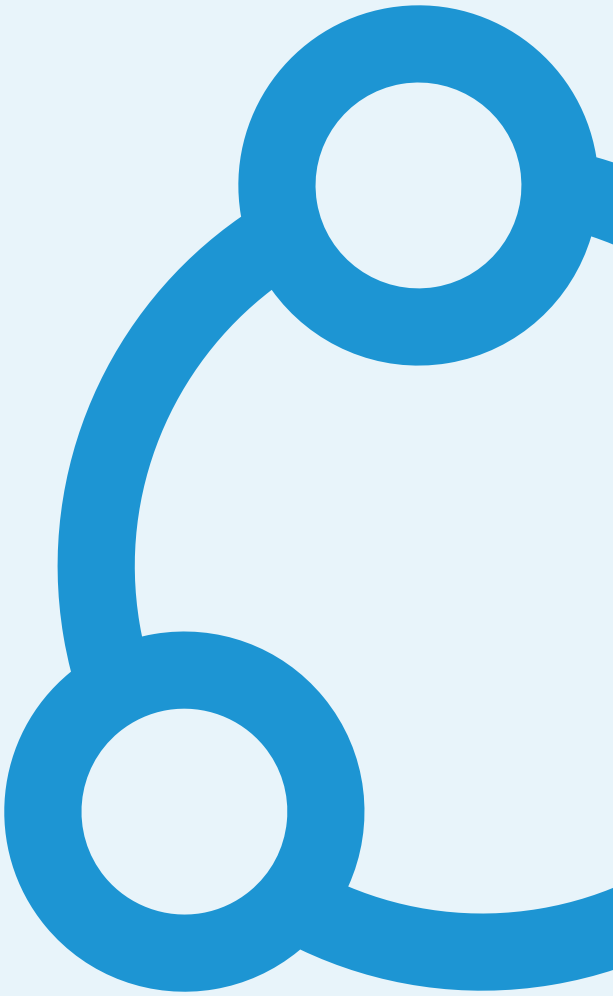


Jump-starting the transition: **focus** on unmissable steps by 2025



NB: These unmissable steps by 2025 focus on how to reduce absolute emissions. As developed on page 19, complementary actions need to be taken regarding negative emissions in order to reach net zero emission mobility, and resilient infrastructure and mobility systems have to be developed concomitantly.

Strengthened collaboration between the 3Cs must rely on more effective, innovative processes



Acting synergistically on strategic imperatives and transformational pillars will not happen without an extremely strong level of coordination between the 3Cs – something missing until today. A framework is needed to create and maintain this unprecedented level of coordination, and enable large scale initiatives. Such a framework should first help to remove the roadblocks and barriers that inhibit action, then guide the 3Cs on the way to innovative collaborative schemes.

Four enabling prerequisites to remove the roadblocks encountered in the transition

Many roadblocks exist in the way to net zero emission-mobility that hold Countries, Cities/Regions and Companies back today or may hold them back in the future. Acting quickly implies recognition of and action on these roadblocks today and opens up avenues of opportunities, thereby paving the way for straightforward action in the years and decades to come. **Four enabling prerequisites stand out** as essential in order to act quickly and overcome existing or future roadblocks:

- Prerequisite 1: Anticipate shifting effects
- Prerequisite 2: Avoid inflexible approaches and make informed decisions
- Prerequisite 3: Challenge all arguments for postponement
- Prerequisite 4: Adapt the fiscal and regulatory environment to foster transformational investment

Prerequisite 1: Anticipate shifting effects

The transition towards a net zero emission-transport sector will necessarily lead to changes in the allocation of revenues, jobs and taxes. These shifting effects need to be anticipated.

