

Launch innovative mobility to drive growth and urban well-being!



**CHENGDU 2014
GLOBAL SUMMIT**



GREEN PAPER



A person wearing a red and black plaid shirt and a helmet is riding a black bicycle on a city street. The background is blurred, showing cars and buildings, suggesting motion. The text is overlaid on the top right of the image.

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Be daring! Be innovative!

Innovate with conviction! And trust in the vitality of a market guided by society's real priorities.

Since 1998, the Michelin Challenge Bibendum has been striving to identify pathways to the development of sustainable transportation of goods and people. Its purpose is to facilitate the transition to forms of mobility capable of reconciling their global expansion with humanity's changing needs.

We feel that everyone should have access to modern mobility, i.e., mobility that is clean, safe, connected, economically affordable and physically accessible.

This document is a call to concerted action. It is the result of a collective intelligence process involving dozens of experts, all of them recognized in their fields and committed to taking a bold, yet common-sense approach.

They feel that mobility must develop to support economic growth and people's fulfillment. They are also convinced that pollution, congestion and the worsening consequences of climate change are not inevitable. To the contrary, available solutions for efficient, low-carbon mobility, combined with digital technologies, will serve as springboards to a new mobility economy. Because mobility is key to access education, health care, jobs and is a growth driver. To achieve this goal, public and private sectors must work together. This Green Paper hopes to compel a powerful initiative in this direction.

When addressing questions as complex as growth, the future of mobility and climate, convictions are crucial and dogmatism is entirely out of place.

So let's start talking today about these issues, whose stakes involve the future and the security of humanity.

Dr Patrick Oliva
Michelin Challenge Bibendum Chairman





SSIBLE

EXECUTIVE SUMMARY

EXECUTIVE SUMMARY



Daring to transform transportation for the good of everyone

Today, demand for mobility is growing around the world. People expect safer, easier, healthier and more pleasant solutions. These demands are especially strong in cities, where demographic pressure is causing the main economic, social and environmental challenges of the future to converge.

These trends concern every mobility stakeholder.

■ **Health** has become a top priority, with a focus on reducing stress, noise, pollution and accidents.

■ The issue of **greenhouse gases** is also becoming critically important, raising questions about the energy transition in transportation and energy efficiency.

■ While aware that their appeal depends in large part on the efficiency of their transport systems, cities often lack the public **financing** needed to meet the challenge of modern mobility. At the same time, **congestion** is becoming the bane of both society and the economy. And the need for **much more inclusive mobility** is rising, in particular to support economic growth and job creation.

All of this means that working together to build new mobility models is a valid objective.

Based on its international expertise and wide-ranging experience, the Michelin Challenge Bibendum community recommends that this process focus on five game changers. To deliver the desired innovation and improved quality of life outcomes, these priorities should be acted on together. This means that we have to:

■ **Set ambitious global CO₂ emissions reduction objectives** for all anthropogenic activities over the medium and long term; implement the relevant economic instruments in transport.

■ **Implement ultra-low emission (ULEZ) that will also be high safety zones in urban areas.** This will help to shift behavior to more efficient intermodal transport and encourage the use of electric mobility solutions, with the corresponding vehicles and infrastructures.

■ **Provide creative door to door solutions for people.** They will build on the currently available station-to-station solutions, strengthening social ties and creating opportunities for innovation, including through relevant web-based applications.

■ **Re-organize urban last-mile freight delivery systems**, a sector that is expected to experience considerable growth but which has not yet completed its technological and ecosystemic changeover.

■ **Promote private investment** in transport infrastructure and innovative mobility services to fund the capital investments demanded by the massive deployment of these recommended solutions.

While most of the tools needed to meet these objectives are already available, albeit often on a small scale, **five actionable levers should take priority**:

■ **Encourage the emergence of innovative ecosystems**, to support the development of new mobility products and services. These ecosystems should be able to break across the traditional boundaries between the public and private sectors and drive development of profitable business models, capable of serving as many people as possible. Affordability and profitability must be reconciled.

■ **Support tomorrow's winning technologies**, particularly in areas required by modern transportation modes, such as electrical power supply, information and communication technologies, automation techniques, intelligent transport systems (ITS), and large database management.

■ **Facilitate the introduction of new economic instruments**, including those with carbon pricing mechanisms. Such instruments will create financing opportunities for sustainable mobility and a different economic rationale.

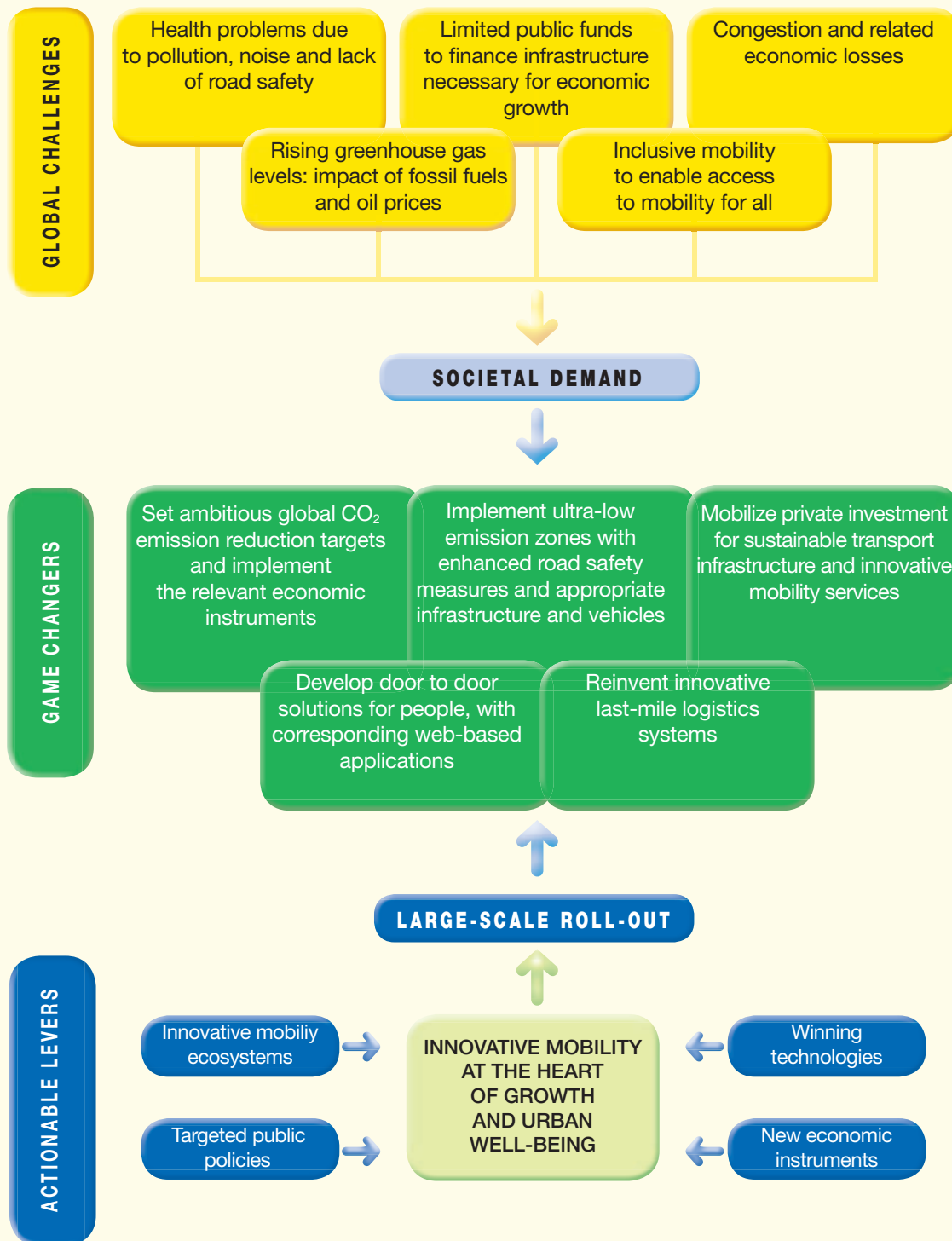
■ **Introduce just the right number of targeted public policies** to support the emergence of new solutions; create the conditions for broader, fair competition; stimulate individual and collaborative initiatives and set ambitious objectives. Together, these policies will drive faster growth in the mobility market.

■ Lastly, because the need for mobility will necessarily increase and the challenges involved are already immense, we need to focus on **large scale, coordinated roll-out of the five game changers**.

Today, when expectations are changing and new technologies can be effectively harnessed, we have a window of opportunity to initiate radical change. The development of the five game changers will have a **significant impact** on the reduction of local pollution and CO₂ emissions. In this area, the initial quantitative simulations show that it is possible for the transportation sector to move close to the International Energy Agency's +2°C scenario in 2100. What's more, at a time when the world's urban population is rapidly growing, investment in innovative solutions and CO₂ pricing instruments are the surest way to drive business development in the transportation sector.

In light of the environmental benefits to be reaped, simulations show that a free fall in economic activity induced by the game changers we propose to introduce in the structural foundations of the current transport system must not be feared.

The diagram below sums up our approach, which is based on 5 global challenges, 5 game changers and 5 actionable levers.





Mounting societal demand calls for game changers!

The demand for safer, easier, healthier and more pleasant mobility continues to rise, particularly in cities where economic, social and environmental challenges are concentrated.

This demand can take multiple forms, including optimizing existing assets and private vehicle parks which are seldom used. Often latent, it frequently expresses itself with the launch of a new mobility service or a technological innovation.

Each mobility player has specific expectations regarding the transportation of people and goods:

Citizens are now demanding better living conditions in urban environments and for ways to reduce the time spent on daily commutes and trips. Congestion, environmental pollution, accidents, noise and stress are reaching critical levels. The situation is not getting any better despite tangible improvements over the last 15 years in car efficiency and urban flow management. Overall, travel remains tedious and costly, especially for those on a low income. Yet mobility is vital for citizen-consumers. Indeed, access to education, jobs, healthcare, food and thus a better quality of life depends on it.

With the rise of information and communication technologies, people are gradually taking back control of their mobility choices. The growing use of new digital applications enables more effective and less stressful urban travel and promotes stronger social ties. Digitization is allowing human ingenuity to express itself and people to adjust to the constraints of mobility imposed upon them by poorly integrated transport systems. New schools of thought about behavioral and conventional economics, as well as experiments in «nudge» theory, are making better use of people's behavior and individual initiative to invent smarter and less resource-intensive mobility. We now know that it is possible to ease urban congestion while preserving individual freedom and appealing to personal responsibility, without relying upon the power of the state or the law maker. More than the cities, it is the people who are becoming «smarter».

Strong demand for new door to door transport solutions that complement the predominantly station-to-station solutions of today also provides great growth opportunities for the mobility market. As a result, innovative solutions to the multiple traveling needs of the public must systematically factor in convenience, customization, safety, accessibility and affordability, pleasure, permanent connectivity, use rather than ownership, and so on.

Companies need more efficient and better-managed transport. That is because they too bear the economic consequences of transport-related externalities such as unnecessary fuel consumption due to congestion, wasted time, accidents, employee stress, etc. In search of growth and optimum satisfaction for their stakeholders, they are now readier than ever to sign up to innovative sustainable mobility programs, provided the legal and regulatory framework is dependable, consistent and stable.

Vehicle manufacturers and their suppliers have made considerable efforts in the last few years to improve the efficiency of combustion engines, reduce fuel consumption and offer a number of alternative energies. The connectivity and IT revolution is opening up new, unprecedented avenues of progress and innovation, while drawing in new players from other industries. The response to global mobility challenges will be effective only if all players manage to cooperate and integrate their skills and know-how in the development of new services. This includes cooperation among industries, public authorities, startups, consultants, academics, etc. Developing increasingly sophisticated and complex solutions that improve urban logistics efficiency requires just such an approach.

Public authorities know that the ability to move people and goods will, in the future as it has in the past, drive much of the economic growth and, therefore, the jobs and well-being of their constituents. But they are also aware that transport growth has been, up until now, responsible for the rise in negative externalities such as congestion, urban pollution, road accidents and CO₂ emissions. As regards CO₂ emissions, gradual awareness of the catastrophic impacts of climate change gives cause for hope that the Paris Conference of the Parties (COP 21) in 2015 will result in concrete measures to tackle this critical issue for humankind. That said, sustainable mobility development calls for higher, and now urgent, investment in infrastructure and maintenance. The later such investment decisions are taken, the greater the costs incurred. However, national governments alone cannot fund the development of solutions to multiple mobility challenges, especially as many of them face gaping budget deficits due, among other things, to the rising cost of their energy bills and their dependence on fossil fuels. Increasingly, therefore, they are trying out new economic instrument mixes and calling for partnerships with the private sector. They are expecting regional and local (city) authorities, in turn, to assume greater responsibility for resolving issues of congestion and pollution.

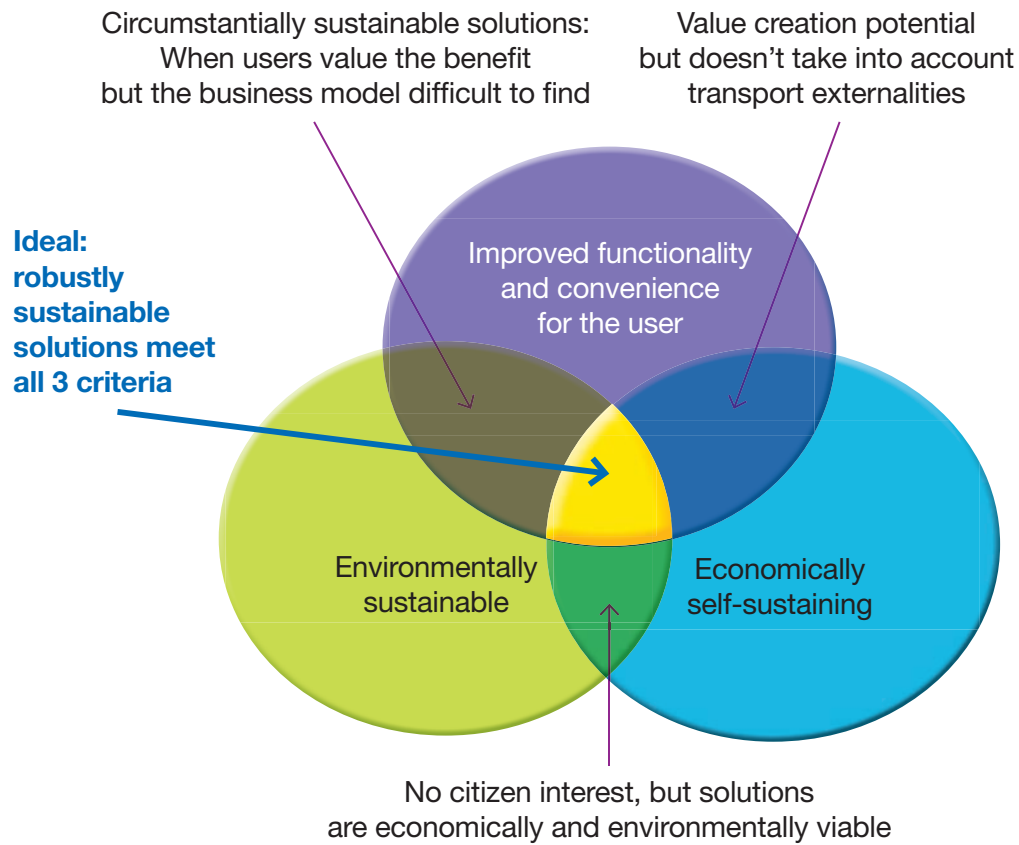
Indeed, **cities** are taking up the slack. While results so far are mixed, it is demonstrably clear that courageous and innovative decisions do pay off. The establishment of low-polluting emission zones is a case in point. Cities realize these zones offer a triple benefit: reduced congestion and stress, lower emissions of local pollutants and of CO₂, and improved safety and quality of life. City authorities are becoming increasingly proactive in encouraging their transport providers to become mobility integrators offering perfectly seamless mobility solutions «from city center to airport». Today's municipalities must become enlightened transport managers in their own right because their constituents will increasingly blame them for any urban mobility management failures. That is why they seek to create ecosystems that will provide them with winning technological solutions and the appropriate economic instruments.

Almost 3 billion people will be converging to cities over the next 35 years. It is abundantly clear that access to mobility for all will not be achieved by simply scaling up existing transport solutions that have reached their limits. We need game changers!

Startups, consultants and academics also represent major sources of innovation. They are able to think differently and come up with new technologies, redesigned economic tools and new business models. Academics are undoubtedly central players in the new mobility ecosystems due to of their scientific, economic and sociological knowledge, as well as their experimental know-how. Experiments are essential to validate proposed solutions before a large-scale roll-out. This is especially true when designing interconnected and combined solutions for specific cities or population segments (women, suburban residents, vulnerable groups such as the elderly, the young, the disabled, etc.).

The success of future, citizen-led mobility initiatives will depend on a proper understanding of these new society-driven demands.





The challenge is to invent positive mobility experiences as opposed to managing – poorly for the most part – the day-to-day operation of inadequately integrated transport systems.

To that end, the «Michelin Challenge Bibendum» community of interest – mindful of the major transformations brought about

by information and communication technologies and by the changing attitudes of the new generations – recommends focusing immediately on five game changers that will radically alter the transport modes of the future.



GAME CHANGERS

Set ambitious global CO₂ emission reduction targets and implement the relevant economic instruments

Implement ultra-low emission zones with enhanced road safety measures and appropriate infrastructure and vehicles

Mobilize private investment for sustainable transport infrastructure and innovative mobility services

Develop door to door solutions for people, with corresponding web-based applications

Reinvent innovative last-mile logistics systems

These initiatives result in synergies and satisfy the significant mobility growth expected in the years to come. They mutually aim to encourage innovation, promote investment in large-scale roll-outs and leverage urban demographics to stimulate economic activity.

Taken together, they can help create a mobility system that redistributes revenues generated from reducing emissions and managing congestion.

We are acutely aware that transportation scenarios in the United States, China and in India are not similar, and are unlikely to be even in 2050!

Nevertheless, we are convinced that the five game changers discussed in this Green Paper will foster, here as elsewhere, the development of sustainable mobility solutions harmonizing economic growth and the future of humankind.

Erik Grab

Vice President, Michelin, Strategic Foresight



1

GAME CHANGERS



introduction

Launching all five game changers today!

The five game changers are able to spur, directly or indirectly, technological or regulatory innovation and facilitate implementation of new business models. All potentially create value.

Indeed, these game changers work in synergy with each other. Implementing one helps to implement the others and boosts their combined effects. By setting ambitious CO₂ reduction targets, we will lower fossil fuel consumption and thereby limit pollutant emissions, especially in urban areas. The creation of ultra-low emission zones (ULEZs) with enhanced road safety measures will thus be facilitated. This, in turn, will help bring to market innovative improvements in the transportation of people and goods, such as new vehicles and services designed to meet the door to door mobility needs of individuals, and an efficient last-mile delivery system with optimized truck loading rates, for example. New business models, and the value they create, will attract private capital when public authorities provide proper regulatory and legal stability and investors are assured of a return on investment in the long term.

Finally, these game changers apply to all modes of transport as part of a multi-modal approach. They target key externalities such as pollutants, accidents, CO₂ emissions, noise and stress. Their simultaneous implementation and technological corollaries will have a positive impact on the convergence of transport systems towards sustainable mobility. A case in point is the large-scale development of electric mobility and intelligent road transport solutions (ITS).

The choice of these five game changers is powerful, simple and realistic. To create a virtuous circle of solutions to global mobility challenges quickly, it is essential to prioritize the multiple responses they engender.



1 Setting **ambitious** CO₂ reduction **targets** and implementing the relevant **economic instruments**

Since the publication of the IPCC* report in 2007, all international experts have gradually come to agree on the need to maintain greenhouse gas (GHG) concentrations in the atmosphere below the 450 ppm tipping point to 2050 and beyond, in order to have a reasonable chance of limiting global warming to 2° C above preindustrial levels in 2100!

Putting off the necessary decisions will only complicate solving the problem. With little more than a year to go to the Paris COP21, and in the face of worrying climate change developments, it is obvious that the international community is dragging its feet over implementing appropriate measures. Yet the status quo is ethically irresponsible. The 2014 Intergovernmental Panel on Climate Change (IPCC) report confirms the critical nature of the issue. The challenge therefore lies in stabilizing atmospheric greenhouse gas concentration. This can be done. The first step is to put a price on CO₂.

The IPCC finding is quite clear – we must act. Now!

1/ PREVENTING DEVELOPMENTS WITH DEVASTATING CONSEQUENCES

This chapter sets out a framework for successfully tackling the situation. A fairly stable climate and a healthy atmosphere are invaluable assets for all living beings on earth. Yet, this heritage could be under threat due to the growing use of fossil fuels, in particular. If current trends are not reversed and steps are not taken to curb the accumulation of GHGs, the scientific community has made it clear that irreversible changes would occur, endangering our climate, our natural ecosystems and our communities. To prevent GHG accumulation and preserve our atmosphere and oceans, we must limit the use of fossil fuels contained in the earth. If all the earth's fossil fuel resources were to be consumed, CO₂ levels in the atmosphere would increase eightfold! Limiting this consumption, however, is a huge challenge, since two thirds of global growth in the last 40 years has been fueled by energy consumption.

Given current trends, the average global temperature in 2100 might rise from 4° C to 6° C, with strong geographical variations.

The earth's mean surface temperature has always fluctuated. What is new and worrying is the speed of recent variations, raising doubts about the ability of natural ecosystems and human societies to adapt. As water and food will be affected first, the global challenge is all the more pressing.

The first greenhouse gas is water vapor, which makes up about 0.4% of the atmosphere. It is responsible for 60% of the solar radiation reflected down to the earth's surface. The rise in water vapor emissions from soil evaporation and plant transpiration caused by global warming, however, does not significantly increase the greenhouse effect since this phenomenon is confined to the lower layers of the atmosphere. The atmosphere is made up of nitrogen (78%) and oxygen (21%). Other gases are naturally present in the atmosphere, including argon (0.93%). Only 0.1% of other molecules in our atmosphere contribute to the greenhouse effect. These include highly active gases such as carbon dioxide (CO₂) which makes up 25%, ozone (O₃) 8%, methane (CH₄) and nitrous oxide (N₂O) 6% between them, and fluorinated industrial gases (PFC, HFC and SF₆). For 450,000 years, the relationship between greenhouse gas concentrations in the atmosphere and the atmosphere's mean temperature has been highly correlative: the more these gases are present, whether naturally or not, the more the surface of the earth warms.

*For all acronym see at the end of the Paper.

Potential synergies between different measures

Anthropogenic greenhouse gases (resulting from human activity) amplify the natural greenhouse effect. Over the past century, increasing industrialization has led to a sharp rise in these emissions. Furthermore, a strong link exists between greenhouse gas emissions and those of the main air pollutants, i.e. finer particulate matter (PM_{2.5}), sulfur dioxide (SO_x) and nitrogen dioxide (NO_x). These air pollutants are generated, as is CO₂, by industrial burning of fossil fuels, energy production, heating and transport.

The effect of cogeneration reveals potential synergy between various anti-pollution and carbon emissions reduction measures. The latter could lead to further substantial reductions in PM_{2.5}, NO_x and SO_x emissions, in addition to CO₂. The table below shows the correlation between pollutant reduction and GHGs in China measured by researchers.

Reducing NO_x through CO₂ reduction (China)

	10 %	25 %	50 %	75 %
2015	5 %	12 %	28 %	49 %
2020	4 %	11 %	26 %	46 %
2050	3 %	8 %	19 %	31 %

Reducing SO_x through CO₂ reduction (China)

	10 %	25 %	50 %	75 %
2015	6 %	16 %	34 %	56 %
2020	5 %	14 %	31 %	53 %
2050	3 %	10 %	24 %	37 %

Source: Synergy between pollution and carbon emissions control, TSINGHUA-MIT China Energy & Climate Project, Oct. 2013.

These figures show that capping CO₂ emissions will directly impact climate change and indirectly impact air pollution.

CO₂ emissions reduction will therefore have a direct positive impact on climate change and an indirect impact on air pollutants, since it involves cities adopting energy systems cleaner than those that burn fossil fuels.

The high cost of inaction

The benefits of acting forcefully and quickly to contain climate change far outweigh the potential costs of inaction. The Stern Review on the Economics of Climate Change had already come to that conclusion back in 2006. The report highlights the potential impact of climate change on water resources, food production, health and the environment. According to the study, the global cost of inaction would amount to wiping some 5% off global GDP indefinitely, year after year. Moreover, a greater number of risks and their impacts could amplify this phenomenon, knocking 20% or more off GDP.

Meeting the world's growing energy needs will require more than \$48 trillion in investment until 2035, according to a special investment report published this year by the International Energy Agency (IEA) as part of the World Energy Outlook series. The «450 ppm i.e. +2° C by 2100» scenario would require an additional \$5 trillion, amounting to only 0.6% of global GDP in additional annual spending.

Ever since the industrial revolution, the global economy has benefited from the free use of the atmosphere for storing greenhouse gases. Economic players have used it as an infinite reservoir capable of absorbing all emissions. Today, the accumulation of these gases in the atmosphere is such as to threaten the very stability of our climate. We therefore need to take action. As explained by Lord Stern in his report published in 2014, nothing will be possible without the involvement of the authorities and will require innovative policies and a stable regulation landscape to promote investments.

The crucial role of transport

Transport plays a vital role because of the sharp increase in traffic and its near total dependence on fossil fuels. Its carbon emissions are on the rise and must therefore be reduced. This can be done, and yet transport is not sufficiently emphasized on the agenda of international discussions on GHG emissions reductions. Notwithstanding, this sector has been striving to reduce its CO₂ and pollutant emissions on a per vehicle basis. Progress, however, can only be achieved at global park level (car, truck, train, boat, plane, etc.).

REGULATORY

1 CO ₂ emission standards	Vehicles must comply with a prescribed CO ₂ emissions level	UE: CAFE (Clean Air For Europe)
2 Fuel standards	Fuel must lower their CO ₂ emission levels	USA: binding targets for biofuels (15% : E15)
3 Speed limits	Introduce appropriate speed limits	Spain: 30 km/h in urban zones
4 Very low emission zones	Permit access to certain areas to low emitting vehicles only	Tokyo: LEZ 2003 Berlin: LEZ 2008...
5 Alternate traffic routes	Condition vehicle access by license plate	Beijing: during the 2008 Olympic Games
6 Restrictions on vehicle ownership	Condition car ownership via vehicle quota systems	Shanghai: clean vehicles enjoy free registration
7 Parking restrictions	Limit parking time slots	London: between 8.30 am and 6.30 pm

INFRASTRUCTURE

8 Reserved lanes	Create permanent or semi-permanent dedicated lanes for high occupancy vehicles	Beijing: for buses during rush hours
9 Soft transport modes	Create dedicated lanes for pedestrians and "clean" two wheelers	Australia: cycling promotion

PRICE CONTROL

10 Review of taxes and subsidies on purchases	Review taxes or subsidies on new vehicles, tax rebates, and subsidies for clean vehicles Introduce scrapping incentives and taxes on company cars	China: 10% mark-up on purchase price (clean vehicles are exempt)
11 Review of taxes and subsidies on usage	Review emission taxes, fuel taxes, kilometers-driven taxes, tolls, parking charges, pay-as-you-drive insurance	London: congestion charge
12 Public transport pricing	Introduce free fares, zonal pricing, customized pricing	Shanghai : tarification progressive

VOLUME CONTROL

13 Allowance trading market	Restrict annual CO ₂ emission volumes and introduce cap and trade schemes	EU: ETS (Emissions Trading System)
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EQUIPMENT AND TECHNOLOGY

14 Vehicle optimization	Promote optimized vehicles (hybrids, EVs, etc.)	China: electric vehicle promotion
15 Intelligent traffic systems	Monitor and regulate traffic and gather big data conducive to the creation of new businesses	Amsterdam: ASC (Amsterdam Smart City)
16 Public transport development	Develop transport systems by BRT, tram, subway, train, boat	Curitiba: BRT (Bus Rapid Transit)

A number of solutions are touched on in this Green Paper. All are underpinned by certain prerequisites. The strongest solution appears to be one in which a price is put on the externality embodied by CO₂ since it is common to all transport solutions. As CO₂ has a global impact, it is necessary to implement an ambitious global project. And because 75% of global CO₂ is emitted by cities, their involvement is crucial.