- **Shifting of jobs:** New energy and mobility solutions will lead to change in the nature of jobs in conventional mobility sectors and to net job loss in some employment areas. The industry automation and robots introduction may imply significant job reductions as well, while new business activities will develop. This can be anticipated, and offset, for example via major programs of professional retraining and through the development of new activities in the areas concerned. The most impacted sectors tend to be concentrated in certain Cities/Regions. Cooperation between those Cities/Regions, employers and national authorities, is therefore essential to smooth out the transition by anticipating rather than simply reacting to job deletions.
- **Carbon or GHG taxes translating into excessive increase in fiscal burden for taxpayers:** As shown by the example of Sweden[17], CO2 taxes do not have to be translated into an overall increase in the fiscal burden of tax payers but can be substituted for existing taxes (such as labor income tax and energy tax) that did not initially attach any price signal to environmental externalities. Communication towards citizens emphasising that the revenues for those taxes are recycled into the economy will also be key to ensure adhesion of taxpayers to the reforms.
- **New mobility solutions leading to real or perceived territorial inequity:** Some of the most impactful levers are more efficient in dense areas (e.g. mass public transport, e-mobility charging schemes). This could lead to a feeling of inequity between urban, peri-urban and rural areas. This can be anticipated with policies targeted on the rural areas including the coherent development of local and on-demand transport, together with energy production ecosystems.
- **Shifts in geopolitical equilibrium:** New mobility solutions will change the energy supply security landscape. While the decrease in oil consumption will lower co-dependencies between current oil importers and oil exporters, the issue of rare minerals and battery production will create new dependencies. The economic and geopolitical impacts of those changes should be anticipated. Depending on the local conditions, national or regional policies to foster the emergence of local industries, such as battery production, can be used to prevent some of the effects of these shifts[18].

Lithium quarry in Asia

Prerequisite 2: Avoid inflexible approaches and make informed decisions

While the levers for net zero emission-transport are well-identified, the best approaches to act on those levers will evolve as a result of technological breakthroughs and shifts in consumers' and citizens' demand. There is a high risk of making uninformed decisions and of locking into irrelevant solutions. Countries, Cities/Regions and Companies alike should keep the following in mind when making decisions:

- **Systematically use complete life cycle analysis,** considering GHG impacts as well as other environmental (biodiversity, water, air pollution, noise) and social impacts. Based on those analyses, mitigative actions should be put in place. For some products with a heavy ecological impact, such as batteries, reutilisation and recycling will be key.
- **Maintain bottom-up approaches** to avoid the premature elimination of solutions. Examples of technological debates for which blunt top-down approaches should be avoided include batteries vs. fuel cells, and water electrolysis vs. steam reforming.

Example of life cycle analysis (LCA) process – LCA of a car

Vehicle manufacture	Vehicle transport	Vehicle operation	Refueling infrastructure	End-of-life disposal
Materials (Fe,Al, etc...)	Road	Energy consumption	Conventional fuels	Recycling
Components	Rail	Maintenance	Electric recharging	Refrigerant
Manufacturing energy	Ship	Refrigerant leakage	Hydrogen refueling	Fuel use
		Emissions		

Prerequisite 3: Challenge all arguments for postponement

Timing is key and the risk of postponing some actions until too late is real. Some areas of action seem particularly sensitive to this risk:

- **Negative emissions need to be taken into account early on:** Most of the anticipated <2°C scenarios rely on a substantial share of negative emissions[19]. The IPCC also notes that "*carbon dioxide removal (CDR) deployed at scale is unproven and reliance on such technology is a major risk in the ability to limit warming to 1.5°C.*" It follows that CDR cannot be used as an excuse to reduce or delay action on emission reduction, including in the transport sector. CDR generation is a cross-sectoral issue that should not be dismissed or postponed.
- **Resilience of transport infrastructure should be ensured in synergy with mitigation efforts:** Mobility relies on a variety of dedicated infrastructures (roads, railways, etc.) and upstream infrastructures (e.g., power plans). To ensure that new mobility solutions reach their target of reducing the impact of transport on GHG emissions, supporting infrastructures must be adapted to withstand the effects of climate change such as change in precipitation patterns or increased frequency of heatwaves. This requires strong cooperation between actors as this infrastructure can, for example, be owned by states or cities while being operated by private companies.
- **Necessary experimentations require adapted and flexible regulations:** The pace of innovation can be faster than the pace of legislative action. In order to avoid delays in the emergence of new solutions, while maintaining necessary precautions, specific attention should be paid to adapt regulatory frameworks to innovations that will contribute to transport decarbonisation. This is the case for regulations surrounding hydrogen use in many countries. Flexibility should be incorporated from the start into new regulations, or maybe a regulatory framework paradigm shift will be needed. The management of data from ITS is also a rapidly evolving issue where discussions between Countries, Cities/Regions and Companies will be key to implementing adapted regulations and offer smoother travels.

Prerequisite 4: Adapt the fiscal and regulatory environment to foster transformational investment

Changing transport to align the sector to a <2°C trajectory will require massive public and private shifts in investments. Some roadblocks hinder current investments or threaten future investments and have to be lifted.

- **Anticipate fears on states' or territories' budget because of decreased oil tax revenues:** The transition to a greener transport sector will lead to a reduction in oil consumption and consequently, a reduction in oil tax revenues. This reduction should be anticipated and alternative tax bases found to ensure that public actors push forward transport decarbonisation without fear of losing part of their budget. Transition toward net zero emission-transport and net zero emission-economy in general means reframing fiscal systems in depth and cannot be realised with only piecemeal improvements.
- **Ensure that electricity price levels are adequately designed:** Reform electricity price design so that users pay tariffs that are better aligned with the real cost of production and supply, and that the cost of the transformation is not entirely paid in the electricity tariff.
- **Enable a market design that promotes investments in low carbon electricity generation technologies:** Given the key role of the electricity sector in decarbonising transport, the functioning of electricity markets should be carefully organised to ensure that producers do not bear an excessive cost of transformation and that they invest in low-emission energies in the middle and long run.
- **Anticipate the fear of inflated mobility prices.** Clear communication will be necessary to inform citizens of the evolution of mobility prices, whether the prices increase or not. Measures targeted towards the most vulnerable populations are also advisable to mitigate this impact. For instance, electric mobility is not necessarily more expensive than conventional transport means, provided adequate social and economic measures accompany its development.
- **Provide long-term visibility to unlock opportunities for investment:** Companies and investors have in mind the various roadblocks listed above. As a result, some are led to believe that the different measures put in place will be only transitory, or that announced goals (related to the path of GHG pricing for instance) will not materialise. As a consequence, these actors maintain their business-as-usual behaviours and refrain from investing in net zero emission-technologies. Providing long-term visibility, and communicating that the aforementioned roadblocks have been identified and anticipated, are therefore essential to foster investment.

A five-step process to facilitate joint action and risk alleviation

Coordination between actors as different as Countries, Cities/Regions and Companies does not come easily: short-term goals might not be aligned, fora for joint decision-making might not exist, decision processes might differ, mutual distrust might sometimes exist, etc. Elements of method are indispensable to initiate and sustain coordination at the local, national and international levels.

Based on its members' experience, the TDA lays the foundations of a five-step process that should guide public and private decision makers to implement favourable conditions for concrete action and risk alleviation. This method results from collaborative work that is still ongoing and might be adjusted and further enriched. It provides general guidelines that should be adapted to fit local conditions and to ease adoption by decision-makers.

A five-step process to guide decision makers in setting favourable conditions for collaborative action between the 3Cs

1. Establish a firm "net zero emission-mobility" target involving all stakeholders in a spirit of irreversible commitment
2. Develop 3C governance at the different scales to steer and monitor the transformation
3. Spread homogeneous, effective tools to orchestrate the transition at the local, national and international levels
4. Open up pro-business initiatives to foster new services and new products
5. Promote international efforts to speed up the transition at the global level

Step 1 - Establish a firm "net zero emission-mobility" target involving all stakeholders in a spirit of irreversible commitment

The priority step for coordination consists of establishing shared objectives at the different levels, and especially at the national level between the national authorities and representatives of Companies and Cities/Regions. Examples of actions that can be taken are provided below:

- **Launch a nation-wide process (Country governments, Cities/Regions, Companies, and citizens)** to investigate willingness and pathways to mobility evolution transformation. Multi-stakeholder discussions should be initiated on what are the main needs and priorities. Concrete scenarios should be discussed so that all actors share a common vision of what decarbonising transport entails. This process is important to ensure that the four domains of sustainable mobility (Safe for all, Green, Efficient and Accessible[20]) are tackled jointly and not independently. Additional specific dialog between the governments and energy companies can serve as a useful basis to determine some of the major parameters that will feed into the discussion on mobility: future energy mix, estimated energy tariffs, grid capacity, etc.
- **Adopt long-term strategies to "root" the GHG-neutral objective[21]** in stakeholders' agenda, in a spirit of irreversible commitment. Such long-term orientations should be put in coherence between the 3Cs and be reflected in the new version of the NDCs (Nationally Determined Contributions) that each party will have to provide to the UNFCCC by 2020. Based on national contexts, such strategies could be made legally binding. The notion of irreversibility is key to
  - secure the support of business and unleash both its potential for creativity and its confidence in investing money in order to transform the sector
  - prepare the general public to understand, possibly support, and anticipate drastic changes in their lifestyle
  - orient and harmonise policies taken at the urban or the territorial levels
  - Confirm national commitment to be transformed by 2050, including key intermediate goals such as the end of sales of new GHG emitting vehicles by 2040[22]
  - Induce education and public R&D evolution toward new energy and transport paradigms.