Creating a carbon economy

Putting an economic value on carbon dioxide will change the behavior of all market players, especially consumers. The idea behind carbon pricing is to encourage players in the sector to choose solutions with low greenhouse gas emissions, create new sources of revenue and make it more expensive to use goods and services that generate high emissions.

Putting a price on this negative externality allows products or services to be distinguished by their carbon footprint. Furthermore, carbon pricing helps optimize utilization of high GHG emission products with the help of existing technologies. It enables income thus created to be channeled to transport infrastructures and/or to lower the cost of mobility of both people and goods.

The various economic tools available are described in detail in the chapter on «New Economic Instruments», with the two main approaches summarized below.

A | Direct instruments:

- Carbon taxation. A carbon tax sets a price for CO₂ emissions. Its rate, expressed in euros per tonne of CO₂ emitted, serves as the basis for calculating that price. The tax adjusts the relative prices of assets or energy sources according to their carbon content (€/tonne).
- Emission trading or cap and trade. In a greenhouse gas emissions allowance trading system, or “carbon trading”, the public authority sets a quantitative emission reduction target and the market then sets a price. A global emissions cap ensures that environmental targets are met. The authorities set the total volume of authorized emissions by distributing or selling a limited number of allowances (1 allowance = the right to emit 1 tonne of CO₂).
Tax or trade: usually at opposite ends of the spectrum, tax measures and trading schemes have more similarities than differences and are often complementary. In theory, tax incentives and negotiable allowances rely on the same pricing

mechanism and produce similar economic effects. Assuming players have perfect information, the two instruments ensure emission cuts at the lowest cost to the community. When properly implemented, they can produce substantial savings compared with public policies imposing mandatory standards. In practice, though, the two instruments seek to achieve different goals. Under a trading system, the focus is on the quantity of emission cuts, whereas in a tax system it is on the price of emission cuts.

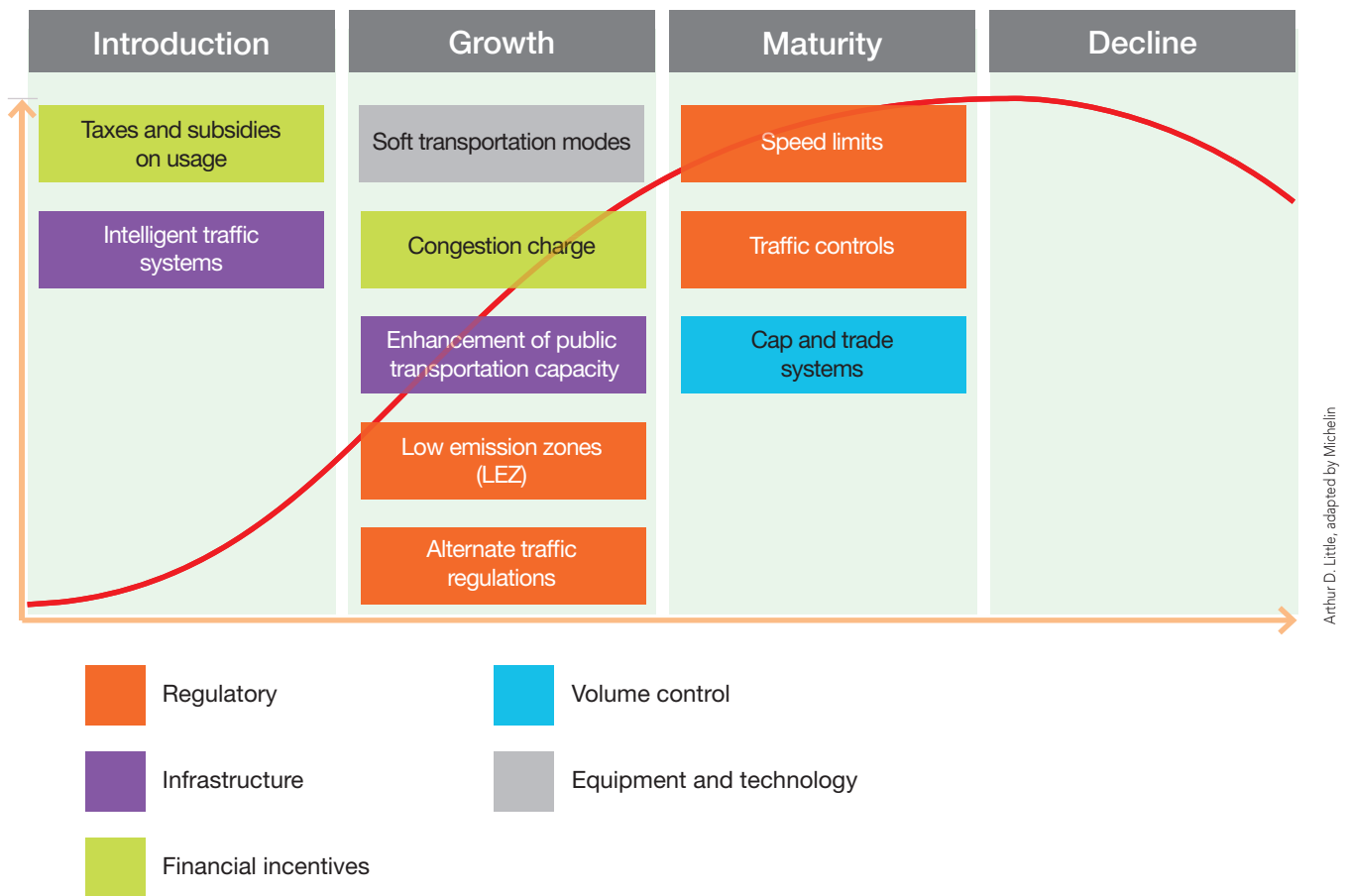
B | Indirect instruments such as low emission zones, scrapping schemes promoting the use of cleaner new technologies, city-center tolls, etc., are also available

4/ RECOMMENDATIONS ON ECONOMIC INSTRUMENTS AND URBAN MOBILITY

Solutions for the transport sector must make road transport their top priority as it is responsible for some 17% of CO₂ emissions from fossil fuel combustion. Halving transport emissions by 2050 while the number of vehicles is expected to double requires a four-fold progress in CO₂ emissions reduction! Given that cars, in real life conditions, emit around 200 g of CO₂ per km on average (from one of the end of chain to the other, or «well-to-wheel»), the challenge is to cut emissions over the entire well-to-wheel cycle to 50 g/km by 2050! Or to about 300 g for trucks! This challenge is manageable.

There are various solutions for promoting low carbon mobility. Some are at the development phase while others are at maturity, as illustrated in the figure below.





As the transport sector is not homogeneous, it is difficult to compare trains, ships, jets, cars and trucks. The best way of providing financial incentives to cut CO₂ emissions is to price CO₂ on the basis of a fuel's CO₂ emission and to charge it on top of the fuel price. This would generate the necessary income to fund a virtuous system.

A regulatory approach to promote technological innovation is also necessary. It consists in gradually capping the road fleet's average well-to-wheel CO₂ emissions by 2050 at 50g of CO₂ /km, 300g/km for trucks and similarly ambitious levels for other transport modes. A gradual progression towards a CO₂ price at \$130/tonne minimum in 2040 is also recommended (IEA). For optimum impact, we advocate the introduction of indirect CO₂ emissions reduction instruments, particularly ultra-low emission zones (ULEZs). It is only by adopting measures at national and international level, backed by local initiatives on a massive scale, that the global economy can be made less reliant on fossil fuels.

To sum up, scientists are calling for strict adherence to a 50% CO₂ emissions reduction target by 2050, while politicians are increasingly in agreement that this is the direction to take.

Although all sectors of activity are not in the same situation, each must contribute and align itself with the 50% reduction target. The technologies and services that should be implemented already exist, so staying focused on them will help drive innovation and growth. This creates a positive dynamic for the planet and society as a whole.



2

Implementing **ultra-low** emission zones with enhanced **road safety measures** and appropriate infrastructure and vehicles

Tokyo 2003: establishment of the first LEZ (low emission zone) which is a resounding success today! London 2008: establishment of a vast LEZ whose outcomes match expectations. London mayor Boris Johnson has announced the LEZ's conversion to an ultra-low emission zone (ULEZ) by 2020, with only zero or very low local emission vehicles allowed to drive in central London during working hours. The development of hybrid buses, zero local emission taxis and low local emission goods vehicles will be encouraged. Construction and building will also be regulated. Current measurements show a leveling off or drop in particulate matter and a fall in NO_x levels inside as well as outside London's LEZ, which covers roughly 1600 km² and serves some 7 million inhabitants.

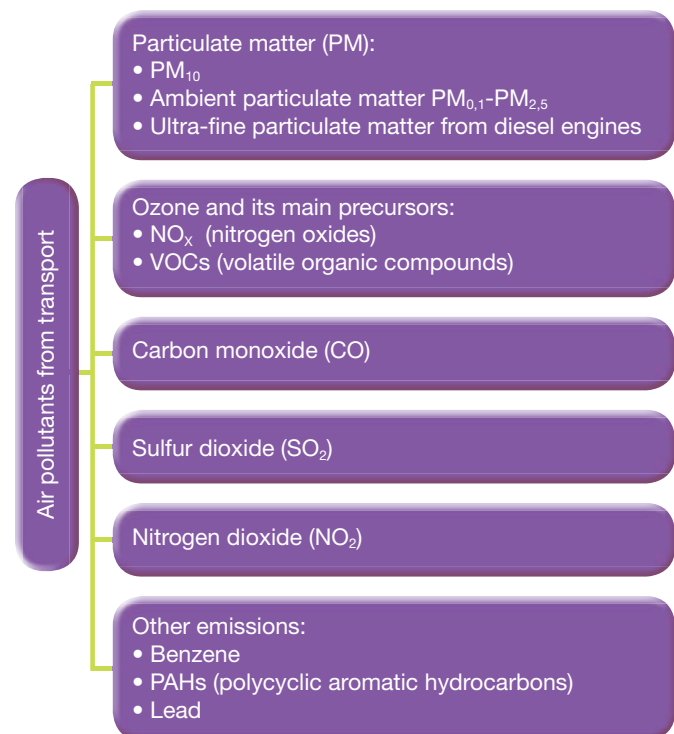
This solution offers bright prospects, so let us develop it!

1/ LIMITING POLLUTANT EMISSIONS FROM TRANSPORT

Rapid urbanization in many cities is leading to growing road uses, ever-increasing pollutant emissions and poorer air quality. The World Health Organization thus sums up the scale and impact of urban air pollution caused by multiple sources such as energy, heating and transport thus:

- more than 1 billion people are exposed to air pollution above the tolerable thresholds; urban air pollution is responsible for 1 million premature and just as many perinatal deaths annually;
 - the cost of urban air pollution (UAP) amounts to about 5% of GDP in developing countries and 2% in developed countries.
- The cost of health impact of road transport has ever been evaluated by OECD (2014).

Air pollutants from transport are divided into six broad groups:



Arthur D. Little, adapted by Michelin

These pollutants are harmful to human health and responsible for chronic diseases. CO₂, of course, is not on this list since it is not a local pollutant. It has a global impact on the planet and a longterm impact on climate but does not directly affect people's health. The primary goal of emissions reduction policies is therefore to improve the state of health of the population.

Exhaust gases from vehicles are a source of PM_{2.5} emission in cities. In Beijing, they would account for 22% of the city's PM_{2.5} levels. Coal combustion is the biggest emitter of this particulate matter in the Chinese capital's suburbs. Cities must find a way to prevent these emissions, chronic congestion and the excessive consumption of energy they imply if they want to achieve their goals of improving the quality of life and easing traffic in city centers. Clearly, a holistic approach is called for so that the problems are not simply shifted from the center to the suburbs.

2/ REDUCING AIR POLLUTANTS, CONGESTION AND ACCIDENTS

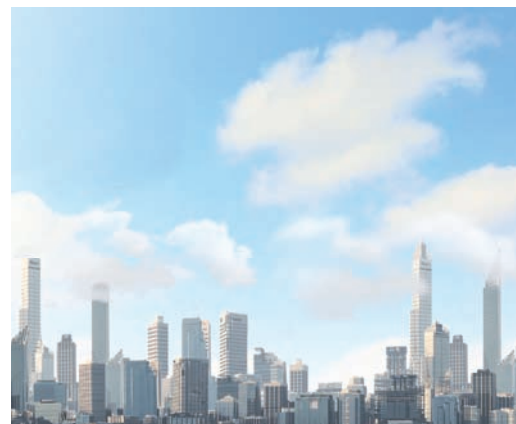
A range of solutions is available, including measures to address the issues of harmful emissions and congestion related to urban mobility: sensible management of the flow of persons and goods in cities, appeals to civic responsibility that facilitate changes in behavior, reduction in vehicle emissions, promotion of green modes of transport, taxation of traffic-based on congestion, and so on. If combined, they would significantly mitigate environmental problems and congestion, improve the quality of life and regenerate city centers. Introducing areas with emission restrictions greatly helps to achieve an overall reduction in CO₂ emissions. That said, the way electricity is generated must continue to be monitored, especially in terms of the pollutant and CO₂ content of each kWh produced. Schemes to reduce vehicle emissions by restricting the access of certain types of vehicle in or around the city center could be implemented over larger areas. Appropriate technological solutions are discussed in the chapter on winning technologies. One such scheme consists in creating ultra-low emission zones. Polluting vehicles are either banned from entering these areas or charged an entry fee if their emissions exceed a certain threshold. The purpose of an ULEZ is to reduce traditional forms of air pollution. At the same time, it reduces CO₂ emissions and congestion, while enhancing well-being.

A complex ecosystem that strikes a balance between public and private players

Tokyo established a LEZ in 2003 and was the first city to do so. Since 2006, LEZs have spread across Europe on the back of tougher air quality standards. Local authorities have decided to roll them out on a large scale. Some 180 LEZs were already established in Europe by 2011, including a hundred or so in Italy alone and strong involvement in Sweden (Gothenburg, Lund, Malmö and Stockholm) and Germany (Berlin, Cologne, Hanover and Stuttgart).

There is no single model, and cities may choose different ways to establish a LEZ based on scale, rules of access, planned pricing, etc. To do so, they must rely on an ecosystem that convenes public and private stakeholders. Most of these zones operate round the clock, 365 days a year, except for some Italian LEZs.

LEZs admission criteria vary, requiring compliance with one or more European standards. However, they are a technological showcase for green solutions designed to improve the quality of life of communities and promote awareness among inhabitants. As such, they serve as life-size laboratories for new infrastructure, public-private cooperation, regulatory harmonization, and so forth. Far from seeking to eliminate road transport, LEZs ensure their sustainable development. It is indeed possible to plan and develop green public and private transport modes for low emission zones without sacrificing economic efficiency or people's comfort – quite the contrary. To ease implementation, they could be introduced over time, with increasingly ambitious measures and wider areas being covered over time.



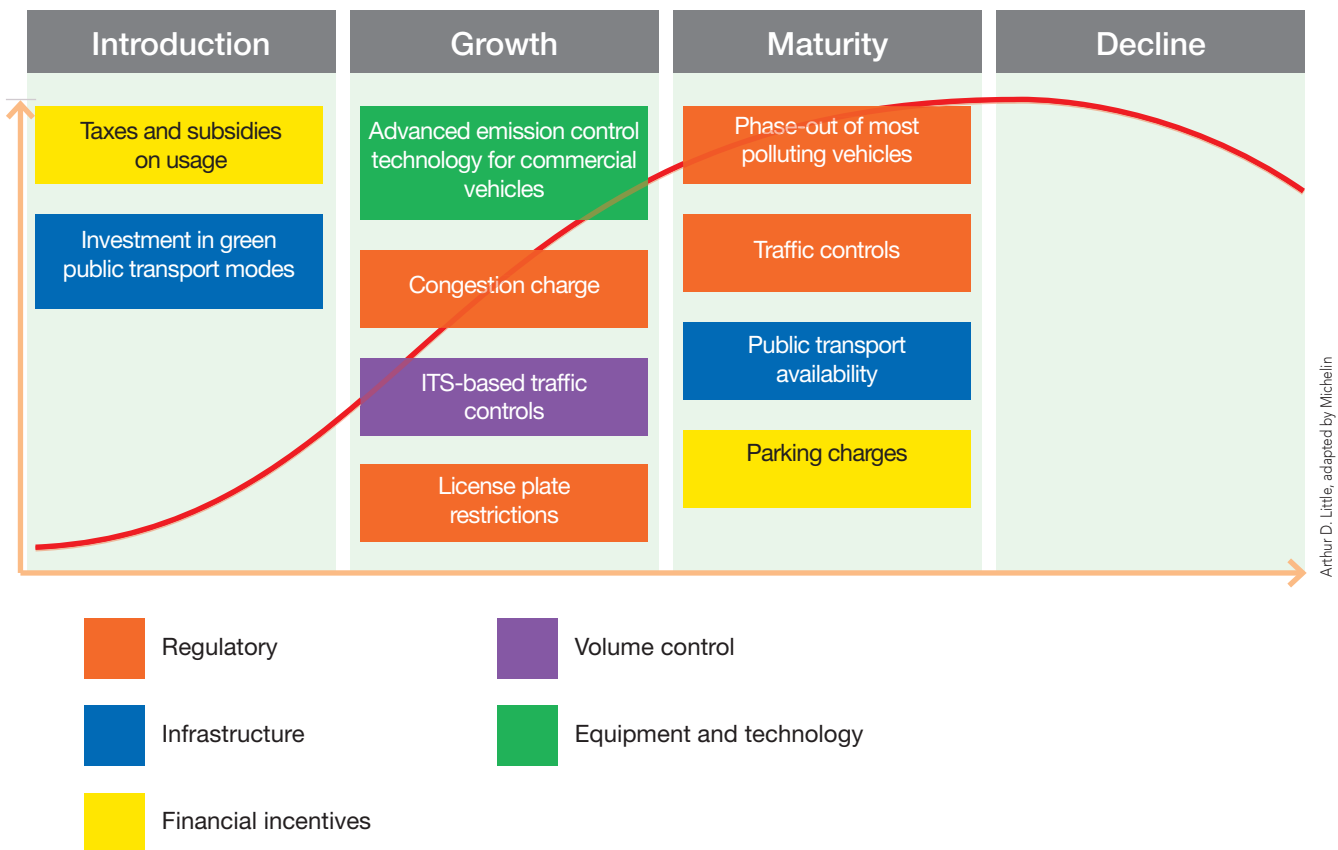
3/ INTRODUCING LOW EMISSION ZONES (LEZS), FOLLOWED BY ULTRA-LOW EMISSION ZONES (ULEZS)

To create a LEZ, the local authority has to define the area to be covered, the emission targets to be met, the pollutants to be measured, the traffic control system to be used and the clean and affordable alternative public and private transport modes to be adopted. The measures should strive for balance, as in Lisbon for instance, where parking charges are high but very affordable for residents. LEZs are the tool of choice for local authorities who have all the instruments at hand to put them in place.

A LEZ has multiple goals from empowering transport users to mitigating local pollution and congestion, increasing eco-efficiency and providing better

safety for pedestrians and two wheelers, among others. To establish a low emission zone in the city center, technically local authorities first need proper infrastructure, intelligent transport systems (ITS) for monitoring and control purposes, and dedicated lanes for the most efficient modes of transport. They also need to finance the setting up and operation of the LEZ through their own funds or via public private partnerships. Most cities phase in their LEZ or develop it gradually through modernization projects.

The curve below shows that the instruments required to set up and operate a LEZ are similar to those used to reduce CO₂ emissions (see 1.1). It also shows that while some are tried and tested, others such as «taxes and subsidies on usage» are still operating on experimental bases.



Presenting the advantages to stakeholders

The first step in the creation of a LEZ is to facilitate the public's understanding of its regulations. In particular, this involves explaining the benefits – less congestion, pollution and noise, better public health – to the various stakeholders, including users. It is essential to communicate the goals and benefits of the LEZ clearly and forcefully so as to ease the concerns raised by the project and the changes in lifestyle it entails. Transparency and frequent reviews are necessary so that concrete improvements can be seen. A LEZ will only be successful if city authorities provide efficient alternative modes of transportation and actively communicate the benefits of the zone. This means performing quantitative impact assessments based on traffic flow and emissions monitoring data, certified by a reliable and independent third party. The LEZ must on no account isolate its residents from outlying areas, nor undermine inhabitants' comfort or need for flexibility. They should serve to boost the economy of the city and to encourage the creation of an effective multimodal urban network. These prerequisites should be factored into the city's development plans from the outset. If public transport is saturated – as in Beijing, Sydney and Osaka where subway usage reaches 135% – people may shy away from using them more.

A raft of measures targeting use (demand) is required. These include vehicle emissions pricing or scrapping premiums to accelerate the transition to vehicles allowed in the LEZ; amended taxation (VAT, income tax, carbon tax, etc.), integrating a yearly road toll calculated on the basis of emissions and applicable to private and commercial vehicles; exemptions for clean fuels (e.g. biofuels); paid limited parking to curb car use during high-congestion periods and encourage the use of alternative transport modes; conversely, free parking for electric vehicles; free or cheap public transport, etc.

It is also necessary to clearly explain that the resulting income will be used to provide renewed mobility, modern infrastructure and redistribution schemes such as free parking close to public transport solutions, for example. Measures targeting service providers (supply) are also required. The infrastructure required includes buildings and access roads designed to ease travel and offer a maximum of services close to the home or the workplace of residents. A large-scale roll-out of ITS solutions (see chapter on Winning Technologies) will facilitate LEZ management, information collection and Big Data analysis with a view to optimizing the zone's performance and developing a range of activities and attractive services.

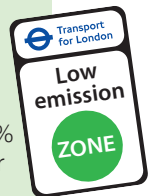
Tokyo

In 2003, the Metropolitan Government introduced a series of measures to combat vehicle pollution, spearheaded by the "Diesel Emission Control Regulation" and the "Retrofit Program". Both measures require some categories of diesel vehicles to be retrofitted with emission control systems to reduce PM emissions. Non-conforming vehicles are banned from the roads and face a fine of 500,000 Yen (about € 3,600), coupled with the naming and shaming of the vehicle owner. Thanks to the LEZ, Tokyo's PM_{2.5} concentrations have dropped by approximately 55% compared with 2000. Other cities such as Guangzhou, Beijing and Paris have tried to lower emissions without creating a LEZ. In Beijing, for example, trucks are banned from some areas and allowed to enter others only during certain hours. Guangzhou has a similar scheme in place.

London

Central London's LEZ is one of the best known. The instrument of choice is the congestion charge. Set up in 2008, it restricts entry of commercial vehicles that do not comply with European Emission Standards: Euro III for light commercial vehicles and Euro IV for medium and heavy commercial vehicles. Passenger vehicles are not regulated. Offenses are punished with fines.

Since inception, congestion has fallen by 30% and traffic by 15%. Journey times are shorter and transport services more reliable and predictable. Buses have benefited the most from these changes as the flow of traffic is smoother and their punctuality has improved. Moreover, CO₂ emissions have dropped by 19% and fuel consumption has fallen. Other effective and easy-to-implement tools include urban access regulation, weight restriction and lorry control, with rules getting stricter every year.



A development model

The ability of a LEZ to impact mobility externalities has been largely confirmed in Europe by the experiences of Stockholm, Cologne and nine Dutch towns, among others. The stricter the rules, the greater the impact on particulate and NO_x emissions both inside and outside the zone. Urban tolls differ

- 1/** in terms of spatial configuration (lane charging in New York, area charging in London);
- 2/** price (variable rate according to hour, day, duration, mileage, emissions class, or a base rate);
- 3/** objective (tackling congestion and fatalities – London, fighting accidents and pollution – Milan, financing infrastructure – Oslo); and
- 4/** revenue allocation (road infrastructure – Stockholm, sustainable mobility – Milan).

The LEZ development model of the future is the subject of studies by the World Economic Forum (WEF) and the Boston Consulting Globe (BCG). Their joint project, dubbed COMET (Condition-based Megacity Traffic Management), has just been published. The system analyzes traffic and forecasts variations in traffic flows to monitor and manage emissions. Traffic is regulated by creating temporary LEZs with tough admission rules that are lifted when emission levels improve. The system is powerful enough to block access to certain areas, make parking places available and launch an electric shuttle network to move people within and outside the «temporary» LEZs.

In May 2014, Milan was acclaimed for its urban road pricing system. The city, one of the most car-dependent in the European Union, put its price review to a referendum, with 71% of the population voting in favor. The results speak for themselves: 28% fewer vehicles accessing the zone, 10% less demand for parking places and 26% fewer road accidents. Urban delivery efficiency has improved by 10%. PM10 pollution has fallen by 10% and CO₂ emissions by 35%. On the other hand, average traffic speed has risen.

The real benefits of a LEZ thus include measurable reductions in air pollutants, less congestion, fewer accidents (particularly among cyclists), shifts to lower carbon and non-motorized modes of private and public transport, faster compliance of urban car and truck fleets with mandatory emission limits, and promotion of car sharing solutions.

The key to success: proper economic anticipation and regulatory compliance

The economic development of a LEZ must be tackled with care. Europe's two early adopters, London and Stockholm served as case studies. As well as requiring technical tools and Open and Big Data databases to manage it, a LEZ needs a dedicated police force charged with enforcing the rules. London's LEZ is not self-financing, while Stockholm's is considered effective due to the improvement in air quality. With both cities targeting trucks, final economic outcomes are heavily influenced by truck-to-car ratios. As one of the main economic effects of a LEZ is to increase real estate values, anticipation effectively boosts a project's prospects.

High-tech tools can help monitor compliance with rules. License plate recognition cameras linked to a vehicle database make it possible to check whether the vehicle is allowed in the zone. In Germany police use a windshield tag, compared to Lisbon where protection-of-privacy laws ban the use of cameras. For a low emission zone to be successful, public authorities must be mindful of all the risks, including the migration of some families to the outskirts due to rising real estate prices and the extra travel associated with it.

A C40 study of these issues presented at the recent Mayors Summit in Johannesburg shows that while congestion and pollution charging are legitimate tools for mayors to create a more eco-friendly city center, they must be backed by transport-focused urban development or TOD (Transit Oriented Development) projects aimed at reshaping city infrastructure.



4/ RECOMMENDATIONS ON THE RULES FOR SETTING UP AND ENTERING ENHANCED ROAD SAFETY ZONES

The undeniable success of low emission zones in Europe, Asia and North America demonstrates that they are instrumental in speeding up fleet turnover and the shift to clean private, public or non-motorized modes of transport. However, they rely on the development of complex ecosystems involving multiple local bodies responsible for mobility, transportation and infrastructure, and private providers who create, develop, operate and even finance the relevant infrastructure. Of course, there is no single model and cities adopt approaches they believe are best suited to creating their LEZ. Developing efficient city center infrastructure based on ITS technology should help to create business opportunities in the near future.

Converting a LEZ into an ULEZ and creating enhanced road safety zones

LEZ entry rules should be regularly reviewed and their area widened or adjusted to offset their adverse effects. We recommend converting LEZs as quickly as possible into ULEZs to cover every type of vehicle, including two wheelers. Retrofitting fleets to meet ULEZ standards could help to stimulate the economy.