To be effective, these strategies need to be communicated widely: not only to the actors that are traditionally concerned (e.g., energy or transport companies), but also to all the stakeholders, including citizens.

The **French "Assises de la Mobilité",** which took place from September to December 2017 provides a relevant example of how such a process can take place in a very short timeframe: local workshops with citizens throughout the territory; thematic workshops with NGOs, thematic experts, elected representatives, company and city representatives, and innovation workshops, all synthetised to feed into a national law[23].

Step 2 - Develop 3C governance at the different scales to steer and monitor the transformation

It is necessary to ensure that coordination between the 3Cs lasts after the establishment of a common goal. Appropriate governance has to be set up, drawing on what already exists in the Countries and Cities/Regions. To achieve this the TDA members have identified the actions below:

- **Facilitate the establishment of an official "net zero emission-mobility Taskforce"**. To ensure comprehensiveness and consistency in their strategies countries could have a dedicated **"NZE mobility Taskforce"** involving the 3Cs and actively contributing to the success of the transformation at the national level. A strongly anchored, well established and proactive taskforce is key to going beyond bilateral consultation and ensuring a unifying process between the 3Cs. The exact nature of such a taskforce will depend on national contexts and institutional setups; it could, for example, result from adapting existing national entities or bodies, or creating a new one. Its role could include the following:
  - Proposing national retro-planning towards GHG-neutrality of transport

- Supporting the definition of requested macro-policies and necessary strategic investments in winning sectors
- Proposing ways to alleviate the social and economic damage in impacted sectors
- Advising public procurement strategies to incentivise the adoption of new solutions

In addition, this NZE mobility taskforce could be linked to regular governmental functioning and national 3C network (to be established).

- **Launch a formal joint "companies and citizens" braintrust** to explore and advance innovative solutions with popular support (and potentially address cross border issues), and **mirror this approach with "cities and companies" and "cities and citizens" braintrusts**
- **Take stock of, and communicate, annual progress.** Assessment of progress will be of paramount importance to realign strategies based on observed impacts.

Step 3 - Spread homogeneous, effective tools to orchestrate the transition at the local, national and international levels

To ensure comprehensiveness and consistency in their strategies, and to facilitate dialog, the different Countries, Cities/Regions, Companies should use homogeneous and effective tools. Five international initiatives led by the Institue for Sustainable Development and International Relations (IDDRI), International Transport Forum (ITF), Paris Process on Mobility and Climate (PPMC), World Business Council for Sustainable Development (WBCSD), World Wildlife Fund (WWF), Carbon Disclosure Project (CDP), United Nations Global Compact (UNGC), and World Resources Institute (WRI) are now cooperating to offer a "transport decarbonisation toolbox" that builds up on their previous tools. Diffusing this type of toolbox to all 3Cs will allow for more enlightened decision-making. It is worth noting that some components of this toolbox can also be used in the first steps of the method for the definition of national goals and strategies. More specifically, in addition to this document:

- **Governments can rely on**
  - The eight-component framework of action proposed in the PPMC macro-roadmap of action (2050 horizon)
  - The Green Mobility chapter of the Global Roadmap of Actions at the 2030 horizon, developed by the SuM4All Consortium under the leadership of PPMC
  - The Decarbonising Transport modeling tools crafted by the ITF
  - The Deep Decarbonisation Pathways (DDP) projects developed by the IDDRI
- **Cities can advantageously use the "SiMPlify"** tool proposed by the WBCSD to facilitate the collaboration between the business and cities, and provide citizens with safe, clean and efficient mobility
- **Companies are advised to use, whenever possible, the science-based target (SBT)** methodology developed by the CDP, UNGC, WRI and WWF.