We also recommend the establishment of an enhanced road safety area in the ULEZ. In 2010, the EU-19 reported 10,837 fatal accidents on urban roads, an increase of 38% in road accident fatalities. Yet in the last decade urban road fatalities have fallen by more than a third (39%), slightly less than the 42% drop in the total number of fatal accidents, according to figures from the European Road Safety Observatory. In London, one of the most pressing challenges prompting the creation of the LEZ was the high number of fatalities involving both trucks and two wheelers. Safety zones are in place in Chicago, Oakland, Toronto and many other cities around the world. France has adopted a number of pedestrian safety measures around school entrances, including speed humps and radars. In the final analysis, however, the purpose of an ULEZ with enhanced road safety is to ensure the safety of all users – pedestrians, cyclists and noise-free EVs.

ULEZs can be implemented on a large scale and their outcomes optimized by seamless door to door passenger mobility modes and last-mile delivery solutions, whose roll-out is, in turn, promoted by these zones.





3 Developing door to door transport **solutions** for people, with corresponding **web-based** applications

Designing and developing door to door transport solutions is an effective way to address the mobility expectations of people, the challenges of urbanization and growing social pressure to render mobility accessible and affordable for all.

Ease-of-access is the key factor in determining which mode of travel to choose. Poor accessibility between home – or work – and the nearest transport hub has a negative impact on both urban life quality and urban mobility performance. The problem is amplified by the increasing number of ever bigger megacities.

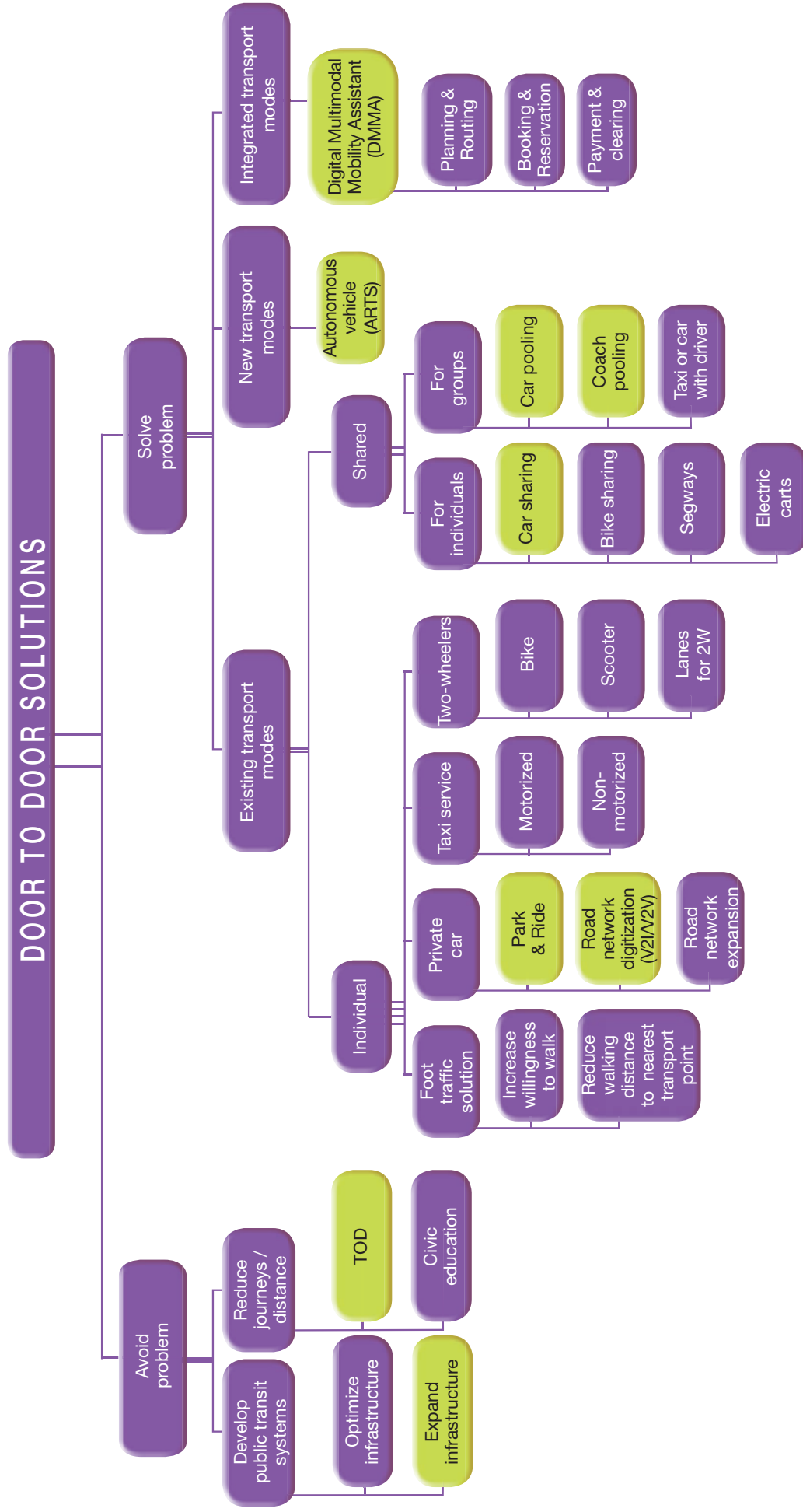
«Door to door solutions» can provide solutions to issues of lost productivity (time lost in travel costs an estimated 0.5% of GDP on average), to urban stress and systematic car use, thus reducing pollution and congestion. They complement station-to-station transportation solutions, which meet people's travel needs and expectations only partially.

Designing and developing door to door solutions means putting the citizen and the consumer back at the heart of the mobility market in order to strike a new balance between satisfaction of their transportation demands and the economic performance of mobility players.

1/FIVE DEVELOPING AREAS FOR DOOR TO DOOR SOLUTIONS

The figure below presents the various solutions, or combinations of solutions, available or ready to be rolled out. They vary in investment cost, minimum viable usage and sustainability. As such, they should be chosen with the needs of the areas and the expectations of the people they serve in mind. Five areas, covering several solutions, hold our attention for reasons we explain below:

- Extension of public transport infrastructure
- Roll-out of TODs coupled with park and ride facilities
- Vehicle-to-vehicle and vehicle-to-infrastructure (V2V / V2I) communications and the advent of autonomous vehicles
- Sharing solutions (car, bike, coach)
- Digital multimodal mobility assistant (DMMA) solutions



This chapter will not go into some of the simple, known, tried and tested solutions shown in this figure (foot traffic for bridging the distance to stations, motorized and non-motorized taxis, electric vehicles or rickshaws, and extension of the road network where it is too poor).

We will touch on less well known, but more targeted and highly promising solutions. Their implementation depends on the economic and social context, urban maturity and the existing multimodal network (subway, bus, BRT – Bus Rapid Transit, train and boat). When developing such solutions, a city must simultaneously think about what infrastructure to build and how to interconnect transport solutions to satisfy individual and collective needs. Be that as it may, improving transport safety – reducing traffic accidents – is a precondition for the roll-out of door to door solutions.

Lawmakers are expected to facilitate their emergence, not run them.



The TOD: developing residential and commercial areas with optimum access to public transport and integrating car use into multimodality.

A transit-oriented development (TOD) provides integrated key urban functions within a radius of 250-500 meters from a transit stop. This approach is showcased by Copenhagen and Hong Kong, where multimodality has been maximized. Park and Ride solutions, i.e. car parks near railway stations, increase a TOD's effectiveness in fast-growing cities, while facilitating sustainable car use. They should be implemented quickly so that drivers can use them with their vehicles and cars can be fully integrated into multimodality.

A TOD involves local authorities preempting land to protect it from speculation and integrating park and ride facilities and the TOD on that land to ensure its economic viability.

TODs offer an effective, integrated upstream solution to inclusive mobility issues by combining economic development, urban planning and social integration. The idea of inclusive mobility encompasses the social responsibility of public authorities or companies and the wider issue of sustainable development, as evidenced by the demonstrations in Brazil in 2013 following a rise in bus fares.

The sharp increase in car pooling

By getting more people to use one vehicle, carpooling reduces fuel costs, tolls and greenhouse gas (GHG) emissions, while creating social ties.

An estimated 10% of Americans use carpooling, with the number of users expected to triple by 2020 (source: UC Berkeley). In France, 3 million new users have been won by Blablacar in just one year.

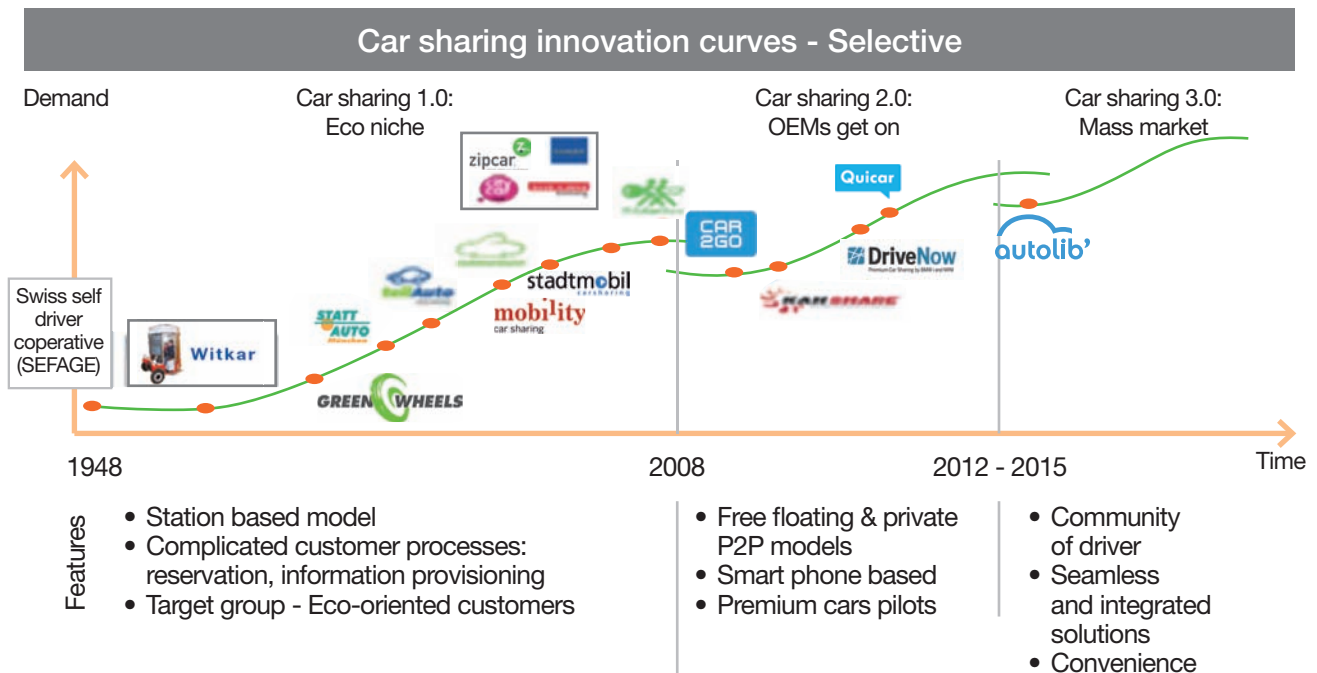
Carpooling companies business models charge a fee for their service (carpooling.com, Blablacar) and can also earn revenue through ridership data monetization (carpooling.com, Waze, etc.). Various derivatives of this broad concept are significantly changing people's traveling habits. Examples include cars-with-driver schemes by Uber and Lyft, and coach pooling services (e.g. RidePal in the US Silicon Valley) that allow remote companies to carry their employees to the workplace comfortably, ensuring they are «always connected» (wifi, phone).

The soaring interest in car sharing

We are witnessing a boom in shared mobility.

Car sharing 1.0 (ZipCar, mobility, Greenwheels) is becoming a growth driver for car manufacturers (2.0) (Car2Go – Daimler, QuiCar – VW, DriveNow – BMW). The key question for the car sharing market is how to turn it into a mass business model (car sharing 3.0).





European figures confirm this boom. According to Roland Berger, the number of car sharers rose from 300,000 in 2006 to 2.7 million in 2013 and is set to hit 15 million by 2018.

In terms of innovation, car sharing has pioneered on-demand mobility. It is also the forerunner of Automated Road Transport Systems (ARTS), a platooning technology for empty vehicle relocation and the first step towards last-mile automation pending legislation that would allow automated vehicles on roads.

Automated Road Transport System (ARTS): autonomous vehicles for customized destinations

ARTS is a mode of public transport using autonomous vehicles to carry small groups of passengers to customized, multiple destinations at fairly low speed.

These automated electric vehicles offer an innovative and forward-looking solution compared to a bus with driver which, with 30% global average daily occupancy at best, is unable to cover the last-mile as cost-effectively or flexibly.

Supported by the right ITS infrastructure, these vehicles (also called Podcars) have good growth prospects among urban young people

who want to be always connected, older people and people with reduced mobility (estimated population of over 1.4 billion by 2040, predominantly in more developed countries).

Their cost will fall significantly if legislation allows them to be mass produced. At the same time, autonomous vehicles will fast track car sharing solutions due to their ability to reposition rental vehicles at the right place without costly human intervention.



DMMA: interconnecting various transport modes for improved performance

A DMMA (Digital Multimodal Mobility Assistant) is a web-based application that acts as a onestop-shop for mobility services (integrated multimodality). DMMA's increase the effectiveness and efficiency of different transport modes by interlinking them. They also educate consumers while meeting their key expectations of convenience, speed, comfort and accessibility.

However, multimodal journeys can only occur if the information on services offered by different mobility providers is bundled in one place and easily accessible. As well as providing information, this innovative technology can offer and sell available services in real time during a journey (regardless of transport mode). To do so, it relies on revolutionary information technologies, such as in-memory cloud computing, Hadoop, and so on, that now deliver integrated benefits simultaneously (inform, offer, sell), thereby opening up new and largely unexplored mobile markets.

Basically, the DMMA debate is not so much about the technology as it is about the fact that these «facilitators» promote the expansion of mobility

as a market. All products and services will no longer be sold in their respective networks, but throughout the journey when and where people need them.

With the advent of the «Internet of Things», the way is now open for new corporate ecosystems and/or public-private consortiums: breaking with the still dominant silos of responsibility can now take place. The borders between different mobility industries are becoming increasingly blurred as all actors either take on new competitors or enter into new partnerships in a race to control the information data that will guide individuals in their choices, including everyday consumer choices.

In the long run, this application will better target the expectations of citizen-consumers and make the most of geolocation tools and Big Data.

Montreal's «Merci» application launched in 2013 with the help of location-based services (LBS), has increased public transport usage by 23% in one year, as well as sales of related services such as bike rentals, cultural outings, store discount vouchers, etc.

The city has only had to make a limited investment to begin with since the business model pegs program designers' compensation to ridership growth – a win-win for both parties.



The Daimler Group has emerged as leader in the mobility systems of tomorrow by bringing together start-ups through acquisitions and partnerships.

For example, Daimler Moovel is a mobile application platform that enables users to compare a variety of mobility options in a single click, including car2go, taxis, carpooling and public transport.

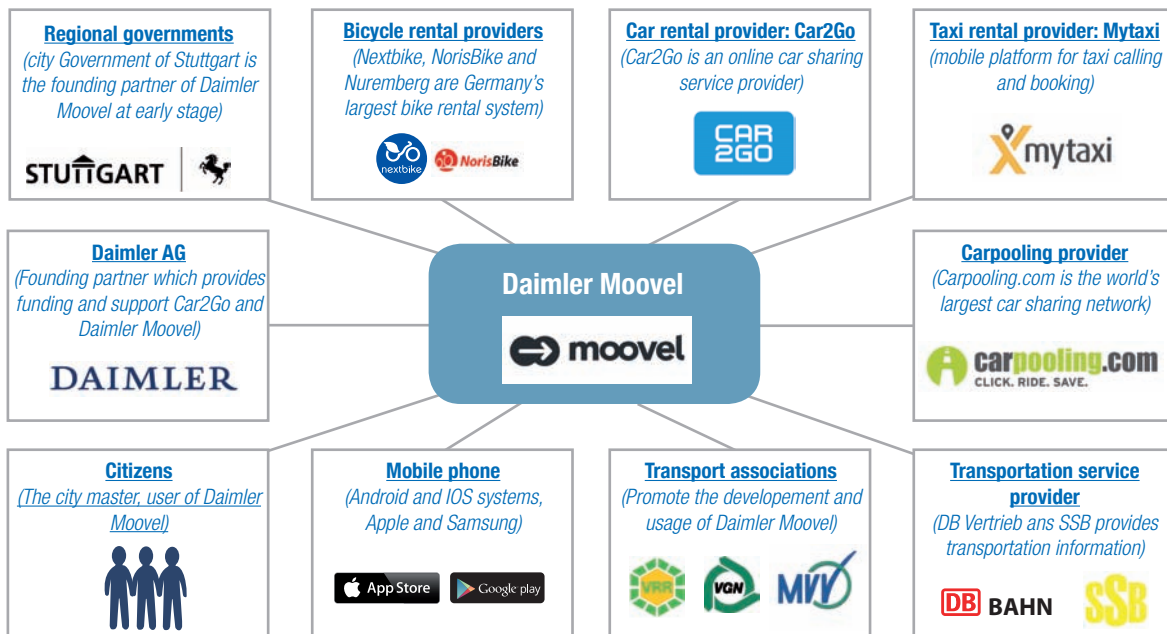
The main functions of Moovel fall into three groups: route planning, booking and payment.

For route planning, Moovel employs several multimodal solutions closely integrated with service providers' applications. The modes of transport covered range from public transport, car rental and

carpooling to bike share and taxi booking. Moovel also offers direct bookings via applications and information on preferred mobility options and their pricing. Payments are made by different methods such as application-based credit cards, initial deposit or a link to other payment systems.

Not only does this service offer users easier access to mobility information and different sets of customized options, it also allows mobility providers to receive pre-orders designed to anticipate needs and facilitate vehicle allocation.

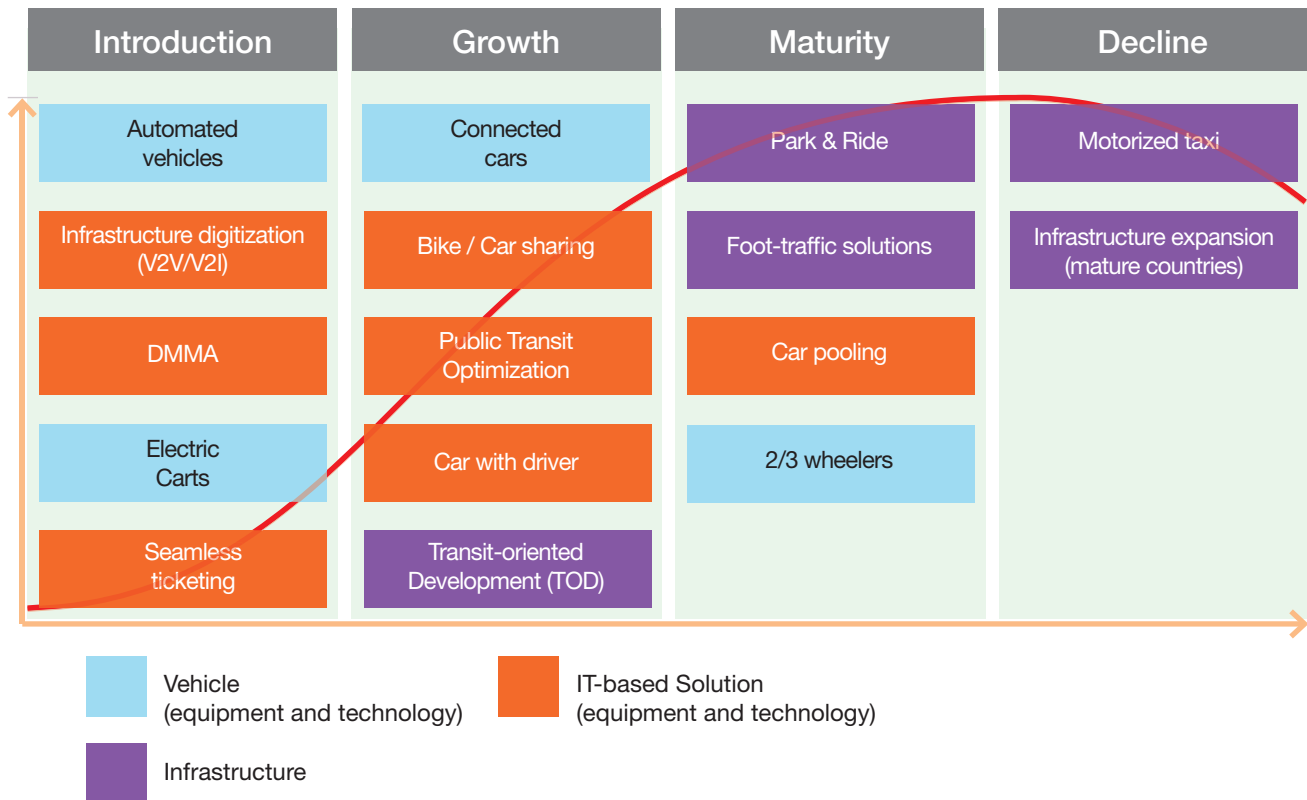
Daimler-Moovel is a promising first incarnation of an integrator of tomorrow's mobility systems.



2/ IMPLEMENTING THREE SOLUTIONS ON A PRIORITY BASIS

As the table below shows, door to door solutions have different maturity levels from mature off-the-shelf systems to emerging programs. All are designed for smart cities which, in turn, can play a pioneering role in mobility.

In terms of benefits (transportation capacity, network coverage, reliability, safety, comfort, pleasure, environmental impact) and accessibility (technological maturity, existence of pilot projects, set-up and operating costs, price for end-user, risks of each solution), we believe three door to door solutions should take priority, depending on the level of development of the economic environment where they are implemented.



These solutions are described below.

1. TODs for rapidly growing economies

In developing countries, where new urban design concepts are emerging to tackle urban sprawl, Transit Oriented Development (TOD) offers an opportunity to align transport infrastructure with urban planning and estimated population density.

Cities in those countries would do well to optimize public transit systems, while integrating private vehicles into those systems. That means expanding the public transport network, improving its efficiency and promoting smart interactions with private vehicles. As private vehicles become increasingly connected, such interaction will get easier. This last point is essential to coordinate the different modes of transport and make getting around the city easier as well as more comfortable.

In 2012, Istanbul (Turkey) started a public transit optimization project called Insights in Motion. The goal of the first knowledge-building phase was to develop a database on each user's activities by tracking meaningful locations, segmenting trips and estimating stop-over duration, purpose of travel, time of day and mode of transport through cell phones and smart phones. In the second phase, the city's transit authority used these tools to design feeder bus routes, including to the city's new subway stations. The target was to reduce operating expenses by 40%, increase demand by 37%, cut commuting time by 60% and lower emissions from transport by 40%.

Rapidly expanding park and ride facilities everywhere

In synergy with TODs, park and ride can be very quickly rolled out in fast-growing economies where the rate of private vehicle ownership is rising sharply. Park and ride is already in place in cities where car density is nearing saturation point (e.g. Beijing, Mexico, Rio de Janeiro, etc.). As urban real estate prices continue to climb sharply, public authorities should take urgent steps to form a group of providers for the project before land becomes prohibitively expensive. This means planning and building adjacent park and ride and the implementation of TOD facilities along subway, BRT and railway lines so as to fully integrate cars into the multimodal systems of tomorrow.

In mature economies, park and ride sites are

a stand-alone solution used to smooth the flow of traffic (San Francisco, Tokyo, Munich, etc.).



2. Encouraging bike and car sharing

Compared to other door to door solutions, bike sharing (low-cost rental), at less than \$80 per bike in China and around \$500 in Europe, is by far the most cost-effective since it only requires light infrastructure.

While this solution's profitability is often a challenge, the investment and operating costs are manageable within a broader ecosystem, as in Paris where the costs of the Vélib bike share scheme are embedded into the city's overall multi-annual advertising contract. It should be noted that the launch of the Vélib scheme brought to bear the concepts of zero emission and sustainable transport on the general public, which is key to the acceptability of other solutions in the future.

However, this system often only covers the last stage of the commuter journey, and not the entire journey. Besides, it may not be suitable for all cities because of their topography or size – situations where car sharing solutions come into their own. After years of experimentation, car sharing is poised to take off on a mass scale, as demonstrated by the aforementioned figures.

The technology is mature, the infrastructure is largely standardized and costs are coming down significantly. Another key factor is that some providers have already developed a sustainable business case.

The Bolloré Group, for example, which started out in France with electric vehicles, is now exporting its know-how (vehicles, batteries, and especially the operational business model) to the USA (Indianapolis) and Asia (Singapore) as part of an all-in-one package.

3. DMMAs for developed transport systems

Web-based multimodal mobility assistants (DMMAs), growing out of the «Internet of Things», enjoy good growth prospects in developed countries because of the size of cities and the wide-ranging nature of the multiple mobility options. The assistants help deliver interconnected mobility solutions the instant they are needed by users, supplemented by a range of value-added services.

But first two major obstacles to the development of a full-fledged digital multimodal mobility assistant market must be lifted:

- Lack of multimodal transport information. There is a dearth of shared real-time public transport information, which remains fragmented among various operators. The problem is developing integrated solutions without threatening the activity of the players in the chain so that they participate and volunteer to share data (open data).
- Immature payment technologies. Transaction payment technology is an emerging component of the system. The near field communication (NFC) technology being developed today is supported by only a handful of smart phones and an underdeveloped connected infrastructure.

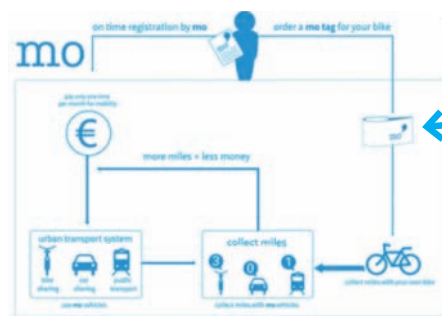
These problems can be ironed out once players start to focus on the services and solutions really needed by consumers. The availability of information is a necessary but not sufficient condition for the system's development.

As with all door to door solutions, the case for the new model is not based on supply (albeit integrated), but on demand. That means clearly identifying the added value and mobility experience really expected by consumers.

Experts advocate the broad roll-out of DMMAs (global web-based platforms or applications) on the grounds that they will produce new patterns of mobility consumption and are already cost-effective.

«Mo-bility», a modern urban mobility system operated by the city of Munich, is a good example because it offers a mixed, convenient and affordable multimodal solution (with usage-based sliding rates) combining bike sharing, public transport and car rental.

In conclusion, regardless of the door to door solutions ultimately selected by each individual, the importance of these new mobility modes lies in the fact that not only will they address the essential societal challenges of pollution, congestion and safety, they will also spur a host of technological innovations and profitable new opportunities that enhance the fun of mobility by offering people a new user experience.





4 Reinventing innovative last-mile logistics systems

According to Frost & Sullivan, annual sales of last-mile delivery services worldwide are expected to soar from \$2.6 to \$6 trillion between 2011 and 2020, making this by far the fastest growing logistics business, with over 300 million urban deliveries a day by 2020. Driven by growing urbanization across the globe, the growth of this segment in value terms will be 1.5 times faster than its already impressive volume growth.

Last-mile delivery is the last leg of the supply chain. It is a key component of urban mobility for a number of reasons:

- 30-40% of tonnes delivered daily around the world are intended for urban consumption, (source: World Bank);
- On average, 30% of tonnes transported are headed for urban production and construction sites;
- Shipment of waste and recyclable materials produced by urban consumption and production, though minor in percentage terms, is a key global challenge.

1/ THE FIGURES SPEAK FOR THEMSELVES BUT SO MUCH STILL NEEDS TO BE DONE

Cities are so caught up addressing people mobility issues that they often neglect goods in their integrated mobility plans.

There are three reasons for this:

- Cities by definition act at a local level, whereas last-mile logistics requires a broad understanding of the supply chain to which it belongs. Local authorities usually do not have such knowledge.
- Moreover, tackling last-mile logistics issues requires close cooperation with private companies, the key players in this business. Such companies are hardly ever just local.

- Unlike the transportation of people, the transportation of goods is still not considered a priority. As a result, it is difficult to develop the appropriate infrastructure and planning mechanisms.

However, growing urban mobility issues are leading public and private players to focus increasingly on last-mile logistics, which accounts for about 20% of miles traveled in cities (source: *Oliver Wyman*) and more if we account for the congestion caused by the vehicles' bulk and unloading stops.

As urban logistics policies pursue sometimes conflicting objectives, multiple parameters must be factored in:

- reducing congestion: distance traveled, vehicle capacity and length, number of stops, better truck utilization (fewer trucks);
- lowering air pollution (NO_x, SO_x, PM_{2.5}): type of vehicle, distance traveled;
- cutting noise pollution: type of engine, level of congestion caused;
- developing the local economy: solution costs, service quality (speed, delivery time slots, flexibility/reactiveness), retail development, etc.;
- encouraging housing policy: increase available space, reduce surface devoted to inner city logistics platforms.

REGULATORY AND LAND PLANNING

1 Equipment and technology	Access to certain areas and/or roads for vehicles conditioned on weight, size and/or age of vehicle	Prague: 3.5 tonnes weight cap in city center
2 Time slots	Opening/closing of some areas to specific types of trucks at certain times	Paris: Time slots by type of truck
3 Exclusive zones	Exclusive access for one or more transport companies to certain areas Limited to some truck sizes and/or time slots	London: Exclusive zone for DHL around LHR
4 Low emission zones (LEZ)	Access to certain areas conditioned on vehicle emissions Transition from LEZ to ULEZ (ultra-low emission zones)	Berlin: LEZ since 2008
5 Special retail and logistics zones	Creation of retail and logistics zones in urban land use plans	Bologna: Bologna Interporto freight village

INFRASTRUCTURE

6 Urban distribution centers (UDCs)	Shared logistics facilities for pooling freight to be delivered in the city Possible award of concessions by the city	Ningbo: DHL UDC; Lyon: LUTB city logistics
7 Direct logistics	Containerized inbound cargo shipments by pooled mass transport (boat, train), needing break-bulking in the city	Paris: Direct injection via waterway from central point
8 Reserved traffic lane/drop-of points	Creation of dedicated loading/unloading areas and traffic lanes for freight transport	Barcelona: Use of bus lanes for freight at night
9 Network of e-commerce pick-up points	Self-service pick-up points for parcel deliveries	USA: Amazon e-lockers

FINANCIAL INCENTIVES/TAXES

10 Congestion charge	Introduction of congestion charging and tolls by vehicle weight	London: Congestion charge
11 (Indirect) subsidies	Short-term financial incentives for exemplary last-mile delivery transport providers	Bristol: Extension of time slots for UDC vehicles

EQUIPMENT AND TECHNOLOGY

12 Greener trucks	Low- or zero-emission trucks (Euro NCAP 5, electric, gas) Often in conjunction with regulatory and land-planning measures	Bonn: Carbon-free project (Deutsche Post DHL)
13 Alternative transportation modes	Use of alternative and electric transport modes (2/3 wheelers, ultra-light vehicles) Often combined with UDCs or direct injection	Paris: Urban logistics by rail (e.g. Monoprix)
14 Intelligent Transport Systems (ITS)	Optimized freight distribution through traffic information systems, freight capacity exchange systems and centralized route planning	Singapore: Electronic Road Pricing (ERP) system

2/ DEVISING A PROPER URBAN LOGISTICS STRATEGY

Several solutions can improve last-mile delivery in the city. They fall into four categories: regulatory & land planning, infrastructure, incentives and technology.

Selecting the best solutions involves an assessment of their local impact and their individual contribution to the objectives sought. In addition, measuring the combined effect of these solutions is highly complex, as adopting one solution may positively impact one objective while negatively impacting another.

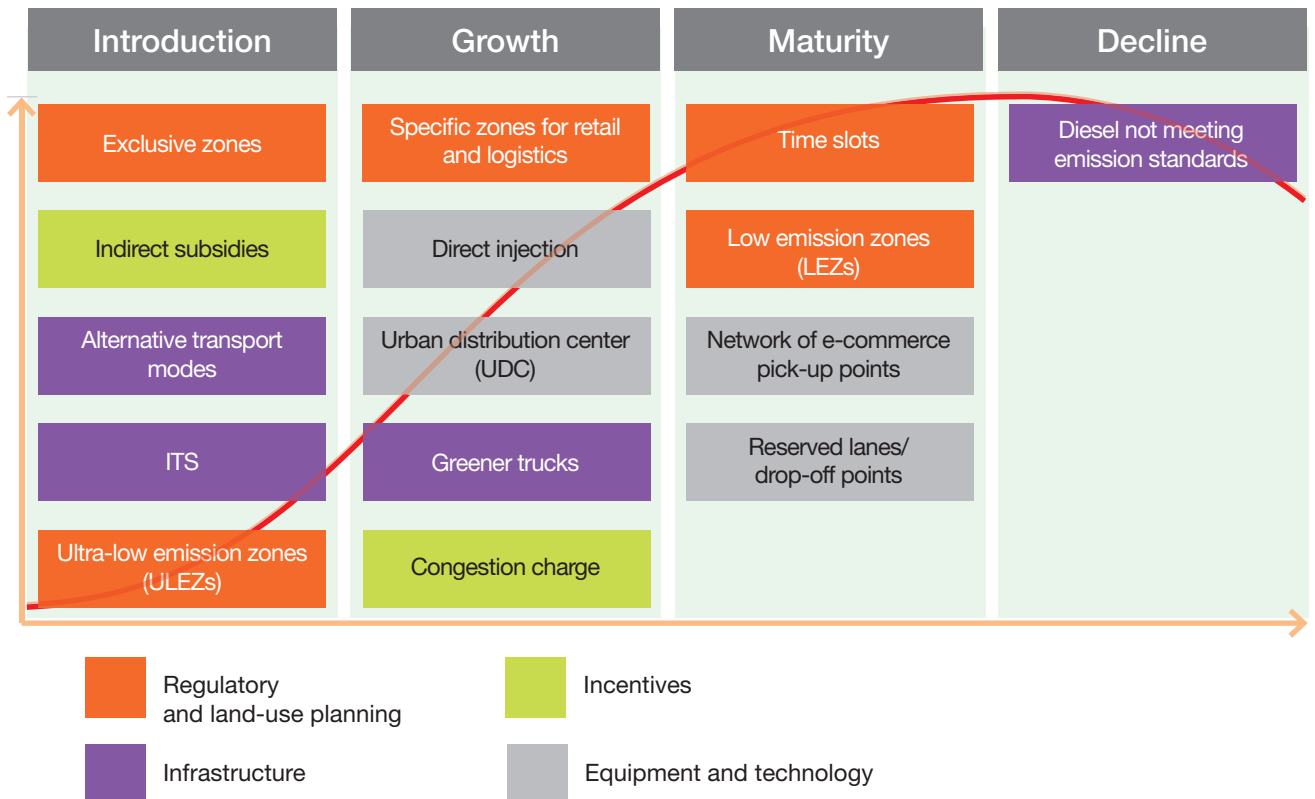
For example, a plethora of small electric trucks may well reduce noise pollution and CO₂ / NO_x / PM_{2.5} emissions, but they would also increase congestion and logistics costs if truck utilization is inadequate.

In the final analysis, the key to an effective urban logistics strategy lies in performing a detailed cost-benefit analysis of the solutions, individually and collectively. We recommend conducting urban logistics pilot studies and trials before undertaking a large-scale roll-out.

Finally, it is necessary to harmonize regulations across cities and regions. National and international logistics companies should be able to rationalize their regulatory compliance costs without undermining the underlying objectives.

For example, they will not invest in complying with the requirements of a district, or a city, (allowing entry for vehicles below 3.5 tonnes), if the authority of that area or the neighboring area applies other rules (allowing entry for vehicles below 6 meters), and if they are unable to recoup the costs. To do so would be counter-productive.

Last-mile delivery solutions are at very different levels of maturity, but the analysis below shows the potential benefits of combining them: a revised business model (freight pooling, massification) offering clean and connected modular vehicles in exchange for which public authorities facilitate transporters' logistics operations.



Some cities already have such solutions in place. Shanghai restricts entry of polluting vehicles, and some Chinese regions regulate access during peak hours. New York has pooled docks and a limited number of dedicated truck lanes.

London requires deliveries of building materials for large construction projects to be consolidated. Many cities are testing e-commerce pick-up lockers, such as Amazon e-lockers in the US, Deutsche Post in Germany, Beijing Collect & Return Corp, etc.

Leading manufacturers of delivery vehicles (Hino, Dongfeng, Iveco, GM, Daimler, Renault, etc.) are also playing their part by developing more efficient ranges (including electric powered vehicles) and looking to expand their ranges of smaller, lighter and more modular vehicles.

3/ WE RECOMMEND DEVELOPING AND COMBINING THREE PRIORITY SOLUTIONS

The key criteria governing the selection of solutions are known: urban density, number of delivery points, market share of e-commerce, fuel (price, availability), existence of integrated infrastructure and level of consolidation of the logistics industry.

Last-mile delivery will necessitate an integrated solution mix tailored to the economic environment. Nonetheless, we recommend three solutions as a matter of priority: freight pooling (urban distribution centers), low emission zones in town centers (LEZ followed by ULEZ) and ITS roll-out. The effectiveness of these solutions will be greatly enhanced if they are combined with each other.

Freight pooling at urban distribution centers (UDC)

The function of an urban distribution center is to decouple the flow of goods to the outskirts of a city from the flow of goods into the city. Shipments are collected in special warehouses at the edge of the city where they are recombined for efficient delivery to the city center. The aim is to optimize truck utilization, the number of trucks entering the city, in short their impact on traffic and its flow, safety and air quality.

Studies show that freight pooling UDCs can help reduce the number of trips by 30-80% and distance traveled by 30-45%, thus lowering emissions by 25-60% (Allen and Browne).

Consolidating goods from different transporters and loaders involves close cooperation and good communication between them and clear rules acknowledged by all. Goods pass through technical platforms that perform real-time delivery management, location mapping and route planning functions.

UDCs can increase transport costs by adding costs for leasing space, handling and transloading. Hence the virtuous mechanism of funding private or public compensation for transporters with the proceeds of royalties paid by the last-mile logistics provider.

Some big companies, perceiving the benefits of UDCs, sometimes even tie up with competitors to establish them, as Nestlé and United Biscuits have done. Another striking example is IGD (Institute for Grocery Distribution), which brings together 40 companies whose logistics cooperation has helped save over 300 million kilometers, or the equivalent of 3,500 trucks surplus to requirements. In sum, the search for the «best-mile» should replace the search for the «most-miles».

As François Michelin put it «companies must ensure that what is good for society is good for them.»

Low emission zones (LEZs) followed by ultra-low emission zones (ULEZs)

Trucks are banned from low emission zones if their emissions are over a set level. The resulting reduction in related emissions, especially of NO_x and PM_{2.5}, is substantial. The zones however require transporters to invest in retrofitting their fleet to meet the standards prescribed. Cities need concerted policies to ensure that **compliance costs** for transporters, who usually operate at national and international level, are kept as low as possible. Ideally, they should receive some form of compensation so that the cost of compliance does not give large, financially strong transporters an unfair advantage over smaller ones. The decision to create a LEZ goes hand in hand with the development of UDCs on the outskirts of the city.

The definition of an ultra-low emission zone (ULEZ) should be embedded into the urban planning process as early as possible. That would facilitate the roll-out of smart infrastructure upstream and speed up the introduction of a cleaner vehicle mix. The longer one waits the harder it will get.

Intelligent Transport Systems (ITS)

Intelligent Transport Systems (ITS) help to integrate information and communication technologies with transport infrastructure, vehicles and users.

By sharing essential information, they make transport networks more effective, while enhancing their safety and reducing their environmental impact. ITS-connected platforms provide route and load optimization solutions for vehicles. Vans and trucks used for deliveries in the city center are only 40% to 45% loaded on average in most large cities around the world. Most of the time they return empty and the routes they take are not optimum. The emergence of ITS-enabled B2B marketplaces is an opportunity for transporters to limit congestion and inform drivers in real time of loading opportunities close to their current point of delivery. The DMMAAs described in «door to door solutions» (see Chapter 1.3) are also vital for developing such marketplaces and delivering benefits in terms of economic growth and urban well-being.

ITS applications make urban transport more efficient by cutting operating costs and improving service. However, applications integrating all the complexities of last-mile delivery are still underdeveloped. With significant investment, ITS will help provide cities with modern infrastructure, thus boosting their competitiveness and growth due to the vast efficiency gains they deliver.

Logistics experts know that ITS can deliver efficiency gains of 15% to 20% by optimizing vehicle utilization and route planning. The potential of ITS can be increased through the implementation of UDCs. These, in turn, will only achieve optimized freight pooling if vehicle, loading rate and road traffic information data are interconnected.

Intelligent Transport Systems have a key role to play in reverse logistics by optimizing utilization so that vehicles return less empty. For this to happen, the entire supply chain, including the availability of transporters returning to the outskirts from their delivery rounds must be under control. They will then be able to backload waste, recyclable materials, unsold items, packages, etc.

Lastly, ITS technologies open the door to innovative transport solutions including combining passenger and freight transport.

For example, trams and autonomous vehicles are ideally suited for moving goods around outside certain hours. By creating an additional activity for public and private transport providers, ITS solutions help them to recoup their investment. Similarly, air drones could be used to provide last-mile delivery services (see the recent experiences of Amazon, Parrott and Wal-Mart), but only if they are supported by ITS infrastructure.





5

Mobilizing **private investment** for **sustainable transport** infrastructure and **innovative mobility** services

It is time to tackle the issue of funding requirements for modern transport infrastructure, which can no longer be met by public budgets alone. It is also necessary to step up investment in the development of new mobility solutions on a large scale. Success in these two areas will affect the transition to a low-carbon society and determine whether we can meet the twin challenges of growth and related job creation.

Each of the game changers we recommend in our Green Paper relies on the development of dedicated public transport infrastructure, parking facilities, vehicle identification systems, inter-vehicle connectivity, storage, urban distribution centers, fleet management systems, etc.

Mobility means new opportunities for the financial world!

According to the International Energy Agency, an estimated \$120 trillion in global transport infrastructure investment is required through 2050. The higher our expectations of sustainable mobility, the greater the likelihood this cost will rise. Public money alone can no longer meet those needs. Private investment, on the other hand, offers policymakers alternative solutions that they must consider.

Following a recent string of OECD publications, we believe that partnership between the public and private sectors offers increasingly interesting possibilities. We use the generic term public-private partnership (PPP) to refer to the many fruitful interactions between public authorities and private companies that, with time and the experience drawn from a few failures, have struck the right balance.

According to McKinsey, these special partnerships account for about 5% of infrastructure funding. PPP funding is rising sharply, especially in the two fields we cover: large-scale public transport infrastructure and innovative mobility service offerings. The strongest growth in such funding over the last fifteen years has come from Canada, the United States, Brazil, India, African countries and Europe, especially Great Britain and France.

Summary of different funding instruments for infrastructure and innovative mobility services

REGULATORY

1 Contractual framework	Establishment of various forms of partnerships (quality/efficiency, hybrid, traffic)	France: "partnership agreement"
2 Public guarantee	Financial support mechanism to secure private investment (~20-40%)	India: ~40%; Canada: ~20%
3 Review clause (risk sharing)	Possible risk restructuring during contract period	All PPP agreements

INFRASTRUCTURE

4 Public	Public budget provides 100% funding for infrastructure, but some mobility services are outsourced	China: railways
5 Traffic risk PPP	Partnership with 100% risk borne by private sector	France: highways (Vinci)
6 Hybrid PPPs (traffic/quality)	Partnership where small proportion of risk is borne by private sector	Milano: railway station
7 Quality and efficiency risk PPP	Partnership where traffic risk is borne by public authority with guaranteed fee for private partner	Ottawa: Ottawa-Waterloo light rail
8 Future privatization	Partnership where private partner owns infrastructure at end of contract	UK: mainly hospitals

FINANCIAL INSTRUMENTS

9 Bonds	Possible bond funding (private funds)	Canada, USA: pension funds
10 Loans	Project finance mechanism (banks)	All PPP agreements

TECHNOLOGY AND SERVICES

11 Mobility services	Private sector financing of new mobility services	Indianapolis: car sharing system (IndyBlue)
12 Shared research programs	Public-private financing of joint research programs	EU: European Green Initiative
13 Public data with private applications	Financing of new mobility applications using monetized public data	Amsterdam: Amsterdam Smart City

1/ KEY SUSTAINABLE TRANSPORT INFRASTRUCTURE FUNDING INSTRUMENTS

The problem of risk sharing in heavily funded projects

Transport infrastructure funding involves a delicate balance between the search for new business models and risk taking. This is especially true of railways, which are complex and unprofitable. The business model for public transport has a variety of components, including traffic demand forecasts, impacts on land values, economic spinoffs for the area in terms of jobs and business, and valuation of negative (pollution, congestion) or positive (safety) externalities. For long-term investments of this nature, financial return should not be the sole criterion. The positive economic and social spinoffs of projects should also be taken into account. The main difficulty is finding opportunities to share risk between the public and private sectors. However, such opportunities are available if certain conditions are fulfilled.

The dangers of making the private provider bear most of the risk

Some types of PPP have proved inadequate for funding large public transport infrastructure projects. In the first type of PPP agreement, the risk relates to traffic and is borne by the private partner. The private partner arranges infrastructure financing and is paid from the sales proceeds (tolls, fare revenue, ticket prices, etc.). Revenue is mainly generated by users. The private partner does not receive any payment from the public authority. The obvious risk in such agreements is low passenger numbers. That explains why they have been effective for French motorways, but have failed for railways. The other problem is that they are highly dependent on GDP growth. In Spain, the economic crisis led to a collapse in traffic putting some providers out of business. That is why we do not recommend this option for public transport.

The advantage of a mechanism that strikes a better balance between risk taking and efficiency

A second type of PPP agreement has been widely used for the last ten years, whereby the risk borne by the private partner is linked to service quality and efficiency. The commercial risk is borne by the public authority since it receives the revenue

from operating the infrastructure. However, it entrusts a private investor with construction, operation and maintenance in return for a fee. Many high-speed train connections from city to airport or from city to large outlying suburbs have been developed in Canada, based on this model. This style of partnership meets the efficiency requirements of public authorities. Its benefits, often cited by the authorities themselves, include fast project delivery, contractually guaranteed service quality, asset preservation and a number of macro-economic impacts such as job creation and increased private investment.

Besides traffic risk agreements and quality-efficiency risk agreements, there are multiple hybrid solutions. As long as the public and private sectors have a common interest and are willing to be flexible, they will strike the right balance between risk taking and profitability. The rising popularity of these agreements bears testimony to this fact.

Rising interest in private funding for large long-term projects with a public guarantee

The first PPP contracts, primarily traffic risk agreements, were financed by long-term bank loans using mainly traditional project finance techniques. The shift towards bond financing and the interest expressed by investment and pension funds is a recent trend originating in the United States and Canada, but one that seems to be getting stronger. By switching from traditional bank loans to debt instruments such as transferable securities (securitization), public authorities are able to tap into the investment capacity of a pool of lenders rather than a single lender.

In return, they have to guarantee a proportion of the amount invested (up to 20% and, in some cases like India, up to 40%) to make the project more attractive to private investors.

Note: Private financing rates are always structurally higher than public financing rates (by 2.5-4 points or even higher depending on the risk of the project). It is important to note that the public authority stands to benefit not just in terms of financing alone, but in transferring risk to the private sector through the introduction of specific, contractual performance and service quality criteria (fast delivery, proper maintenance). It also gains by substituting a fee, albeit a high one, for a capital investment that can be significant during the construction phase of a project wholly financed with public money.

New funding models: land value capture and retail development

Private investors are able to create additional funding models, the most interesting of which are land value capture and retail development conditional upon passenger numbers. Mumbai (below) is a prime example. We also cite many examples of innovative and successful co-funding in the chapter «New Economic Instruments».

Raising finance from the sale of new serviced land in Mumbai, India

«Description»

The most significant form of land value capture is acquisition, followed by the sale or lease of surplus land. Governments which acquire (or already own) land around an infrastructure project can either rent it or sell it at a profit once the project is completed.

Example

The Mumbai Metropolitan Region Development Authority has developed infrastructure for the 553-acre Bandra-Kurla complex. It has sold land parcels to finance additional infrastructure and public works projects.

Impact

USD 510 million raised (including the highest land valuation in India to date at USD 7,330 per m²)»

Source : McKinsey

The rise in 100% private initiatives

The example of Tesla is particularly pertinent and revealing. To support its commercial success, Tesla needs to have a good network of electric charging

stations. In the face of inertia from US federal and state authorities, the company decided to finance the US network fully from its own funds and plans to do the same in other countries.

2/ FUNDING INNOVATIVE MOBILITY SERVICES

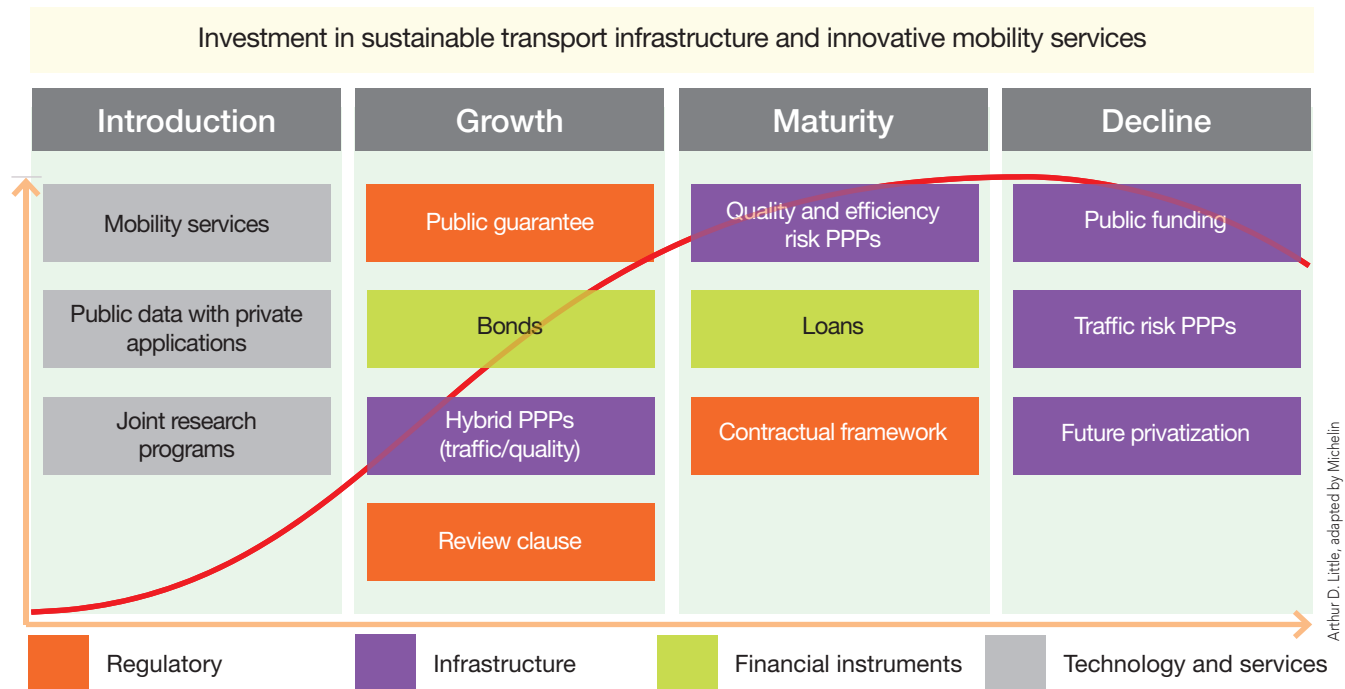
Developing new mobility services also promotes innovative systems of funding and can lead to new solutions that do not require heavy infrastructure funding.

Increasingly frequent – and pragmatic – use of private investment in innovative sectors (smart towns, energy, mobility, new services) is often driven by urban development policies. The widespread adoption of information and communication technologies (ICT), operational efficiency and rapid roll-out are key to meeting the new mobility needs of people.

Examples include bike sharing and car sharing, new user services (Amsterdam smart cities), public data management for online applications to manage users' choice of transport system (Edmonton and Montreal).

The private sector enjoys the confidence of cities regarding its ability to innovate, find new business models and manage risk.

The curve below shows the key factors of success in partnerships between the public and private sectors.



3/ INTERIM CONCLUSIONS AND INITIAL RECOMMENDATIONS

Summary: advantages and drawbacks of PPPs from a public and a private standpoint

Point of view	ADVANTAGES	DRAWBACKS
Public	<ul style="list-style-type: none"> Improves project efficiency in line with private sector average Spreads technological, operational and financial risks Helps to gradually reform public sector organization Identifies alternative sources of funding for transport infrastructure projects Facilitates management of cyclical costs (flow of funds is stabilized over the entire duration of the project via a fee) 	<ul style="list-style-type: none"> Complicates the project by multiplying the number of stakeholders involved Needs specialist team with good knowledge of the private sector Cannot be used in situations of uncertainty (very expensive/ unattractive to private players)
Private	<ul style="list-style-type: none"> Facilitates large contracts (big amounts at stake, long-term contracts) Enhances market knowledge and anticipation Facilitates access to additional resources Spreads operational and financial risks 	<ul style="list-style-type: none"> Requires company to adjust to public sector approach Leaves the company open to the risk of having to deal with evolving administrative management over the term of the agreement

McKinsey, adapted by Michélin

- Private funding's share of investment is rising sharply, especially in new technologies.
- Partnerships between the public and private sectors deliver benefits. Ecosystem-focused, they allow the public authority to quickly and effectively meet infrastructure or mobility service needs. Private players find participatory, innovative and profitable business models in this mechanism.
- Absolute transparency between parties is a key condition of success throughout the partnership.

A legal framework is necessary to ensure that the public authority provides protection and stability for the term of the agreement.

- Governance should help clarify the conditions for transparency, efficiency and balance of interests of all parties. If possible, provision should be made for risk-sharing review clauses.
- It is vitally important to measure the positive financial, social (service quality) and economic (job creation) impacts of the partnership over the entire duration of the agreement.



A close-up photograph of a computer keyboard. The focus is on a blue key in the lower right foreground, which has the text "Next step" written on it in white, sans-serif font. The key is slightly raised and has a soft shadow. Surrounding it are several white keys with standard symbols: a key with an asterisk and underscore, a key with a plus and equals sign, a key with a comma and less-than sign, a key with a period and greater-than sign, a key with a forward slash and backslash, and a key with a hash and dollar sign. The keyboard has a clean, modern design with a light gray or silver frame.

Next step



2

ACTIONABLE LEVERS



introduction

Game changer implementation enabled by **actionable levers**

Citizens increasingly making their own mobility choices, existing or emerging technologies offering winning solutions, empirically validated economic instruments, targeted and redistributive public policies successfully tested in some of the world's forward-looking cities, not to mention new ecosystems to activate – these are some of the actionable levers and techniques for putting efficiency and fun back into mobility.

What is now critical is the political will on the part of the various players to massively embrace action and cooperate on creating shared value (in the sense used by Porter & Kramer).