Further coordination around these tools and further improvements taking into account the 3Cs' needs in terms of design and implementation of clean transport strategies and actions will help accelerate change.

Step 4 - Open up pro-business initiatives to foster new services and new products

The NZE mobility task force can also play an important role in accelerating and facilitating private sector initiatives to bring new innovative products and services. Economic and fiscal solutions should be proposed to:

- **Allow more synergies between public and private solutions** to boost innovation and quality of service, in all parts of territories fostering healthy competition between new business models (from product to service) and other innovative solutions
- **Encourage private investments and healthy competition** via adapted economic incentives relying, for instance, on green fiscality to increase the returns of green investments.

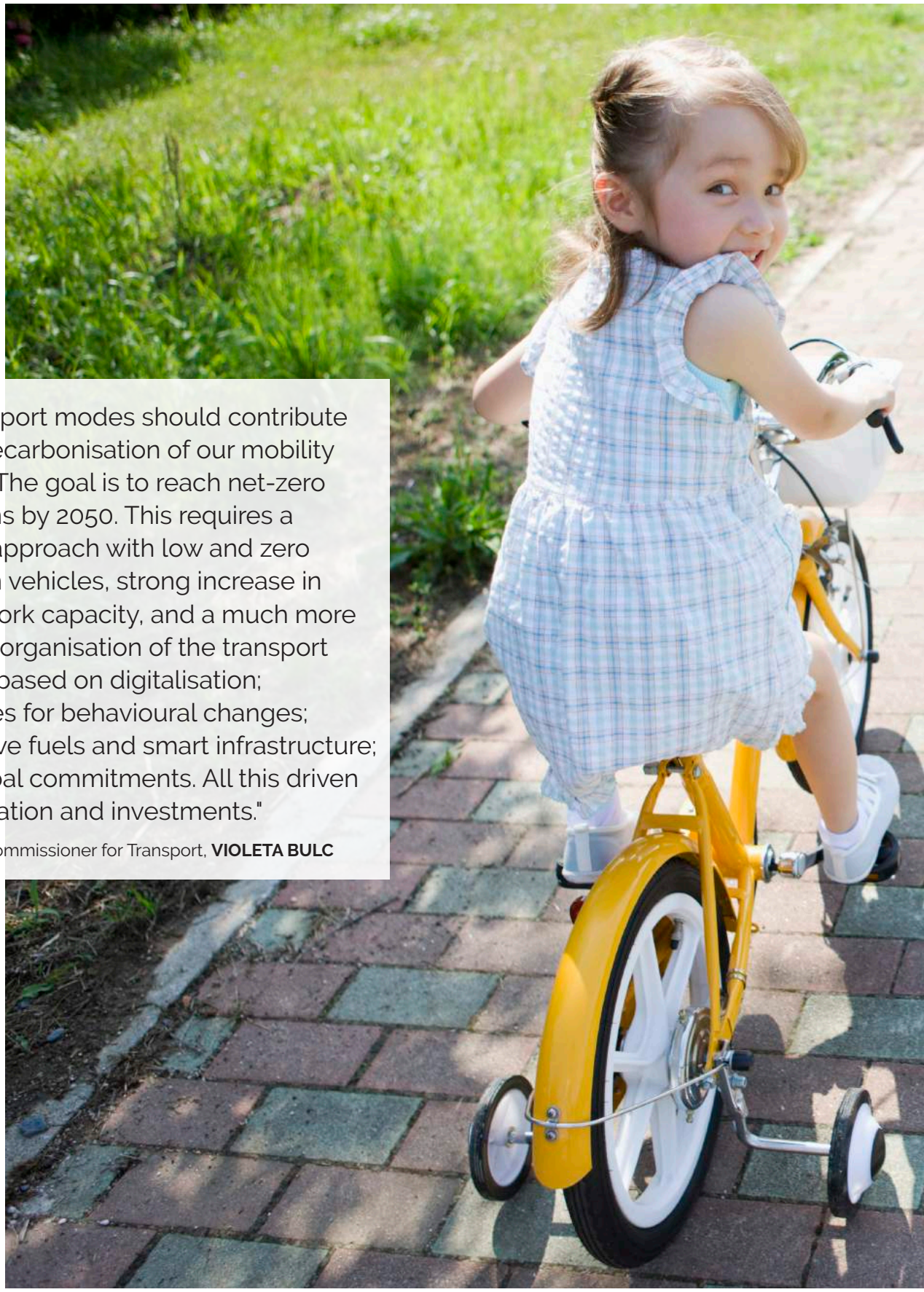
Step 5 - Promote international efforts to speed up the transition at the global level