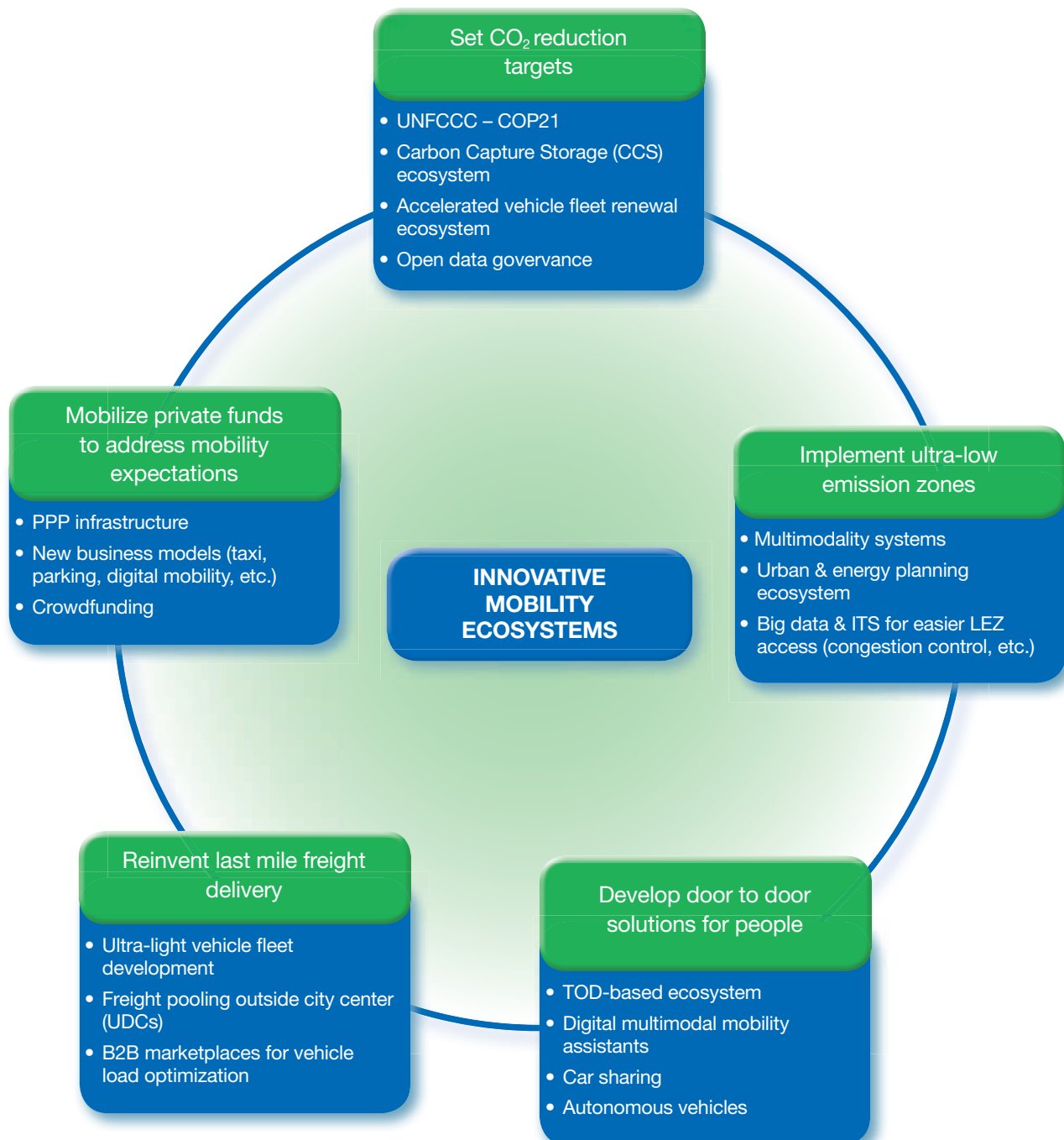
The next five chapters will detail the manner in which to tackle mobility issues with actionable levers in a coordinated manner.

1 Innovative mobility ecosystems

The new mobility systems pioneered by the likes of Uber, AutoLib', Blablacar, Moovel and Waze have necessitated the development of new ecosystems, illustrating the latest responses to growing mobility needs worldwide.

Often informal, ecosystems have been more in the domain of ideas rather than concrete forms of human organization with their related economic issues.

The emergence of formal ecosystems bringing together multiple companies and private or public providers is explained by several factors:



Consumers seek enjoyable user experiences. They demand seamless «all-in-one» solutions rather than separate products or services they then have to combine by themselves. They expect integrated mobility solutions that will make their lives easier.

Companies need to diversify their business models. In search of growth, they are increasingly opting for solutions that enable them to diversify their core activities by expanding in adjacent markets. This trend is driven by the functional economy in which combined technologies and services generate new know-how and business opportunities. This in turn leads to startups and new innovative players building ecosystems rather than control a value chain in its entirety.

New shared technologies and data open the door to innovative systems. Never before have we enjoyed so many shared languages, sources and technologies. When combined, they will unlock the potential of the new ecosystems for inclusive growth.

The public sector has taken on a new role. Local authorities are faced with increasingly complex issues as they attempt to forge the conditions for growth and job creation. They must be competitive and business-friendly in a multi-polar world, while struggling with a debt burden that hampers their ability to fund infrastructure projects. The relationship between the public and private sectors has traditionally been conducted along national lines and so is not yet globalized. To some extent, the public-private dichotomy has become obsolete.

Universities, professional schools and research centers are changing fast as they seek to open up internationally, integrate into the mainstream economy and develop incubator structures on a wider scale.

The economic challenges we face are global and complex. They call for a multidimensional approach. No single player, whether public or private, can ensure implementation of our game changers on all three levels – economic, social and ecological – simultaneously.

Some specific innovative ecosystems are already in place to meet huge mobility needs and its most pressing challenges. Others have yet to be developed.

This chapter describes the ecosystems which, without seeking to be exhaustive, appear, in our view, to make the most sense, based on the collaborative work undertaken with Michelin Challenge Bibendum's partners, including companies, public authorities, consultancy firms, universities and civil society at large.



Appropriate ecosystems will contribute to the combined implementation of the five game changers recommended in this Green Paper. Other solutions, such as long-distance logistics or extension of mass transit systems (rail, air, sea, etc.), will serve to complement this approach. They have been included in our recommended innovative mobility ecosystems, whose link with the five game changers is summarized in the flowchart [previous page](#).

1/FOUR ECOSYSTEMS TO MEET AMBITIOUS GLOBAL CO₂ REDUCTION TARGETS

Since the Kyoto Protocol and its preparatory treaties, it has been widely accepted that the issue of CO₂ emissions calls for a global ecosystem. The UNFCCC (United Nations Framework Convention on Climate Change) is supposed to form the core of such a system. People all around the world, moreover, acknowledge that no serious measures will be forthcoming without a broad international agreement.

The transport sector must be a major player in this ecosystem. That means officially setting up a sub-ecosystem between international agencies, national authorities and transport players. While it may dispense with the need for a consensus between all the parties concerned, at the very least it needs to integrate the positions of the four zones responsible for more than half of the world's CO₂ emissions: China, the European Union, India and the USA. This will not only have a significant impact, but also a knock-on effect on the other nations involved.

The Paris Conference of the Parties (COP21) will have to make agreement on the principles of CO₂ valuation one of its goals.

This, in turn, will drive technological innovation and the CO₂ pricing process, resulting in companies being better rewarded for their R&D efforts and investments in this field.

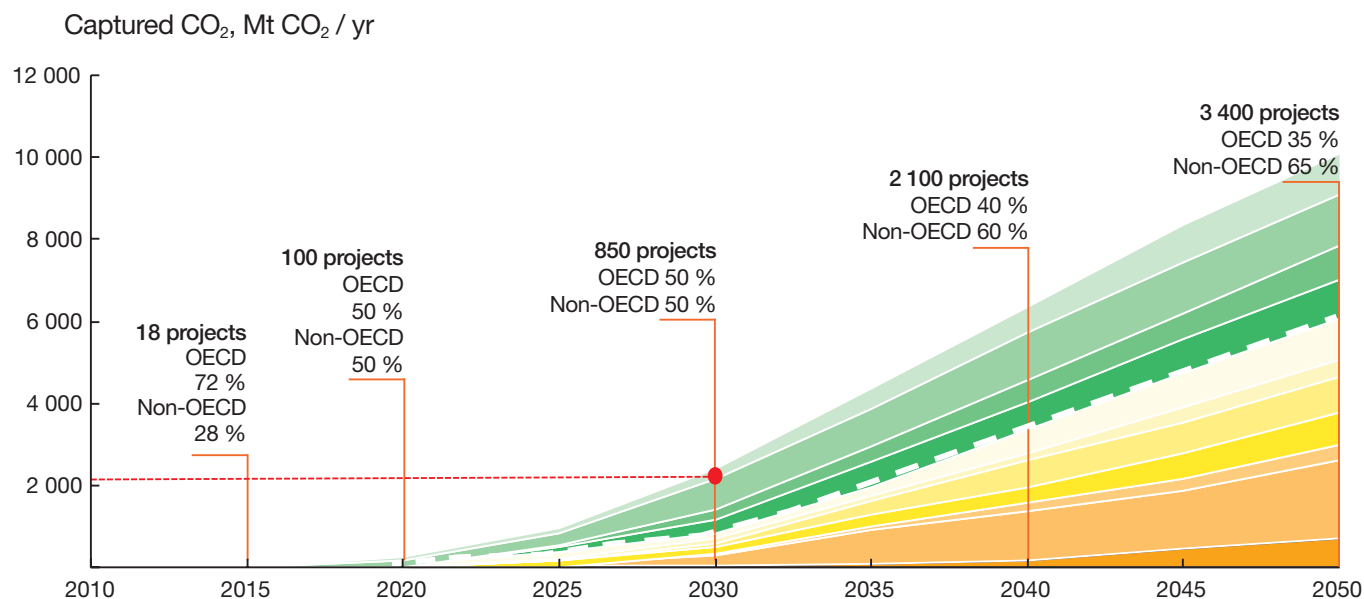
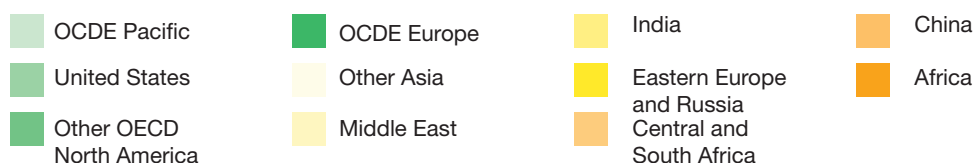
Carbon Capture and Storage (CCS) is the second area in which an ecosystem needs to be built to achieve a significant impact on CO₂ levels in the atmosphere. In its 2013 Technology Roadmap, the International Energy Agency reiterated the urgency of «introducing financial support mechanisms for demonstration and early deployment of CCS to drive private financing of projects».

The world emits an estimated 50 gigatonnes of CO₂ per year. A global ecosystem designed to capture 2 gigatonnes per year in 2030 would be the first significant measure to reduce emissions and the risks associated with anticipated frequent extreme climate events.

The figure below confirms the realistic nature of the target, lead times, growth potential and overall beneficial impact of ecosystem-based CCS.

IAE '450' scenario depicts Carbon Capture and Storage as a major future global growth industry

Global CCS deployment 2010-2050 by region (Mt CO₂ captured / year)



Note: The dashed line indicates separation of OECD/non-OECD groupings.

Sources: IEA World Energy Outlook 2010; McKinsey report. The Case for Commercial Carbon Capture and Storage Industry (March 2011)

Used in conjunction with other low carbon policies, this approach makes a convincing case for increasing the required price per tonne of CO₂. After all, CCS aims to use CO₂ for purposes other than capture, which implies capitalizing on the value creation potential of CO₂!

Two other ecosystems, which are easy to develop and put on government agendas, would contribute to synergies between low carbon policies.

The first is coordinated global car fleet renewal known as yellow label scrapping.

Although there are scrapping policies at national level, a coordinated international ecosystem would encourage the adoption of greener vehicles, thereby enhancing well-being and accelerating the somewhat sluggish renewal of the global vehicle fleet mix (growth).

The second is international open data governance. This would ensure more reliable and systematic integration of all CO₂ emissions measurements, enhance progress and efficiency and accelerate multimodality.

We believe it necessary to focus on these four ecosystems in an effort to reduce the size and complexity of the issues and to address them most effectively. The main advantage of this modular architecture is that it simplifies tasks and reduces coordination costs.

It also spurs innovation, which is key to change. Indeed, companies would factor the CO₂ variable into their policies much more if it were directly relevant to their specific field of activity and know-how.

2/INTRODUCING LEZS AND ULEZS TO PROMOTE THE DEVELOPMENT OF APPROPRIATE INFRASTRUCTURE AND VEHICLES

The world's first low emission zone (LEZ) was established in Tokyo in 2003. Since 2006, LEZs have rapidly spread across Europe. EU air quality legislation has got progressively tougher and calls for LEZs to be introduced more widely, and even expand into ultra-low emission zones (ULEZs), such as the one planned for London in 2020.

Policies dealing with passenger and goods transport only make sense if they secure beforehand the involvement and acceptance of the various players (users, consumers and drivers).

With regard to the mobility of persons, ultra-low emission zones (ULEZs) entail upstream integration of walking and cycling with other urban mobility modes. They also entail a denser network of public transport (i.e. new infrastructure), a viable city-wide car sharing solution, and an effective communication strategy highlighting their cost advantage, comfort and convenience so as to make them more attractive to different sections of the public. At the same time, cities must create smart goods transport ecosystems to support growth, including reserved lanes for the cleanest vehicles, freight pooling, central warehouses, dedicated pick-up points for parcels ordered on-line, etc.

Three sub-ecosystems it seems to us, play a role in the creation of low emission zones with enhanced road safety measures: multimodality, integrated urban and energy planning, and coordinated ITS (Intelligent Transport Systems) solutions:

- **Multimodality** (and its "integrated" variant, i.e. intermodality) is essential to gain people's support for the establishment of a LEZ. The expected revolution will stem not from the prevalence of one mode of transportation (all are welcome given the needs!), but from the networking of all modes to facilitate interaction between people and the exchange of goods.
- **Integrated urban and energy planning** policies on housing, heating and transport, hitherto usually dealt with separately. Integration will unlock a potential of CO₂ emissions reduction policies, while reducing the global energy bill.
- **Big Data and ITS** should help reduce congestion, enhance safety, control emissions and deliver door to door mobility solutions. This data has to be coordinated and used to offset the economic impact of restrictions on access to the city center. A LEZ or an ULEZ is not just about regulation and infrastructure; it also requires people and goods to be transported efficiently.



3/ ECOSYSTEMS FOR DEVELOPING DOOR TO DOOR TRANSPORT SOLUTIONS FOR PEOPLE, WITH CORRESPONDING WEB-BASED APPLICATIONS

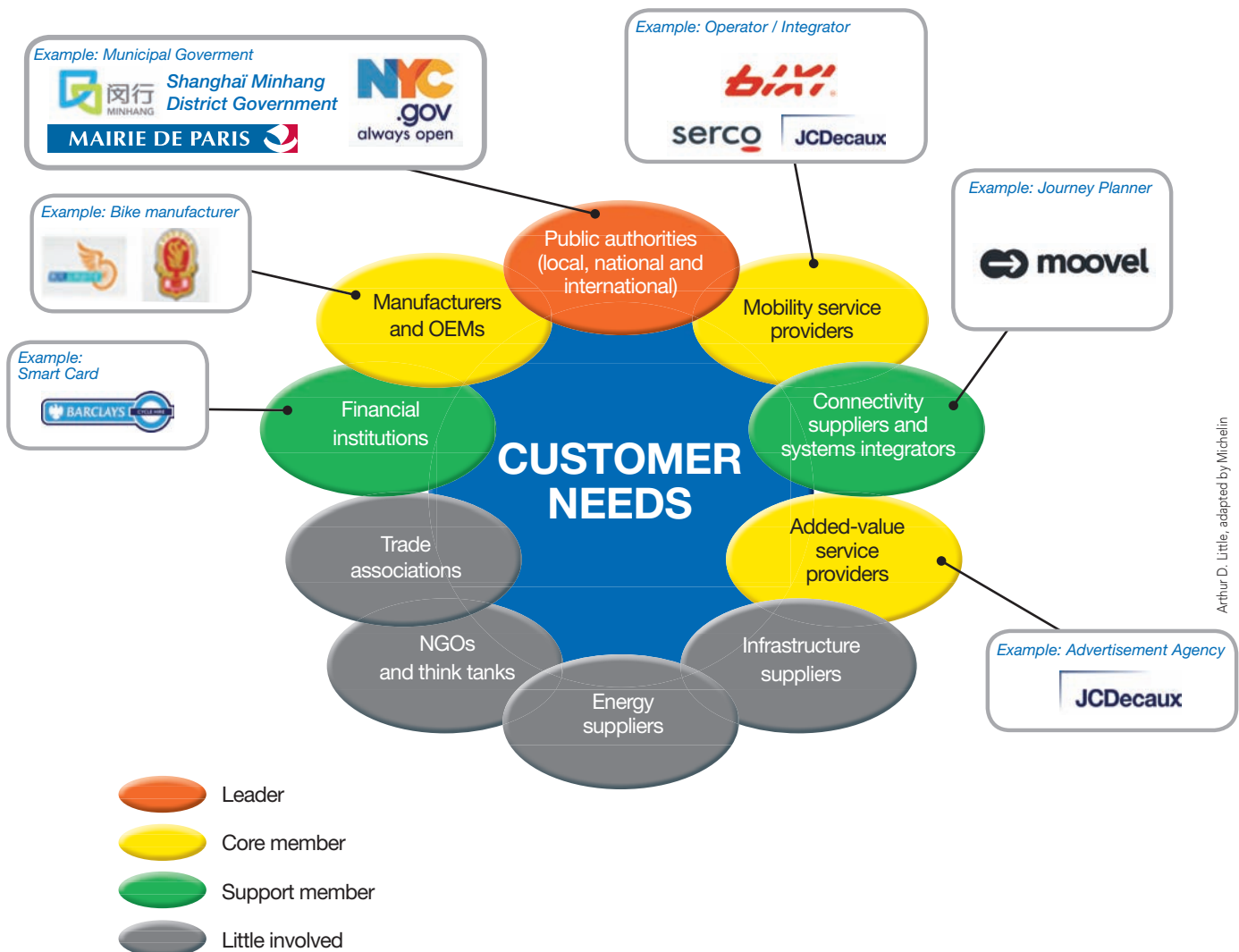
For the last-mile to home, large-sized buses with a daily average occupancy of 15-30% are simply not suitable. Except for the main lines, they do not offer the flexibility or coverage required by users.

The development of door to door solutions is underpinned by different ecosystems depending on the solution being sought, the players involved and the benefits delivered to each party.

The bike sharing ecosystem

The best outcomes in the world demonstrate that several functions can be performed by a private company as part of a partnership with the local authority. In Paris, for example, JC Decaux manages the sale of advertising space and operates, maintains and manages the Vélib bike sharing network, adjusting the fleet by moving bicycles to areas where people need them most.

Other private players are now offering bike sharing as one modal option among others. «Mu by Peugeot», for example, includes bikes, e-bikes, scooters and cars.



Arthur D. Little, adapted by Michelin

The car sharing ecosystem

Car sharing is emblematic of the new uses of mobility in the 21st century. New private providers offer an accessible, on-demand transport service based on an innovative business model, thereby

supporting efforts by local authorities to address the issues of congestion and pollution. Clearly, service providers are at the head of this ecosystem, relying on cities to introduce the required mobility infrastructure (locations, road signs, etc.), on manufacturers to produce the vehicles and on web-based applications to create a direct interface with users.



Arthur D. Little, adapted by Michelin

Beyond the ecosystem itself, the table below highlights the role and interests of each car sharing player. It also shows the right balance between the well-being of people, the renewed pleasure of driving, and opportunities for economic growth (average annual growth up 28% over the 2006-2012 period, according to McKinsey – «A brief look into the global car sharing market », July 2013).

Players	Contributions	Rewards
1 Mobility service providers	<ul style="list-style-type: none"> Own and drive growth of car sharing services Deliver fleet management solutions Responsible for operations, day-to-day maintenance and marketing 	<ul style="list-style-type: none"> Income from delivery of car sharing services to users
2 Public authorities (local, regional and national)	<ul style="list-style-type: none"> Promote car sharing as sustainable mode of transport Stimulate demand by «nudging» users 	<ul style="list-style-type: none"> Enhanced customer satisfaction through seamless multimodal mobility Improvement in road traffic and reduction of GHG emissions
3 Connectivity suppliers and systems integrators	<ul style="list-style-type: none"> Offer customer interface for real time information, booking and payment 	<ul style="list-style-type: none"> Fee received from mobility service providers
4 Manufacturers and OEMs	<ul style="list-style-type: none"> Produce vehicles for mobility service suppliers and deliver fleet management solutions 	<ul style="list-style-type: none"> Brand awareness and optimization Income from sale of vehicle fleets
5 Financial institutions and payment suppliers	<ul style="list-style-type: none"> Deliver payment solutions Deliver financing and insurance for fleet and infrastructure 	<ul style="list-style-type: none"> Better brand image Income from payment, financing and insurance services
6 Added-value service providers* (e.g. advertising, web applications, etc.)	<ul style="list-style-type: none"> Contribute to financing of car sharing services through advertising sales and embedded value offerings 	<ul style="list-style-type: none"> Fee from advertising sales (or media management, with clawback for operator) Increase in popularity of embedded application

*Except transport, covered by transport service providers

The Automated Road Transport (ARTS) ecosystem

Autonomous vehicles will be the most flexible and profitable component of the public transportation network. Privately-owned vehicles could restore the sense of freedom and enjoyment of traveling by road, with fewer accidents and freed-up time in congested traffic (see chapter 1.3 on Door to Door Transport Solutions for People).

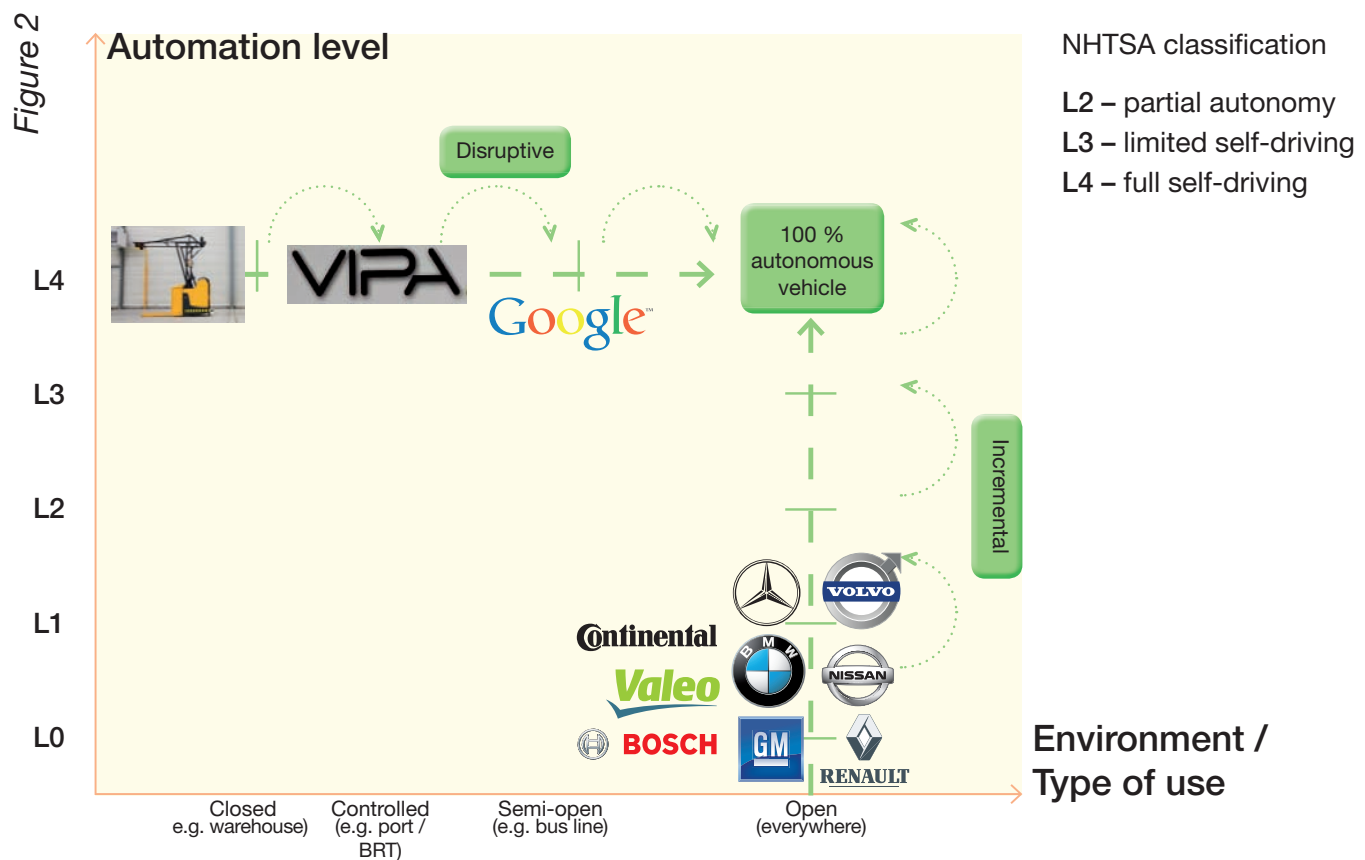
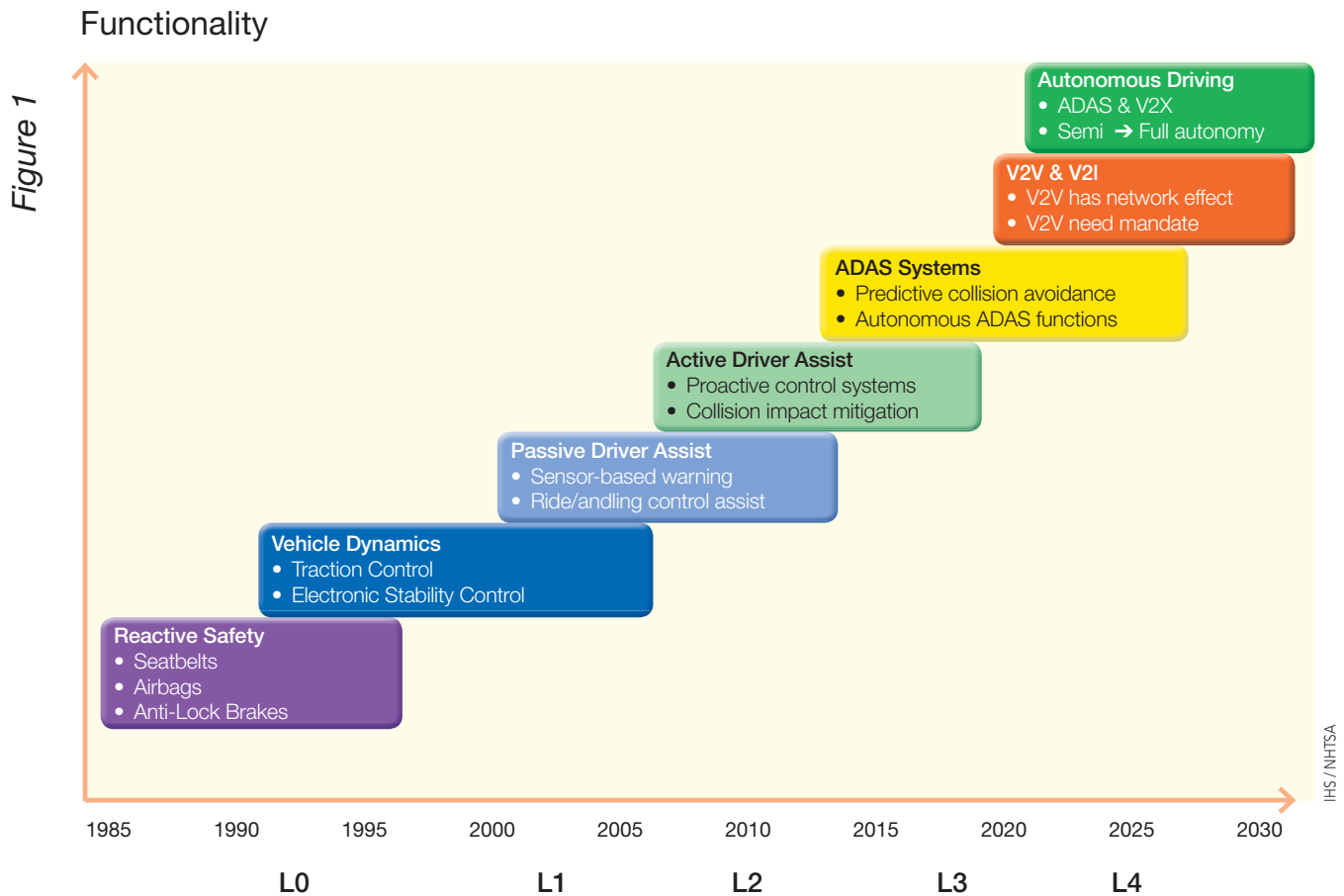
Some regulatory and technological restrictions, however, need to be lifted to unlock the benefits in the years ahead. Experiments on an operational ecosystem have already been carried out by Google Car (State of California), CityMobil2 (Europe) and LTA-Smart (Singapore), among others.

Economically, there are possibly two distinct ecosystems for achieving fully autonomous infrastructure and vehicles.

The first one is the progressive automation

of existing private vehicles (figure 1). The second, provided the implementation of a regulated usage framework, would leverage the already available 100% autonomous technology.





So far the field is open and the autonomous vehicle system is still at the experimental stage. As a result, no clear «leader» has yet emerged in this ecosystem, which requires contributions from:

- public authorities – at international level for vehicle regulations and at local level for trials and roll-outs;
- vehicle manufacturers, original equipment manufacturers, new autonomous mobility players such as Google and robotics players;
- public transport providers to integrate autonomous vehicles into their existing network;
- academics who developed the first autonomous vehicles (CMU Pittsburgh, Stanford, MIT)
- ITS suppliers for flow management and digital mapping (Here, Google, etc.);
- connected service providers to make meaningful use of freed-up time.

The DMMA (Digital Multimodal Mobility Assistant) ecosystem

We are still in the early stages of reaping the impressive benefits delivered by DMMA (cf. Part 1, “Game Changers”). This ecosystem is the most user-friendly, since the services directly interface with it. Therein undoubtedly lies its greatest strength and its potential for transforming mobility.

A DMMA ecosystem is led by a mobility service provider, who in turn relies on a mobility integrator. Other stakeholders include policymakers (for facilitating open data sharing), financial institutions (experts in payment solutions), connectivity and system integration specialists (facilitators, not contractors), infrastructure managers, and consumer associations who will become natural regulators of the services on offer (NGOs, think tanks, universities).



Arthur D. Little, adapted by Michelin

4/ INNOVATIVE ECOSYSTEMS FOR LAST-MILE LOGISTICS

The last-mile is a thorny issue and its resolution requires interaction between large numbers of stakeholders. It needs an innovative ecosystem capable of linking contributions from various private and public players. The latter need to share a vision, objectives and a set of solutions described in the chapter on Game Changers, or even to develop new solutions.

Operationally, an urban delivery ecosystem coordinates at least six key participants, each with specific roles:

Transport and infrastructure providers must take the lead in last-mile logistics ecosystems.

They include logistics providers, transporters, loaders and distributors running their own transport service. Since these players own and/or distribute the goods delivered, last-mile solutions impact their core business. This aspect must be borne in mind when developing solutions aimed at supporting the industry's economy. In what is an increasingly complex industry, the skills required are highly specific. The «multi-local» experience of these providers fully justifies their inclusion.



Arthur D. Little, adapted by Michelin

Policymakers are a core member of these ecosystems. They decide the regulations and grants designed to maximize value for the last-mile delivery system (people, planet, profits) at local, regional, national and international level. Policymakers also choose which R&D avenues to encourage through targeted subsidies. There are two areas on which they should focus:

- harmonization of regulations that enable transporters to operate in all cities (as opposed to city by city);
- refinancing of load loss for transporters required to pool freight on the outskirts of cities (via income generated from the concession awarded to the operator of the urban distribution center).

Vehicle manufacturers and OEMs supply the ecosystems with transport solutions and new technologies, such as low emission combustion engines and electric vehicles designed to reduce the environmental impact of urban deliveries.

Trade associations, which represent their members before policymakers, participate by sharing best practices and promoting the adoption of common standards. Competitiveness clusters (such as LUTB in France) spearhead research initiatives. Their analyses provide public and private stakeholders with insights that enable the right decisions and strategic choices to be made.

The contributions of and benefits for each participant in the last-mile logistics ecosystem are summarized below:

Players	Contributions	Rewards
1 Mobility service providers	<ul style="list-style-type: none"> • Move goods sustainably and efficiently in urban areas • Propose last mile delivery solutions to public authorities 	<ul style="list-style-type: none"> • More efficient transport • Better brand image • Lower investment risk
2 Public authorities (local, regional and national)	<ul style="list-style-type: none"> • Adjust and harmonize regulations for smoother last mile logistics (times, zones, etc.) • Test urban distribution centers and secure financial compensation for transporters 	<ul style="list-style-type: none"> • Reduction in externalities due to last mile delivery (economic, social and ecological)
3 Infrastructure suppliers	<ul style="list-style-type: none"> • Store goods and integrate the supply chain • Operational management of urban distribution centers • Incorporate digital technologies into infrastructure (V21) 	<ul style="list-style-type: none"> • More efficient logistical activities* • Better brand image
4 Manufacturers and OEMs	<ul style="list-style-type: none"> • Develop innovative vehicle and equipment technologies (hybridization, emissions reduction, enhanced safety, modular vehicles, etc.) • Integrate ICTs and ITS into vehicles 	<ul style="list-style-type: none"> • Growth/sales potential • Expansion of business model
5 NGOs and think tanks	<ul style="list-style-type: none"> • Coordinate expert contributions and necessary trials • Represent interests of different stake holders 	<ul style="list-style-type: none"> • Influence on public policy
6 Trade associations	<ul style="list-style-type: none"> • Represent logistics industry before decision-makers and enable them to take account of impact on industry • Spread innovative initiatives and best practices 	<ul style="list-style-type: none"> • Support from association members

Each player has their own set of objectives. Generally speaking, transport and infrastructure providers look to provide service quality for their customers and generate comfortable profit margins. Politicians, on the other hand, are primarily concerned with the interest of residents and businesses. In the context of last-mile delivery, these goals may be difficult to reconcile. It is of paramount importance, therefore, that there is agreement on the objectives of the ecosystem before selecting and implementing last-mile delivery solutions.

Three sub-ecosystems could be given priority:

- Urban distribution centers (freight pooling outside the city – see Part 1, Game Changers),
- Experimental business models for ultralight multi-purpose vehicle fleets (serving long-distance providers of road, rail, air and river transport),
- B2B marketplaces that allow last-mile logistics providers to increase sales by optimizing vehicle utilization. At less than 45%, global average utilization is too low and must be optimized first.

5/ MOBILIZING PRIVATE INVESTMENT

The growing mobility needs of a rising urban population, necessitating as they do infrastructure, electrification, smart networks and new transport solutions, clearly offer a growth opportunity to private companies.

The hardest part about mobilizing private funds is to ensure an appropriate regulatory framework for those investments.

What is needed is a guaranteed level of service quality for public players and return on investment visibility and stability for private players.

That implies a structure and processes for the ecosystem within which players operate. Since the measures are interdependent, coordination between players is all important.

Limiting political intervention to coordinating and leading the ecosystem

As Adam Smith showed in 1770, the market regulates itself naturally. He called this the «invisible hand». If players are motivated – i.e. the cost-benefit tradeoff is favorable – they do what is expected of them and the system works on its own without undue public intervention.



The «invisible hand», in the case of mobility, is human ingenuity which can be seen in the advances and innovations primarily designed to address the expectations of users (safety, convenience, cost, enjoyment, etc.).

If market forces are unable to make the system work, political intervention may then be necessary to achieve a targeted goal. Political intervention serves to coordinate interaction between various players in an effort to address the societal challenges we face. Accordingly, coordination should focus on lifting obstacles and encouraging positive, game-changing innovations. Intervention, however, should be restricted to the coordination of players so as to limit the risk of substituting public management failure for market failure (or failure of the economic model used).

At the municipal level, in particular, the role of government is determinant, and this is highlighted on pages 108 - 109.

Segmenting issues into modules

For optimum operation, the golden rule of governance is to break issues up into modules. The idea is that each player should focus on the module that interests them or where they are capable of generating growth and a return on investment.

Moreover, this form of segmentation encourages creativity and innovation. Players are more likely to innovate if they do not have to deal with other modules in their value-creation proposals.

Beyond coordination, there are other important questions to be addressed. Who appoints the relevant players? How is interaction between modules to be managed so that every module gets the information it needs from the other modules?

Who decides if a module is working properly or not? Who corrects any errors and how?

Who referees? Who monitors and assesses the performance of a specific module? And so on and so forth.

In answer to these questions, each ecosystem should set up a Coordination Committee for each game changer module, overseen and managed by the private players concerned. Each committee will operate in consultation with an innovative mobility ecosystem governance committee. Overseen by the public authorities, the committee will set targets and measure progress, but again leaving operational responsibility to the private players.

To a large extent, what makes the innovation ecosystem in California's Silicon Valley so remarkable and well performing is this model of governance, allied with the formation of local clusters of innovation, investment and talent.

Accordingly, three ecosystems for mobilizing private funding should take priority:

- Public/Private Partnerships (PPP): Special focus must be placed on new styles of governance and new goals to ensure that these ecosystems function as they should and are not hampered by uncertain profitability and ill-defined goals. For this to happen, separate coordination and governance committees (see above) must be set up. This in turn requires public authorities defining the roadmap in terms of operational modules and related business opportunities, thereby enabling private players (manufacturers, mobility players, ITS suppliers) to focus on their respective modules.

- New business models (taxi, valet parking, etc.). Public authorities must encourage their emergence with a view to better satisfying the expectations of citizen-consumers, including their need for «on-demand mobility».

- Crowd funding. Although this mechanism is perfectly suited to participatory economics and helps place the consumer at the heart of the concerns of mobility players, it is still poorly regulated or unregulated. Such an ecosystem could lead to the creation of investment products that match the expectations of private investors looking for a steady return over the long-term.

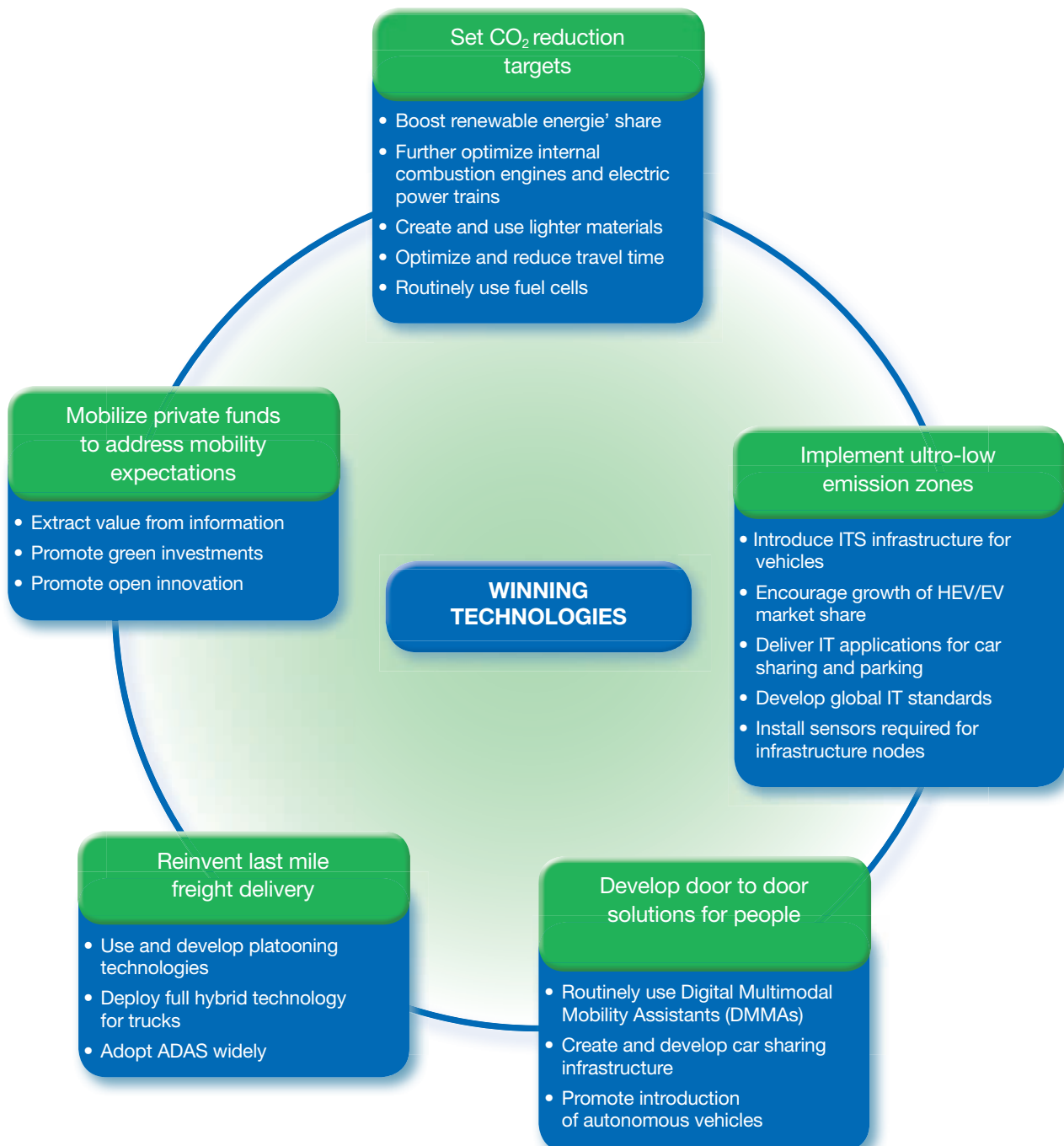
By way of interim conclusion, introducing the ecosystems identified for each of the game changers recommended in this Green Paper will help determine the winning technologies that can be rolled out today, the relevant targeted regulatory measures and the funding instruments available for large-scale roll-out.

The following chapters will address these issues, with a view to keeping mobility enjoyable for everyone and facilitating the transport of freight.



2 The **winning** technologies of **tomorrow**

The technologies required to implement the recommended game changers are sufficiently mature to be rolled out in the next 10 years. For this to happen, the only developments that still seem necessary, apart from incremental ones, are local adjustments and appropriate regulations (on autonomous vehicles, for example).





“Winning technologies” provide the technical foundations for truly innovative mobility ecosystems. They will usher in a new era of growth for both industry and services. Examples of successful deployment abound when the political will is present. The coming decade will culminate in the call for a second phase of innovations ready for mass deployment which build on the first wave of applications we already know (hydrogen, first and second generation bio-fuels, brain-machine interactions, etc.).

Implementing the five game changers presented in this Green Paper involves developing five fields of winning technologies:

- 1** Mass data collection and real-time data processing capability, in harness with ITS applications in particular, comprise the most revolutionary tool for improving passenger and goods transport.
- 2** Advanced driver assistance systems (ADAS) and automation technology are essential to enhancing safety, eliminating pollution, and combating congestion and related stress. They will pave the way to autonomous vehicles;
- 3** Multimodality and intermodality, if well coordinated and backed by new service offerings, are crucial for tomorrow’s mass transit systems;
- 4** Electrification of road vehicles, albeit partial, is a prerequisite to almost total urban pollution abatement (since subways, trams and trains are often already electrified, and two-wheelers, boats and even some planes are on the way to being so);
- 5** The availability of clean energies that reduce pollutant and CO₂ emissions from one end of the chain to the other (well-to-wheel) is key to energy diversification in the transport industry.

1/DEVELOPING INTELLIGENT TRANSPORT SYSTEMS

ICTs (Information and Communication Technologies) and ITS (Intelligent Transport Systems) are the cornerstones of modern transport solutions. Already available on the market, these technologies will shape urban mobility by:

- enhancing safety for everyone through automatic emergency calls, real-time roadside assistance, remote assessment, advanced driving assistance and obstacle avoidance systems;
- preserving the environment through more efficient public transport, travel optimization and traffic management, car sharing, multimodality, arrival on the market of green services, etc.;
- stimulating the economy through new economic opportunities stemming from business models based on monetization of Big Data streamed by vehicles (real-time traffic flow, infrastructure congestion levels, traffic monitoring, route planning, driving behavior, etc.). The resulting income streams will lead to the creation of new jobs and skills;
- promoting new user attitudes and behavior such as eco-driving, telecommuting, new mobility models (pay-as-you-drive), sharing, multimodality, services offered at intersections (transport infrastructure nodes), entertainment, not to mention everything that goes into making driving and moving around enjoyable.

The four most promising ITS technologies are:

- V2X communication systems that help to enhance safety. Their deployment implies that all vehicles are fitted with standardized systems;
- collision avoidance or pre-crash systems and directional control;
- automatic speed change (congestion/fuel consumption/platooning);
- GPS-based sign recognition (safety/congestion).

By being connected, tomorrow's transport systems will be cleaner, safer and more reliable.

New players and markets

The prospect of vehicles connected via ICT and ITS systems not only concerns traditional road transport players, but encompasses a complex ecosystem of stakeholders, including public authorities, regulators, operators, vehicle manufacturers, providers of other travel modes, service providers, new technology suppliers, financial institutions, etc. This breakthrough innovation relies on a wide spectrum of applications offering connectivity between people and services, between vehicles and infrastructure (V2I) and between vehicle and vehicle (V2V). Many types of communication technologies are available today (smartphones, GPS, etc.), each with ITS-specific applications.

The necessary condition for mass deployment of ITS is large-scale use of on-board sensing and communication technologies: radio frequency identification (RFID), V2V and V2I, sensors, induction loops and video vehicle detection, beacons at all transportation nodes, etc.

The primary effect of these technologies, driven by electronics, software, sensors and actuators, is to account for up to 40% of the vehicle's price. This entails new providers, including parts suppliers, maintenance service providers and mobility integrators, among others. The automotive industry is in a state of flux as it shifts its focus away from mechanics to greater reliance on electronics and information technologies.

The second effect of these smart technologies and the consolidation of data derived from them is the provision of new services which people will undoubtedly pay for because they match their new lifestyles.

ITS technologies lie at the interface between operational improvement in the transport mode itself and communication with the outside world (location, safety, information, payment, entertainment).

The various players are jockeying for position at the different stages of development of ITS technologies:

- real-time data collection: recognition, surveillance (cameras, GPS, etc.);
- real-time data processing;

- response to infrastructure: traffic lights, smart displays;
- response to vehicle:
 - steering correction,
 - automatic toll payment,
 - parking space management,
 - route management, etc.

Much needed international regulation

Public authorities need to step up the deployment of ITS technologies. For example, the 5,000 or so Chinese ITS equipment and network installation companies must coordinate efforts to facilitate data sharing and synchronization. The lack of a standard traffic control protocol makes it difficult to integrate existing software with complex maintenance.

The role of public authorities will be decisive in promoting a sound ITS-based ecosystem, while protecting rights to privacy. It is vital for cities to analyze traffic data, create their own urban mobility dashboard and so provide themselves with the means of taking documented decisions. This approach will foster more appropriate user behavior through innovative digital applications which, in turn, will raise additional financing from data monetization by private firms.

Creating value from Big Data

Processing vast amounts of data (Big Data) gathered by ICTs will help create new services for consumers and professionals alike. As a result, insurance premiums linked to driving style, or special offers from stores during a journey based on the passenger's buying tastes and preferences, are among the first possible applications. Service packages can be offered by providers delivering commercial solutions based on user habits and routes. Beyond mobility itself, the information collected would foster the development of a wide range of services and new business models that stimulate growth and job creation.

ITS : Intelligent Transportation Systems and matching services

Real-time data collection



- Cameras
- GPS
- Inductive loops
- Sensors



Real-time data processing



- Software
- Hardware
- Powerful and fast computers



Response to infrastructure



- Traffic lights
- Smart street signs
- No-access streets



Response to vehicle



- Direction correction
- Route management
- Automatic tolls



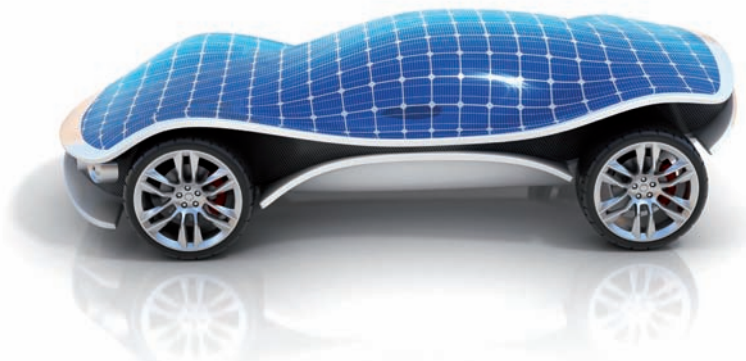
Data-bases business models



- Pay-as-you-drive insurance
- On-route service offerings



McKinsey and WEF, adapted by Michelin



2/ MOVING FROM DRIVING ASSISTANCE SYSTEMS TOWARDS AUTOMATED TRANSIT SYSTEMS AND AUTONOMOUS ROAD VEHICLES

Autopilot systems for planes and boats and driverless subway trains are already part of everyday life and will become increasingly widespread.

Advanced driver assistance systems (ADAS) for road vehicles release drivers from some tasks, improve their understanding of the vehicle's surroundings and even take over from them in an emergency. Their ability to ensure steadier driving, avoid unnecessary acceleration and optimize journeys will contribute to reducing pollution and congestion. The driver will be more relaxed and far more able to just enjoy the pleasure of driving and cruising. To fulfill their potential, though, ADAS technologies need to be standardized and technically compatible. Along with automation systems, they are a forerunner of autonomous vehicles. These technologies already exist, but the sooner legislation takes account of their added value, the faster they will develop.

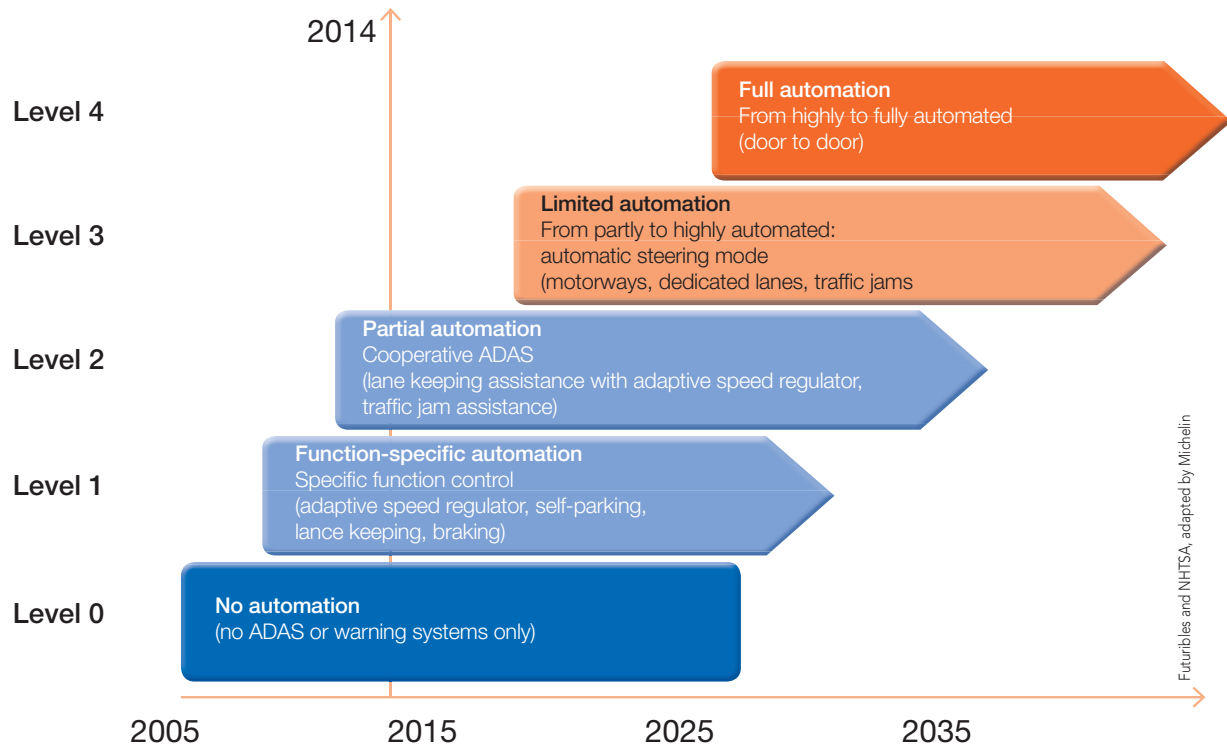
The ultimate in ICT/ITS technologies, autonomous vehicles will soon constitute a revolution in road transportation! They already exist in one form or another: limited autonomy vehicles available on the market such as the Mercedes Class S, or prototypes such as Google Car and Ligier VIPA. Often only used for short-distance applications, they can pave the way for major advances in mobility planning. Their development requires wide public acceptance and shared responsibility with lawmaking authority. «The car to which we are accustomed and the way in which it is used are going to change radically and quickly», says Bill Ford. He believes «the automatic car of the future

will come sooner than we think». The main obstacle to its entry into service is the lack of a definitive legal framework. Laws need to be sufficiently robust to be enforceable in all jurisdictions around the world. Addressing this vital issue would pave the way for new players and stimulate the creativity of existing manufacturers.

Automatic control of the vehicle's main functions optimizes its use and reduces its fuel consumption. It also ensures smoother vehicle operation and prevents driver error. This solution could be used in high safety zones as an adjunct to vehicles and infrastructure designed to significantly enhance the safety of all users, be they pedestrians, two- and three-wheelers or cars.

While some technologies such as automatic parking, low-speed emergency braking and white-line detection are already built into a number of market-available vehicles, others such as automated driving in traffic jams and lateral/longitudinal vehicle control are on their way. These highly automated driving systems will be available by 2020. The ability of the driver to relinquish control of the vehicle on the motorway, for example, is still some time away as long as there is no legal framework or consumer acceptance. Low emission zones in cities would be an ideal test-bed, providing a well-demarcated area – with few and at night very few vehicles – conducive to deliveries by autonomous vehicles, for example.

The US National Highway Traffic Safety Administration (NHTSA) classifies autonomous vehicles according to their level of sophistication and emergence on the market:



It should be noted that drones could also soon be making a significant contribution to light-weight logistics operations. Amazon's plan to deliver parcels under 2.3 kg in less than 30 minutes within a radius of 15 km from 2019 opens the door to new applications for these machines which have proved their mettle on the battlefield.

3/OPTIMIZING INTERMODAL MASS TRANSIT SYSTEMS

In big cities, public transport is the only affordable solution for moving vast numbers of people over long distances. Developing mass transit systems on a best practice basis is therefore essential.