To get to net zero emission-transport by 2050, cooperation between the 3Cs within national borders, using the method proposed above, will be essential. However, on major issues such as international transport; access to finance for transport decarbonisation; or the development of international methods and tools, cooperation is also needed beyond borders:

- International communities of interest dedicated to the entire subject of transport decarbonisation, or focused on specific challenges, can facilitate this sharing of good-practices and contribute to the Global Climate Action Agenda on transport. Due to their nature, international companies have a specific role to play to spread good practices
- Pioneer Countries, Cities/Regions, and Companies also have to steer international negotiations towards greener transport and initiate best practice-sharing at the international level. Examples of such negotiations and initiatives include:
  - **Taking steps within International Civil Aviation Organisation (ICAO) and International Maritime Organisation (IMO)** to ensure that ambitious operational measures are put in place to reach or strengthen the existing commitments of those organisations
  - **Discussing within the World Trade Organisation (WTO)** to reconsider trade externalities and rules to promote locally produced goods, more efficient supply chains, and the circular economy without killing international exchanges
  - Systematically promoting actions and support initiatives that aim at **enhancing transport decarbonisation policies within the UNFCCC processes,** especially through the update of NDCs.

Those five steps have to be initiated quickly and orchestrated in time, in order to lay the ground for collaborative, transformational action:

Proposed process to facilitate joint action and risk alleviation



"All transport modes should contribute to the decarbonisation of our mobility system. The goal is to reach net-zero emissions by 2050. This requires a system approach with low and zero emission vehicles, strong increase in rail network capacity, and a much more efficient organisation of the transport system, based on digitalisation; incentives for behavioural changes; alternative fuels and smart infrastructure; and global commitments. All this driven by innovation and investments."

European Commissioner for Transport, **VIOLETA BULC**

The way ahead

Key takeaways emerge from this manifesto:

1. TDA members agree that **net zero emission-mobility by 2050 can be achieved,** if strong, structured action is launched now.

2. The key levers for reducing the GHG impact of mobility are **all the more effective when activated in synergy - something missing until today** - relying on active cooperation between the 3Cs to **create the favourable economic, technical and social conditions, without which the transformation will fail,** and helping focus efforts on finding ways to go the extra mile towards full success.

3. Adopting **a common process framework in this "no return" journey towards net zero emission-mobility is a sine qua non condition for success.** The four prerequisites and the five-step process proposed by the TDA, when adapted to local conditions, should immensely help decision makers foster collaboration and accelerate progress.

4. "Decarbonising transport" is no solitary endeavour. The TDA **urges other Countries, Cities/Regions and Companies to initiate and sustain cooperation**. It welcomes actors eager to embark on the transition to join as new TDA members or supporting organisations.

We look forward to welcoming you aboard.

© René Frampe

Coradia iLint, first hydrogen fuel cell powered train developed by Alstom for Germany

Appendix: Examples of good practices per strategic imperative

This appendix presents a more exhaustive list of good practices corresponding to each of the four main strategic imperatives. This detailed list is meant to be adapted and enriched by the future works of the TDA.

Not precluding further detailed works, the rating per level of impact or per cost is provided in an indicative way, based on expert opinion and available literature. The categories used (medium, high and very high, etc.) aim to represent a qualitative estimate of the financial investment required and of the estimated impact on GHG emissions reduction. This analysis can serve as an initial guide to establish decarbonisation strategies, but should, however, be accompanied, whenever possible, by precise quantitative assessments. It is important to note that these quantitative assessments will be highly dependent on national and local conditions.