Today, intermodality is all about seamless passenger-friendly coordination between different transport modes. In this age of telematics, this means providing connectivity applications between vehicles, infrastructure and traffic control centers, which in turn relies on the development of sensors and intelligent transport systems (ITS). At infrastructure nodes in particular, where several transport modes intersect, it is essential to have a network of effective sensors that allow the flow of passengers from

one mode to another to be monitored. Lisbon, for example, is preparing a project aimed at offering everyone two multimodal alternatives to using their own vehicle. Several highly creative avenues exist for combining mass transit systems with more customized solutions. For example, a combination of electrified bus rapid transit (BRT) systems and electric vehicles is suitable for fast-growing countries in control of their urbanization (Transport Oriented Design). BRT solutions have demonstrated their ability to limit congestion and deliver services tailored to the needs of city dwellers, provided they are well connected to other transportation modes. They are much more economical to build and run than underground networks like the subway (about 18 times cheaper). Associating the development of BRT systems with ongoing research on electric vehicles is clearly a winning technology mix. The infrastructure for BRT systems could be equipped with battery recharging capacity in a way that preserves the peace and quiet of the areas crossed. Since these buses operate within a radius of 30 kilometers, every stop could technically be equipped with wireless recharging systems.

Autonomous vehicles will be needed in specific areas for last-mile logistics or to offer residents a door to door commuter transport service. The complementarities between BRT and autonomous vehicles running, when necessary, on dedicated bus lanes should definitely be developed as part of a seamless transport policy because they are both convenient and reliable (see IHS report «Impact on new urban mobility»). These vehicles should be economically affordable and physically accessible to all. They should be deployed on a large scale only in conjunction with ITS solutions that facilitate mobility management during peak hours. Outside rush hours, their scalability could also be used for freight transport and for participating in the last-mile logistics supply chain.

4/ ROUTINELY USING LOW ENERGY AND VERY LOW EMISSION SOLUTIONS

Lower energy consumption and diversification of energy sources are the watchwords for all types of transport. It is not feasible to sustain a doubling of fossil fuel consumption resulting from a doubling of transportation. That is why we need lighter vehicles with optimized electric or combustion engines and a wider use of hybridization (not just hybrids combining an electric and combustion engine, but also vehicles using the latest air and hydraulic hybrid drives). If toxic emissions are to be reduced, however, the inevitable shift to more electric powered urban transport must stimulate the development of necessary low-carbon electric power generation processes.

All the figures presented in this report are «well-to-wheel» precisely to factor in this requirement and to avoid shifting the environmental impacts to another stage in the life cycle of tomorrow's transport systems.

Above all, development of electric energy production and vehicle charging infrastructure is required, as well as rethinking electricity use and smart grid interconnection between geographically dispersed producers and consumers on the one hand, and high-capacity power stations on the other (with batteries either charging or sending back electricity to the network).

China's two-wheelers are a highly successful example of the shift to electric mobility. The country has become the world's leading producer and exporter of these vehicles, with the domestic market alone accounting for about 90% of global sales.

However, we need to widen our technological horizons. Internal combustion engines and liquid or gas fuels also have a promising future. That is why it is important not to be dogmatic, but be mindful of the breakthroughs required in each technology.

Internal combustion vehicles. While significant progress has been made to improve the energy efficiency of engines, most vehicles are still too heavy to be energy efficient and much still remains to be done. There is potential for improvement both inside the vehicle (engine, particle filters, weight reduction, etc.) and outside through the use of new concretes in urban infrastructure able to degrade air pollutants.

Electric power trains. So long as they are based on traditional platforms, even the most sophisticated consume too much power to:

- offer sufficient autonomy outside urban areas and a viable economic alternative, except for high-end niche or targeted applications;
- keep well-to-wheel CO₂ emissions down to satisfactory levels in every country.

We therefore need to design more energy-efficient and lighter electric vehicles that offer users customized autonomy. The technologies are available, including batteries, fuel cells and supercapacitors.

Developing much-needed new generations of vehicles

The challenge facing us, for example, is to develop three- or four-wheel vehicles that are attractive for city use, consume less than 10 kWh/100 km in electric mode and emit less than 50 g CO_{2eq}/km well-to-wheel (regardless of mode based on CO_{2eq} of electricity). Assuming that a truck consumes six times more fuel than a light vehicle, it would mean cutting freight-related emissions to 300 g CO_{2eq}/km. This challenge can be met – and previous Michelin Challenge Bibendum events have shown as much – since the solutions are both environmentally and economically viable.

Overall, technological innovations, like societal demands, are growing rapidly. Key advances include:

- reduced fuel consumption by internal combustion vehicles with the help of «Stop & Start» technology, improved lubricants, better aerodynamics, regenerative braking for hybrid drives, etc.;

- cleaner engines and exhaust systems, with combustion optimization (smaller engines and lighter materials), direct injection, turbo-compression, exhaust after-treatment, etc. As well as allowing drivers to enjoy their habitual driving behavior, these solutions are adapted to actual vehicle use cycles;
- low-carbon fuels, such as natural gas, liquefied petroleum gas (LPG) and biofuels (whose world production rose from 9.2 million tonnes of oil equivalent (toe) in 2000 to 65 million toe in 2013). Also recycled fuels (cooking oils) or fuels derived from animal fat, depending on the availability of those products;
- battery-supercapacitor-fuel cell combinations providing better performance and driving range in electric mode;
- very low energy auxiliary systems (lighting, heating, air-conditioning, etc.);
- more efficient driving styles, backed by built-in electronic assistance and driving lessons for learners. Journey times will be the same, or even quicker, at lower speed;
- smoother traffic, parking information, real-time route planning with ITS and ICTs;
- more fuel-efficient, ultra-low rolling resistance tires offering 5-10% energy savings, coupled with equal or better safety performance. The rolling resistance coefficient has been cut by 30% in the last 20 years. Lower fuel consumption also means greater driving range.

Solutions aimed at achieving 95 g CO₂/km by 2020 in Europe (or regions that have similar regulations) should be pushed to attain 50 g CO₂/km by 2040.

Vehicle platooning – a convoy of autonomous trucks behind a lead vehicle offers a low-carbon mobility solution on highways thanks to vehicle-to-vehicle communication technologies. It has been tested in Germany, the United States, Sweden and Japan. Its many advantages include steady convoy speed, less utilized space and optimized loading through the pooling of cargo shipments. By optimizing aerodynamics due to the small space separating the vehicles, platooning reduces fuel consumption, half of which results from air resistance created by higher speeds. Continuous speed control improves driver comfort and safety. The convoys also enable existing infrastructure capacity to be increased. Then there is the positive impact of pooled deliveries on product prices. In future, convoys will converge on urban distribution logistics platforms where their cargo is loaded on to small vehicles designed for city center deliveries.

These connected vehicles with access to traffic assistance systems, city-center parking and intermodality will be perfectly suited to last-mile logistics and door to door commuting.

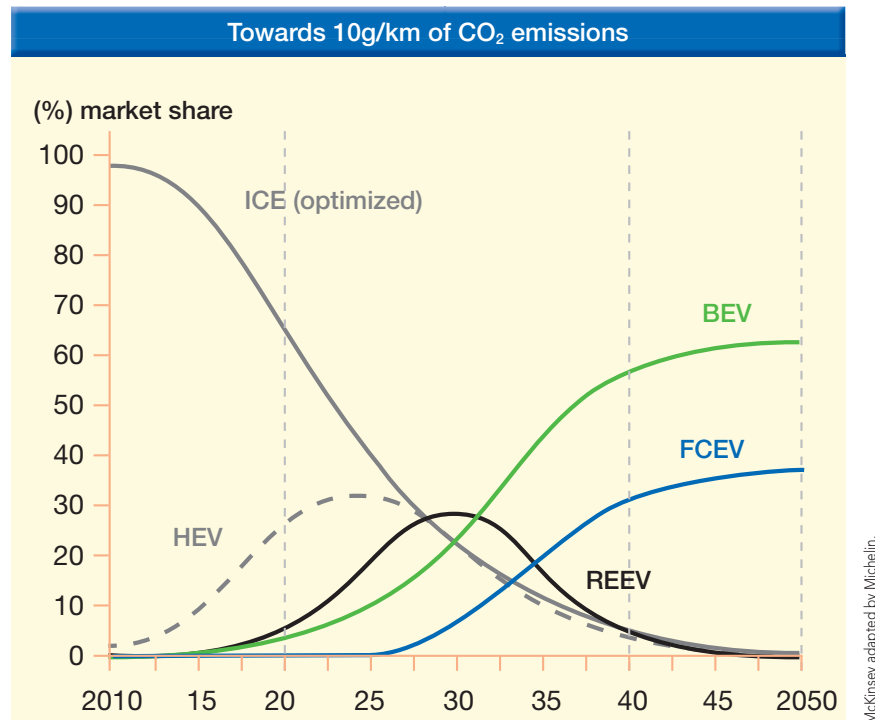
The advantages of hybrid vehicles

Hybridization is ideal for moving within low- and ultra-low emission zones and making inter-city journeys. A significant number of vehicles could be designed with plug-in features (rechargeable hybrids), smaller turbo-compressed engines and regenerative braking. Such hybrids would also have sufficient 100% electric driving range (30-50 km) to move around easily in city centers. Within the next 15 years, hybrid power trains with their vastly flexible design may well become predominant. They will significantly reduce emissions without disrupting driving habits. Fast growing countries have the opportunity of leading this development through rapid implementation. Many government initiatives are driving this innovation, including the China New Energy Vehicle Program and Quebec's Transport Electrification Strategy. As noted, however, the problem of CO₂ emissions from electricity generation remains. While 97% of Quebec's electricity comes from dams and therefore emits very little CO₂, 78% of China's electricity is generated by coal-fired power stations.

Rising electric mobility and the advent of hydrogen

The future undoubtedly lies in meeting a greater share of overall transport requirements with electric mobility. As pointed out by McKinsey in a recent study, this change is unavoidable and will occur on a significant scale by 2030. Batteries and fuel cells continue to improve, opening the door to more and more applications. Their cost continues to drop as a result of economies of scale and productivity gains. Fuel cells are being widely tested in planes, boats and road vehicles. Fuel cells and hydrogen are essential to higher-range electric mobility. In an optimistic scenario of 10 g CO_{2eq}/km from road traffic, McKinsey sees hydrogen playing a major role by 2050, after a ramp-up in 2025 (see figure above).





ICE dominant until 2025 but loses market share to electric vehicles (EVs)
In the long term, battery powered vehicles (BEVs) lead small vehicle segment and fuel cell vehicles (FCEV) the large vehicle segment

ICE : internal combustion engine
BEV : battery electric vehicle
HEV : hybrid electric vehicle (potentially rechargeable)
FCEV : fuel cell electric vehicle
REEV : range extended electric vehicle

Electric mobility promotion policies will focus on lightweight vehicles using X-by-wire systems and collision avoidance technologies for improved traffic safety.

Governments will have a key role to play in promoting these vehicles. The Canadian government already provides a grant of C\$8,500 towards the purchase of an electric vehicle and C\$2,000 for the installation of charging infrastructure.

Let us not forget that home-based power generation or hydrogen production is feasible via solar and wind energy systems and can be shared through «smart grids» like those already used in Japan. Automotive manufacturers are also exploring solar power, as is the case with the C-Max Solar Energi prototype unveiled by Ford.



Placing increasing emphasis on safety

All the developments touched on in this chapter should aim at improving safety across all transport modes, with special emphasis on road safety. China is concerned about the high number of deaths on its roads. Many other countries, where vehicles may have 4 to 5 times fewer safety features than in developed countries, are faced with the same problem. The introduction of regulation will play a key role in improving road safety. As the demand for mobility increases, regulations will get tougher for manufacturers (crash tests, airbags, ABS, ESP), drivers (speed limits, breathalyzers) and people (adherence to the new rules introduced by the authorities).

A WHO report published in 2013 shows the loopholes in legislation regarding major risks and safety equipment in passenger cars. Other than regulation, a range of technologies can help bring improvements that make vehicles substantially safer. They fall into two categories:

- active safety systems to reduce the probability of an accident: vehicle dynamic control, electronic braking and stability systems;
- passive safety systems to minimize the effects of an accident: vehicle architecture (management of energy produced at impact, pedestrian protection); protection devices (inflatable bags, seat belts with pretensioners and force limiters); interior padding, etc.

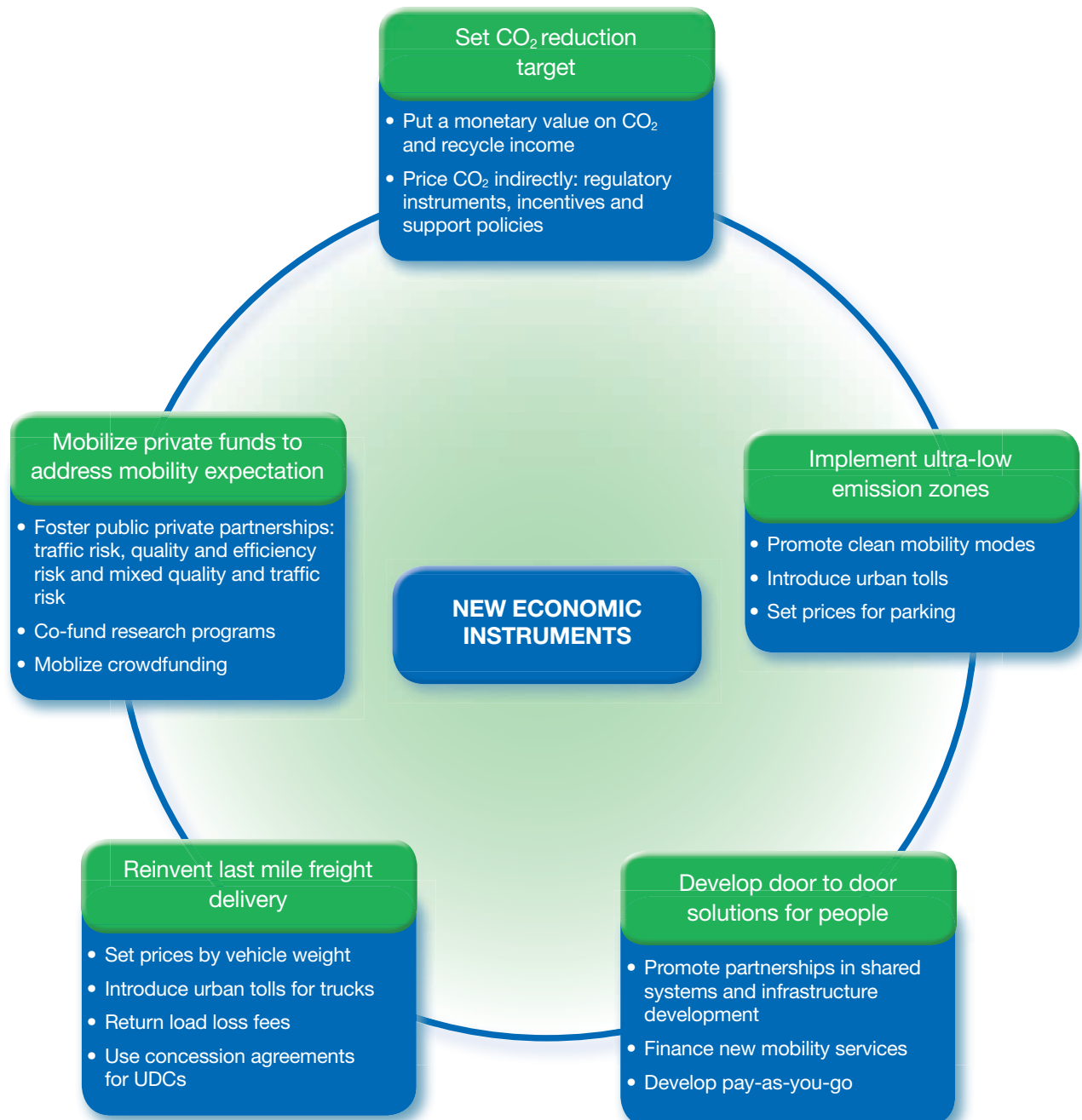
Active and passive safety technologies are increasingly effective. Manufacturers have developed a fully integrated approach from collision avoidance to reduction of its impact on both passengers and vehicle. The systems are designed to improve the protection of passengers and pedestrians, absorb crash forces and limit the damage caused to the vehicle. The cars, due to be released on the market very shortly (some already have been), will be fitted with automatic accident information systems that notify other vehicles, the infrastructure network and the emergency services.

We should never forget that safety is at the core of people's expectations!



3 New economic instruments

An economics of externalities must therefore be re-invented, starting with CO₂. This will help generate new streams of income, which could then be recycled into the economy through greater investment in networking, infrastructure and new technology aimed at making fares affordable for everyone and easing labor taxation.





«There is a time for weighing evidence and a time for acting. And if there's one thing I've learned throughout my work in finance and government, it is to act before problems become too big to manage...»

Henry M. Paulson, Chairman of the Paulson Institute at the University of Chicago and Secretary of the US Treasury (2006-2009)

«The coming climate crash: Lessons for Climate Change in the 2008 Recession», *The New York Times*, June 21, 2014.

«Putting our economies on a low carbon and more sustainable footing involves ground-breaking innovations in technology, regulation and social organization. These breakthroughs will not emerge spontaneously, but will result from the introduction of a wide array of economic and regulatory instruments that must complement each other, avoid red tape and promote individual initiative and entrepreneurship».

Christian de Perthuis, President of the Scientific Committee of the Climate Economics Chair, Paris

As well as offsetting labor tax reductions, the income generated from CO₂ externality pricing should be used to fund infrastructure and new mobility services. Both would benefit from opening up projects to private sector funding, including those traditionally financed with public funds.

In this chapter, we also touch on the recent emergence of innovative financing and payment solutions for individual mobility services. After their experimental phase, these solutions will take off.

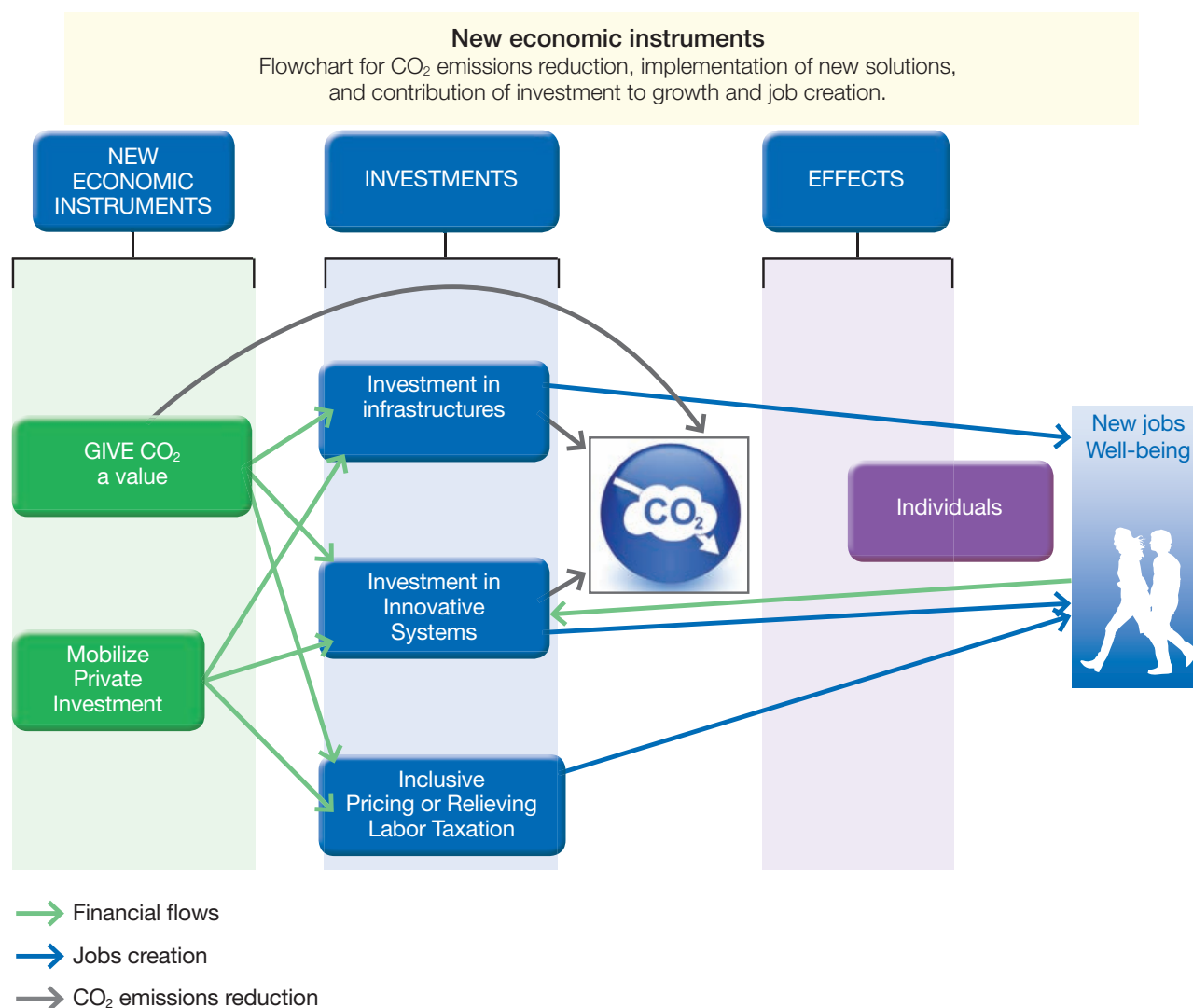
1/INTRODUCING EFFECTIVE ECONOMIC INSTRUMENTS

1.1 Putting a monetary value on CO₂

Carbon pricing sends a strong and increasingly clear, indeed much awaited, signal to the business community. It is the cornerstone of the abatement system for two major reasons. Firstly, it will encourage the switch to carbon-free goods and lower fossil fuel consumption. Secondly, it will generate income, thereby accelerating the funding and development of sustainable mobility solutions and infrastructure, reducing fares and easing labor taxation.

Should the price of CO₂ gradually reach the IEA recommended level of USD130/tonne (in 2040), or that of USD150/tonne, successfully adopted by Sweden today? It's up to States to decide.

Below these levels, some experts think that the value of CO₂ will be insufficient to contribute significantly to CO₂ emissions reduction. There are two possible direct pricing options: establishing a CO₂ emissions trading system for transport, or introducing an emissions tax.





CO₂ emissions trading for transport: an economically attractive solution still at the experimental stage

Various CO₂ emissions trading systems are undergoing trials around the world. In China alone, no fewer than six test markets in six different cities were launched in 2013. Globally, there are now about ten experimental or pilot markets dealing in transport emissions, in addition to China, California, Quebec, Europe and Kazakhstan.

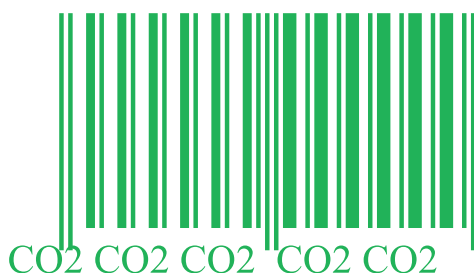
Transport is by nature very diverse and difficult to cover under a single scheme. The systems of measurement, data collection and verification are complex since it is necessary to establish a method of allocating and monitoring allowances for each individual. Admittedly, CO₂ allowance trading market trials which include transport have yet to demonstrate their effectiveness, but we are only at the beginning of this experimentation process.

Nonetheless, this solution offers a considerable window for creating economic value. It will probably take some time to make the transition from experimentation to maturity. This is why we believe quicker CO₂ pricing measures can be adopted as a first step. Once the different stakeholders are made aware that CO₂ emissions carry a certain value, allowance-based regulation and trading will probably be easier to introduce.

Incentive-based CO₂ pricing – an interim and probably quicker alternative solution

We draw here on Sweden's successful pricing of CO₂. Creating a CO₂ tax applicable to all modes of transport would in our view be a more appropriate method of direct monetary valuation, provided that:

- all countries are encouraged to reduce CO₂ emissions, the fight against global warming being in the service of a global public good. The scope of a carbon tax must be as wide as possible so as to avoid a situation where only a handful of countries make the bulk of the effort. Nevertheless, to ensure the effort is proportionate, the amount of tax has to be adjusted in terms of purchasing power parity.
- the ideal implementation regime would be one that results from an agreement between the biggest emitting countries: China, European Union, the United States and possibly India. Such an agreement would have a significant knock-on effect on the other countries of the world, as it would give them clearly defined revenue collection and redistribution responsibilities.
- since our aim is to spur innovation, introducing a carbon tax will create a virtuous circle of lower energy consumption and innovation.
- many experts propose immediately recycling, by way of incentives, the resulting revenues into at least three key sectors of the economy: employment support via measures to ease labor tax; investment support, especially for infrastructure requirements; support for technological innovation.



Impacts of CO₂ monetary valuation on CO₂ emissions and job creation

Impacts on	CO ₂ emissions	Job creation
All sectors	Shift to low-carbon goods	All sectors via recycling of carbon revenues to ease labor tax
Transport	Increase in share of modes that emit less per passenger/km	Sectors of public transport and new mobility services
Energy	Improvement in energy performance of different transport modes	Energy industry (excluding fossil fuels)
Innovation	Low emission technologies	Research and development (electric, hydrogen, etc.)
Infrastructure	More efficient infrastructure	Construction industry (building, ITS, etc.)
Urban Planning	Urban densification	All sectors: driven by growth in urban development and densification (agglomeration economies)

Direct CO₂ pricing alone will not be enough to make the transition to low-carbon mobility. It will be essential to use indirect pricing mechanisms as well, usually in the form of targeted usage incentives decided locally, for example at city level.

1.2 Effect of indirect CO₂ pricing on mobility

Several indirect mechanisms can be successfully introduced locally in conjunction and synergy with direct CO₂ pricing. They fall into three categories:

Regulatory instruments (traffic, CO₂ standards for vehicles, etc.)

These are measures to encourage behavioral changes in mobility demand. Standards are decided at national level or, as with the Euro standard, at a wider level. Traffic optimization measures are decided locally at city level. Regulatory measures, however, can be costly to implement. By their very nature, they do not seek to raise revenue, and unlike taxes they do not bring in revenue. On the other hand, they require the introduction of control systems such as license plate recognition. Care must be taken to ensure that they do not raise issues of fairness, especially as the poorest households usually also have old and, therefore, high-emitting vehicles.

Incentive instruments (bonus-malus, public transport pricing, etc.)

Some incentive measures such as vehicle or fuel tax may be decided at national level. Others, such as tolls and public transport or car park pricing may be decided locally. There are costs related to the introduction of a collection system. These instruments moreover raise problems of acceptability. «Bonus»-based incentives or «social pricing of public transport» also constitute a cost, but allow the poorest to be included. Most financial incentives generate income (taxes, tolls, penalties) that can be used to fund other incentives (bonuses, public transport fares) or new transport infrastructure.

Support policies (eco-driving instruction, walking and cycling projects, etc.)

The goal of these complementary measures is to reduce congestion through public transport development, pollution reduction and health improvement. The success of these measures is highly dependent on local conditions such as demography, landscape and street safety levels, especially with regard to promoting cycling.

1.3 Introducing ultra-low emission zones (ULEZs)

CO₂ pricing is entirely consistent with the creation of ULEZs and their corollary, pollution abatement.

It is essential to target urban emissions because cities are the source of 75% of global CO₂ emissions. Gothenburg, for example, plans to establish an ULEZ by 2020 in which only EURO VI vehicles will be allowed. Introducing a CO₂ tax will at the same time limit journeys by extremely polluting modes of transport outside the boundary of an ULEZ (interurban travel).

As timing is important, we recommend phasing in the CO₂ tax, starting low and raising it gradually to ensure its acceptability. As the tax increases, behavioral changes will become more commonplace. As efforts to renew fleets with cleaner vehicles continue, ULEZ criteria will only be restrictive for a small proportion of vehicles.

When households are forced to give up their polluting vehicles to enter an ULEZ, the demand for low emission door to door solutions is bound to increase. The same reasoning applies to goods transporters and last-mile delivery solution providers.