Example of best practice	Strategic imperative
Encourage nonmotorised trips: walking and cycling	Lower the energy intensity of our mobile economy & lifestyles
Defragment and shorten supply, and production and distribution chains	Lower the energy intensity of our mobile economy & lifestyles
Improve occupancy of vehicles: pooling, empty trip banning, road cabotage, lane dedicated to shared vehicle, etc.)	Lower the energy intensity of our mobile economy & lifestyles
Improve load of vehicles (new urban logistics scheme and planning)	Lower the energy intensity of our mobile economy & lifestyles
Limit urban sprawling	Lower the energy intensity of our mobile economy & lifestyles
Company or administration mobility plans for employees including flexible working	Lower the energy intensity of our mobile economy & lifestyles
Demand management (e.g., trade or sport competition induced traffic, ...)	Lower the energy intensity of our mobile economy & lifestyles
Move from road and air to rail for freight and people	Lower the energy intensity of our mobile economy & lifestyles
Move from road and air to waterways (mostly for freight)	Lower the energy intensity of our mobile economy & lifestyles
Develop extended and reliable public transport systems	Lower the energy intensity of our mobile economy & lifestyles
Implement incentives to use public transport (travel fare for families, incentives for cleaner daily commute, etc.)	Lower the energy intensity of our mobile economy & lifestyles
Increase the purchase of low-energy vehicles for national and local government fleets	Lower the energy intensity of our mobile economy & lifestyles
Develop integrated multimodal information systems for travelers	Lower the energy intensity of our mobile economy & lifestyles
Develop infrastructure for better connectivity between modes	Lower the energy intensity of our mobile economy & lifestyles
Develop low energy consuming vehicles (lighter, with less power, sometimes slower).	Lower the energy intensity of our mobile economy & lifestyles
Increase efficiency of internal combustion engines	Lower the energy intensity of our mobile economy & lifestyles
Develop ITS (Intelligent Transportation System)	Lower the energy intensity of our mobile economy & lifestyles
Deepen improvement on e-mobility including efficiency of batteries	Lower the energy intensity of our mobile economy & lifestyles
Avoid excessive reliance on conventional biofuels whose real benefits depend on geography	Focus on very-low-carbon-content energies

Legend

Anticipated level of impact	Medium	High	Very high	
Indicative level of investment	Quick win	Medium investment cost	High investment cost	
Indicative level of involvement	limited or none	Low	Medium	High

Lever	Indicative GHG impact	Indicative cost	Involvement of the 3Cs		
			Country involvement	City/region involvement	Company involvement
Avoid unnecessary motorised trips					
Avoid unnecessary motorised trips					
Avoid unnecessary motorised trips					
Avoid unnecessary motorised trips					
Avoid unnecessary motorised trips					
Avoid unnecessary motorised trips					
Avoid unnecessary motorised trips					
Shift to lower-energy-consuming motorised modes or vehicles					
Shift to lower-energy-consuming motorised modes or vehicles					
Shift to lower-energy-consuming motorised modes or vehicles					
Shift to lower-energy-consuming motorised modes or vehicles					
Shift to lower-energy-consuming motorised modes or vehicles					
Shift to lower-energy-consuming motorised modes or vehicles					
Shift to lower-energy-consuming motorised modes or vehicles					
Improve modal energy efficiency					
Improve modal energy efficiency					
Improve modal energy efficiency					
Improve modal energy efficiency					
Avoid locking in alternatives with too limited or unconfirmed GHG (and other) benefits.					

Example of best practice	Strategic imperative
Avoid excessive reliance on natural gas (<15% improvement in GHG effect vs oil derivatives)	Focus on very-low-carbon-content energies
Move from ICE trains to electric trains	Focus on very-low-carbon-content energies
Move from ICE boats to electric or low-GHG boats	Focus on very-low-carbon-content energies
Implement economic incentive for the purchase of low-GHG vehicle (bonus-malus systems, fiscal incentives, etc.)	Focus on very-low-carbon-content energies
Establish better information of shippers about carriers to make informed decisions (potentially supported by economic incentives)	Focus on very-low-carbon-content energies
Shift to bio-methane and sustainable gaseous or liquid fuels derived from the "power to gas" or "power to liquids"	Focus on very-low-carbon-content energies
Deepen improvement and reduce cost of fuel cell vehicles	Focus on very-low-carbon-content energies
Deepen improvement on e-mobility energy performance	Focus on very-low-carbon-content energies
Develop retrofitting of old vehicles as a cheaper and more ecological alternative to manufacturing new vehicles	Focus on very-low-carbon-content energies
Develop reutilisation and recycling of batteries, lower mine material use, and improve manufacturing sustainability to reduce the lifecycle impact of e-mobility	Focus on very-low-carbon-content energies
Develop R&D to optimise bio-methane production, power-to-gas or liquids yield.... for gaseous and liquid fuels	Focus on very-low-carbon-content energies
Develop infrastructure for clean mobility (e.g., optimised EV charging, hydrogen refilling and networks)	Prepare the physical and IT infrastructure needed to accompany those changes
Develop technical synergism among various modes (e.g., hydrogen hubs for trains, planes, trucks, buses and cars)	Prepare the physical and IT infrastructure needed to accompany those changes
Develop intermodal seamlessness	Prepare the physical and IT infrastructure needed to accompany those changes
Facilitate ITS, including via the development of 5G services and IoT	Prepare the physical and IT infrastructure needed to accompany those changes
Increase awareness of the 4Cs: countries, cities, companies and citizens	Develop information, education, training
Develop curricula that integrate net zero emission-mobility at their core	Develop information, education, training
Develop continuing education to adapt to the changes in the professional environment induced by the transition toward net zero emission-mobility	Develop information, education, training

Other examples could include:

- Higher cities densities
- Higher mix use or/multifunctionality of cities
- Higher cycling network (will be needed also for kickscooter and other light modes)
- Higher rRestrictions for circulation
- Higher restrictions forto parking
- Higher multimodality
- Higher shared mobility services

Lever	Indicative GHG impact	Indicative cost	Involvement of the 3Cs		
			Country involvement	City/region involvement	Company involvement
Avoid locking in alternatives with too limited or unconfirmed GHG (and other) benefits.					
Shift to radically lower emitting energies					
Shift to radically lower emitting energies					
Shift to radically lower emitting energies					
Shift to radically lower emitting energies					
Shift to radically lower emitting energies					
Improve modal energy efficiency					
Improve modal energy efficiency					
Improve modal energy efficiency					
Improve modal energy efficiency					
Improve modal energy efficiency					
Develop adequate physical and IT infrastructure					
Develop adequate physical and IT infrastructure					
Develop adequate physical and IT infrastructure					
Develop adequate physical and IT infrastructure					
Inform countries, companies, cities and citizens of the need and possibilities of net zero emission-transport					
Educate to create the build of the net zero emission future					
Train current workers to adapt to changes in the short- to medium-term					

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1 See for instance IEA, 2017, *Energy Technology Perspectives 2017* chapter 5 as well as tools listed on page 23 (PPMC, IDDRI-DDP, SIMPlify, ITF-Decarbonising Transport)

2 Transport and Environment (T&E), 2016, *The role of natural gas and biomethane in the transport sector*, Tables 2-29, 2-30 and 2.31

3 For each concrete measure the level of involvement of each C (Countries, Cites/Regions and Companies) as well as the indicative level of impact on each strategic imperative is presented in an indicative manner. The level of impact and of involvement are rated from 1 to 5 based on the TDA members' collective expertise.

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17 See for instance: Anthesis Enveco AB, Institute of Energy Economics, Japan (IIEJ), 2018, *The Swedish CO2 tax – an overview*, http://www.enveco.se/wp-content/uploads/2018/03/Anthesis-Enveco-rapport-2018-3.-The-Swedish-CO2-tax-an-overview.pdf

18 See for instance the European Battery Alliance developed by the EU, some EU countries, the European Investment Bank and private actors.

19 IPCC, 2018, SR1.5, Technical Summary – 8, http://www.ipcc.ch/report/sr15/

20 Definition provided by the Sustainable Mobility for All initiative.

21 The French SNBC ("Strategie nationale Bas Carbone" – National Low Carbon Strategy) and PPE ("Programation Plurianuelle de l'Energie" - Multi-annual Energy Programming) which state long term goals with intermediate milestones and include a mandatory review every five years can be used as potential examples.

22 To date, many states have taken such steps or are in the process of doing so for GHG emiting cars including the Netherlands (ban by 2030), the UK, France, California (ban by 2040).

23 For more details see: https://www.ecologique-solidaire.gouv.fr/sites/default/files/17160_brochure_presentation_Assises%20nationales%20de%20la%20mobilit%C3%A9_8p-EN.pdf

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