The «ULEZ + carbon pricing» combination can be broadly implemented. Nevertheless, the acceptability of these instruments has to be factored in. The same is true for the expression of the carbon tax in purchasing power parity terms, existing mandatory levies, the urban density criteria used in ULEZ delimitation and public transport infrastructure.

2/ PROMOTING NEW MOBILITY BUSINESS MODELS

2.1 Devising new ways to finance sustainable transport infrastructure

In our game changer «Mobilizing private investment for sustainable transport infrastructure and innovative mobility services», the advantages of new forms of partnership between the public and private sectors were pointed out. We will limit ourselves here to illustrating this point with concrete examples.

Developing partnerships that create innovative business models: the example of railway station funding

Recent railway station refurbishments or developments in Asia (Tokyo, Hong Kong), New York State and Europe (Milano Central, London's Canary Wharf, etc.) point to the existence of multiple funding models.

Land value capture appears to have the greatest potential. In Asia, Hong Kong's MRT (Mass Railway Transit) and Japan's railway station developments are mainly financed from real estate earnings.

Joint developments, in which the property developer obtains the right to develop a section of the site in return for participation in the construction of the railway station, are tried and tested models. (e.g. refurbishment of the Saint-Lazare railway station in Paris).

New retail developments can be highly effective. A minimum of 50,000 passengers a day are needed to establish a profitable project.

Capitalizing on the economic, social and financial benefits of such partnerships

According to the Canadian Council for Public-Private Partnerships (2004-2014), total PPP investment in Canada for the last ten years amounts to CAD 51 billion. PPPs have generated 290,680 direct FTJs (Full Time Jobs) over the period, CAD 32.2 billion in wages and social security benefits, CAD 48.2 billion towards GDP (including 25 billion towards direct GDP), CAD 9.9 billion in savings and CAD 7.5 billion in miscellaneous tax revenues.

The Canadian government believes these figures show that PPP projects drive GDP growth and boost the country's «competitiveness».



Below are two other success stories:

The PPP between the Indian Railways Ministry and the French rail company SNCF signed in 2013.

A framework agreement refocused cooperation between the two partners on four priority areas: high-speed lines, railway station refurbishment, modernization of India's rail network, and urban and suburban transport systems. SNCF, together with its specialist subsidiaries Gares & Connexions, AREP, Keolis and Systra, will be involved in implementing this agreement.

The agreement would not have been possible without the presence of SNCF in India for several years, mainly through its subsidiaries Systra and Geodis. Under the agreement, the rail operator will bring its technical expertise and operational skills to bear on managing risks and ensuring headway in the projects.

Electric battery vehicle charging stations in New York State

The 'Charge NY initiative' has invested USD 50 million to promote electric vehicle development over a 5-year period. A PPP to this effect has been signed by the Governor of New York. The first stage consists in setting up 80 charging stations in Manhattan. The project provides for the installation of 3,000 public charging points in New York State by 2018.

2.2 Mobilizing private capital to develop new mobility services

Co-funding experiments are particularly effective in spurring innovation at a community level. These «forward-thinking projects» factor in citizen and user demand, the public authority's vision and the innovative potential and implementation capacity of private companies.

Amsterdam Smart City (ASC) is a unique partnership among companies, local authorities, research institutions and the people of Amsterdam. Their common aim is to develop a smart city within the city. The project is based on the city making available a maximum of data enabling all players to offer innovative solutions for the well-being of its people.

Autolib. Launched in Paris, Bolloré Group's car sharing service has expanded to North America (Indianapolis), with plans afoot to develop it in Asia and London. The model relies on the privatization

of surface parking spaces and the payment of a public subsidy to participate in the investment and operating costs of the service, and so strikes a proper balance. However, to break even, it must attain critical mass in terms of customer numbers.

The European Union's Green Vehicles Initiative (EGVI). The automotive sector, which accounts for 12 million direct jobs in Europe, is facing unprecedented technical challenges in order to meet environmental requirements. Finding technical solutions, bringing about a successful transformation and preserving jobs has led the EU to call on several industries to combine their innovation resources. A PPP has been entered into between the European Green Vehicles Initiative Association (EGVIA) and the EU, with a research budget of €1.5 billion, financed on a fifty-fifty basis.

Open Data in Montreal and Edmonton (Canada).

In Edmonton, an open data application provides direct access to urban mobility performance data. Urban services have round-the-clock access to 400 data sources enabling them to make decisions aimed at improving performance and resource management (vehicles, energy, human capital, etc.).

Montreal has developed a partnership with SAP allowing this private company to analyze mobility flows in real time and to offer new services that provide income generation opportunities.

Cooperative Research & Development Agreements (CRADAS). This US initiative focuses on setting up cooperatives that bring together federal laboratories from key public sectors (defense, healthcare, energy) and industrial organizations. In the absence of joint funding, the aim is to share projects, researchers, resources and infrastructures, pool R&D resources and work together in areas of common interest to spur innovation. This partnership model is used in the aeronautics industry and could be extended to other fields of transport.

2.3 Encouraging private investment by and for the people

Private monetary and non-monetary investment by people

To be successful, the mass roll-out of a new mobility offering has to attract massive public support. The principle of crowdfunding is not effective for infrastructure projects where the investment requirement is extremely high.

However, it comes into its own as a solution for funding mobility.

Examples of innovative mobility solutions financed by crowdfunding.

- Items used for individual mobility (door to door): Leev electric scooter, Onewheel Urb-E, Riide, ZoomAir electric scooter, etc.
- Items used for deliveries (last-mile delivery): Kubo.

If people are unable to participate in mobility financially, they can still access public transport through exchange systems.

In **Curitiba**, an experiment allows the poorest city residents to exchange their refuse at a waste treatment center for bus tickets and food.

This initiative has a positive impact on the cleanliness of the poorest urban areas.

In **Beijing**, reverse vending machines at some subways accept plastic bottles as payment at the rate of 5-15 cents a bottle.

In **Moscow**, a special ticket machine has been installed at the Vystavochaya subway station offering passengers free tickets in exchange for 30 squats with the two-minute transaction period monitored by camera. The aim is to raise awareness about public health.

Private investment for people

Micro-credit is an innovative solution for mobility.

In **India**, cycle rickshaws (cycle taxis) play a vital role in the mobility of people living in medium-sized towns. The Dippahan Cycle Rickshaw Bank Project encourages drivers to acquire their own vehicle through a micro-credit. An advertising space on the cycle helps to improve the project's profitability.

In the **Philippines** the Mayor of San Fernando has started phasing out 1,200 of the most polluting three-wheelers. Their owners have been offered an interest-free loan of USD 200 to buy a new, less polluting vehicle. The initiative has been turned into an environmental program.

2.4 Promoting new pay-as-you-go solutions

Pay-as-you-go solutions are expanding very fast and meet a wide range of needs. Their rapid growth is exemplified by the rise of companies like Uber. New business models will emerge because there is strong societal demand for pay-as-you-go solutions.

The **taxi** is the traditional example of pay-as-you-go in transport. Only the kilometers traveled are payable.

A **kilometer tax** trial has been taking place in Brussels and its outskirts since 17 February 2014. Each participant is given a GPS which they log into at each journey. The GPS measures the distances traveled and calculates the amount payable for each journey. The tax is 9 cents per kilometer during peak hours in urban areas, but motorists pay nothing if they drive between 10 pm and 5 am. The kilometer tax replaces the traffic tax already in place in Belgium. The purpose of the trial is to compare the amount paid towards this new tax with the amount of traffic tax.

A **mileage allowance for people cycling to work** in France is also a pay-as-you-go experiment, but in reverse. The allowance amounts to 25 cents a kilometer. The trial will run for 6 months from 2 June 2014. 19 companies and organizations totaling 10,000 employees will test the system. Four criteria will be tested: changes in the number of persons cycling to work, whether or not they stop using their private car, the procedures for claiming the allowance, the factors behind the scheme's success or failure. This incentive is a «bonus», unlike the Belgian kilometer tax which is a «malus».

Still on the subject of mobility, **pay-per-use insurance** has already been available for some years. A PAYD (Pay As You Drive) box sends the insurance company a monthly account of the exact number of kilometers traveled by you and the journeys you have made. In addition to a fixed monthly fee, only the kilometers traveled are payable.

Nantes in France offers a **tailored package** for public transport. Only journeys made are billed and that too at the cheapest hourly rate of €1.38. If a person travels frequently, their charges are capped at the monthly ticket price for their age group, with no commitment or subscription fees.

3/RECOMMENDATIONS

A range of measures at various levels must be considered in order to make a successful transition to a low-carbon mobility economy.

The first of these consist of strong incentives decided at national level, with a synergistic effect among countries. CO₂ pricing will contribute, as a result, to the reduction of other negative externalities, especially pollution and congestion. It will also release economic resources for faster transition to low-carbon mobility.

Such an approach inevitably involves convergence between the main emitting countries.

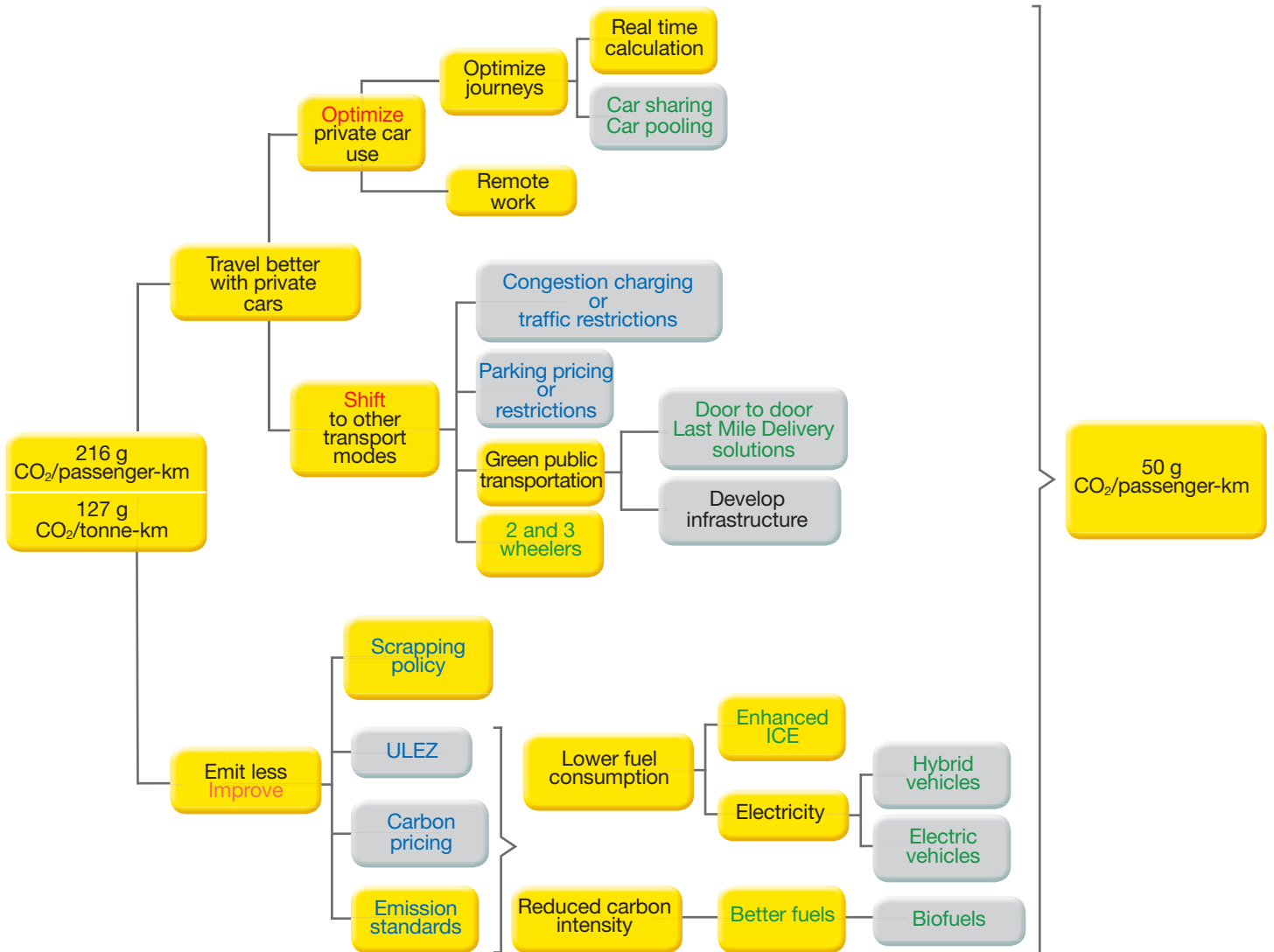
We recommend pursuing the two following dynamics:

- Incentive measures aimed at establishing the appropriate CO₂ monetary valuation mechanism (carbon pricing), coupled with the introduction of ULEZs (congestion charging, parking pricing);

- Economic measures to promote new mobility business models. This involves funding infrastructure necessary for the development of public transport (green public transport, infrastructure development) and sustainable and innovative mobility services and technologies (hybrid and electric vehicles, car sharing and carpooling, door to door and last-mile delivery).

The decision tree below illustrates the virtuous paths to achieving a shift away from current (2010) CO₂ emission levels of 216 gCO₂/passenger-km to a possible target level of 50 gCO₂/passenger-km by 2050, as a result of leveraging the dynamics we recommend.





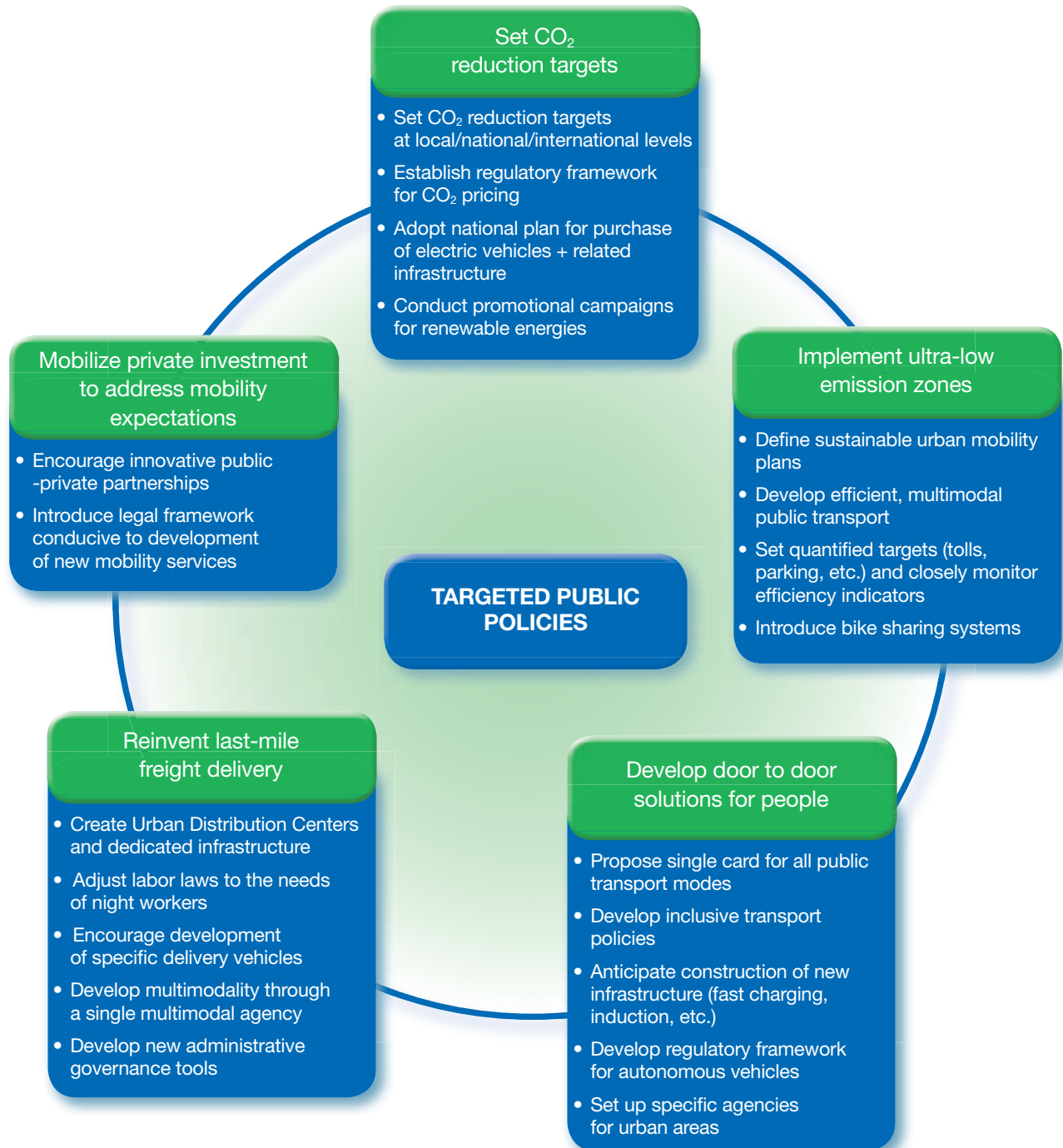
Technological and service solutions

Economic instruments

Ways to reduce CO₂

4 Targeted public policies

For public authorities, developing mobility will not be resolved by building more roads, harbors, railway stations and airports. Governments have to fully understand that there is an urgent need to foster a new urban mobility culture. In January 2012, the United Nations identified «sustainable transport» as one of its priorities and encouraged governments to take initiatives in that direction.



This involves:

- thinking beyond the traditional boundaries of the transport sector and focusing on access to mobility;
- integrating both people and freight;
- optimizing the use of all transport modes and organizing co-modality between various public and private modes of transport;
- ultimately, integrating sectoral policies (parking, roads, transport, environment, air quality, traffic management and controls, policing, safety services, maintenance, etc.) so that the various services and administrative authorities, who have not typically worked together, may develop strong synergies.



What are the legislative and regulatory instruments to facilitate implementation of the five game changers?

It is necessary to define an institutional and governance framework setting out the guidelines to be adopted. In the absence of a single management authority, excellent coordination is needed between the various public players potentially concerned. The decisions to be made must be backed by a public authority with budgetary powers. Governments and local authorities – each operating within their specific jurisdiction – can shape tomorrow's mobility using an array of measures (laws, decrees, regulations, orders, circulars, etc.), provided that the role of each authority is clearly defined beforehand, that the mechanisms are adapted to the circumstances, and that, once ratified, they are properly enforced. The same authorities may also determine future choices by earmarking specific budget allocations and subsidies.

	Traditional transport approach		New urban mobility culture
Purpose	Provision of transport	➔	Response to people's mobility needs
Targets	Transport flows, capacity and speed	➔	Accessibility and quality of life
Methodology	Appointment of government expert	➔	Involvement of multiple stakeholders
Technology application	Mainly focused on transport modes	➔	Innovation stems from different departments and fields
Content	Priority given to large, capital intensive infrastructure projects.	➔	Global planning approach that takes market structure, services and information systems into account. Priority given to cost-benefit tradeoffs, efficiency improvements, service quality and performance
Impact study	Limited impact study (sometimes even post-project)	➔	Reinforcement of ex ante impact studies by reviewing, if necessary, environmental, social and economic assessment criteria

1/DEVELOPING POLICIES TO REDUCE GLOBAL CO₂ EMISSIONS

To reduce overall CO₂ emissions, especially with regard to all transport-related activities, governments must take three types of measures.

These will help reduce individual consumption and promote an energy mix. Transitional policies, aimed at lowering CO₂ concentrations in the atmosphere and oceans through CO₂ capture and sequestration could be subsequently implemented.

a) The first step is to control energy demand by encouraging more responsible user behavior and offering incentives (shared transport grants, etc.).

As mentioned, in December 2015 Paris will host the international conference on climate change (COP 21). This should be a decisive step towards the negotiation of international agreements for the period beyond 2020. These agreements are necessary to ensure that all countries, including both developed and developing nations responsible for the heaviest greenhouse gas emissions, are actively committed to the goals of preservation. Each country should aim to conclude agreements that are applicable to all countries and are sufficiently ambitious to attain the global warming abatement target. To meet this challenge, three key players – the United States, China and the European Union – must come to a unanimous view. The success of these agreements will primarily hinge on cooperation among these players.

The first task is to strike a balance between the Kyoto accounting-centered approach, in which the results achieved by each country are added up, and the Copenhagen accord, a set of non-binding national commitments devoid of comparable features. The Paris conference will need to make a paradigm shift whereby the climate challenge is not viewed as a mandatory «sharing of the emissions burden», but an opportunity to create jobs and wealth and invent new patterns of production and consumption.

Existing international mechanisms already offer the possibility of finding solutions within a proactive framework. They are in fact seldom used. For example, the Clean Development Mechanism (CDM) could be used to help many countries develop environmentally-friendly infrastructure. This mechanism for financing carbon emission reductions is defined under Article 12 of the Kyoto Protocol. Under this arrangement, the industrialized countries pay for projects that lower or stop

emissions in less wealthy nations and are rewarded with credits that can be used to achieve their own emissions capping targets. The receiving countries enjoy free access to advanced technologies that enable their factories or power plants to operate more efficiently.

Cities too have a key role to play, particularly cities in developing countries should account for 90% of global population growth by 2050. In addition to administrative mobility plans to facilitate mobility of their staff, cities should also adopt wider climate plans and avail themselves of the funding instruments available at international level.

*For example:
the US Conference of Mayors in 2012 led to an agreement on climate change, with more than 1,000 Mayors signing on!*



International campaign to promote co-modality, European Commission

b) The right energy mix should be promoted. It is important to encourage the development of renewable energies (wind, solar, hydro, etc.). As the price of these technologies falls, renewable energies are becoming increasingly competitive, particularly in the emerging countries (Asia and Latin America). Governments can facilitate the development of these energies by adopting a stable regulatory framework. Governments also have a role in organizing energy markets.

As regards the question of what transport energies to promote, each country must carry out a case-by-case review of electric, hydrogen, NGV (Natural Gas for Vehicles), biofuel and fossil or synthetic fuel modes based on their climate and their topological, water, agricultural and even maritime resources.

The role of new information systems in transport must also be taken into account. International governance of open data would ensure more reliable and systematic integration of all CO₂ emission measurement data, thereby promoting progress and efficiency. In addition, the onus should be on improving energy efficiency through new energy production, transformation and utilization systems, as is the case in Hong-Kong and Rizhao (China) and Malmö (Sweden).

Vehicle taxation based on fuel use could also be considered (see chapter 2.3 on New Economic Instruments).

Lastly, governments should introduce carbon pricing tools and in doing so develop new economic channels conducive to the creation of new business activities and, potentially, jobs.

c) If only for a limited period, governments must encourage public and private players to launch CO₂ capture and sequestration programs where the circumstances allow, i.e. within sites fit for purpose. They should define a legal framework for secure, long-term carbon dioxide geological storage on their territory, exclusive economic zones and continental plates. Storage permits should be subject to periodic reviews every 5 years initially and, most likely, every 10 years thereafter. Upon termination of this period, sites should be transferred to the state which then becomes responsible for surveillance and the introduction of corrective measures, if any. Prior to transfer, as well as making a financial contribution to the state, operators must demonstrate that the carbon dioxide will remain permanently confined.

2/FACILITATING THE ESTABLISHMENT OF ULEZS

Public authorities must confront the fact that «transport policy» is now tightly bound up with «urban development policy». Public policies must therefore be integrated and sustainable.

a) First and foremost, local authorities must draw up a sustainable urban mobility plan. Such a plan is drawn up jointly at national and local level, in consultation with all interested stakeholders, starting with the citizens themselves. It involves first analyzing the functional urban area used for transportation, and then embedding the mobility promotion measures into a wider urban strategy. Urban mobility plans encompass all mobility players, including taxis and short-term vehicle rental firms, treating each as a «mobility public service» provider in their own right. The players are fully included in the policy-making process, since they are an important link in the transportation chain. They should, therefore, be subject to special measures with respect to parking, road access and integrated airport and railway infrastructure. The plans should contain incentives where necessary, to encourage the siting of public entities or service centers close to public transport points, for example.

They could be supplemented by traffic flow and speed regulations based on local traffic conditions.

Examples of cities which have developed such traffic controls and measures include Tokyo, New York City, San Francisco and Stuttgart.

b) Then, ultra-low emission zones with enhanced road safety measures have to be carefully defined. The local authority initiating the project chooses the vehicle groups allowed in the zone, based on legal vehicle classification definitions, possibly using criteria such as level of vehicle technology identified by the mandatory technical check (rather than the date of first entry into service).

To create an ULEZ, it is necessary to:

- carry out technical studies establishing poor air quality;
- delimit the target area based on number of inhabitants (e.g. upwards of 100,000);
- establish a dialog with the target population, explaining the range of decisions to be taken. A public information and awareness campaign is essential;
- define a timescale for close scrutiny of the changes produced by the scheme. A period of three years seems adequate before introducing new measures;
- make absolutely sure to have appropriate intermodal infrastructure (including information systems, energy supply, parking spaces, etc.) in place, clearly marked cycling tracks and public transport accessible at reasonable cost (multimodal areas). Easy and fast access to city centers from airports must be carefully planned. An annual performance assessment report is also submitted to the relevant national (or in some cases supranational) authority, mainly to facilitate sharing of good practices.

c) Towns that have introduced such zones have received strong support from the local community. Non-motorized modes must be properly integrated into the defined areas, with the local authority promoting walking and bicycle use. Bicycling, in addition to its health benefits, leads to a fifteen-fold increase in the catchment area of a subway or train station. Soft mobility modes must also be backed by national campaigns and incentives.

*Examples:**the Netherlands promotes professional bicycle use through tax incentives.**The French Paris' Vélib initiative has led in the Netherlands to a sharp increase in the number of bike share stations, with 45,000 bikes in use at some 7,000 stations across fifty towns.**In Korea, Changwon has become the bike sharing capital, with more than 300 stations built since 2008.**In China, Wuhan and Hangzhou have the largest bike sharing network, with 90,000 and 40,000 bikes, respectively.*

The use of new, light and individual modes of transport (two- or three-wheelers) requires a proper regulatory and legal framework to ensure safe use of shared public pedestrian thoroughfares. Draft regulations to this effect are under preparation in the State of California and the European Parliament, for example.

d) Finally, local authorities have at their disposal other highly effective and easy-to-use tools, such as parking spaces and car parks. «Smart car parks» providing cutting-edge services are an effective way to cut pollutant emissions (better management of available spaces, bays reserved for clean vehicles, etc.), promote intermodality and encourage soft transportation modes, along the lines of San Francisco and Lyon (France).

3/ENCOURAGING AND CONNECTING DOOR TO DOOR SOLUTIONS

In the context of urban expansion, public transport must adapt and bring on board door to door solutions.

To develop high-quality public transport, substantial improvements need to be made in terms of timeliness, frequency, timings, safety, information and accessibility.

As a first step, some straightforward measures could be widely adopted:

- Use of a reserved bus lane, especially in large urban areas, with priority for buses at intersection traffic lights;
- Space sharing with priority for public transport;
- Intermodality, with necessary institutional adjustments (use of tools such as Digital

Multimodal Mobility Assistants (DMMAAs), as noted earlier);

- Specific services such as «public taxis».

As a second step, additional measures could be devised:

a) Government encouragement for the gradual switch to multi or intermodal travel through the introduction of a single ticket or single invoicing system. Each government would define an action plan for streamlining the transport system and providing a nationwide user-friendly system across all key criteria (timetables, information, on-line booking, etc.). Setting up regional-level agencies would provide private operators with the necessary public information.

Given the expansion of different modes of transport, a citizen mobility charter could be proposed by each country's ministry of transport that sets out the various user rights (to information, accessibility, protection, etc.).

b) Specific legislative instruments to clarify the relationship between the transport organizing authorities and the operators, and to promote open procedures. The specifications agreed between both parties must be detailed and long term (upwards of 5 years). In addition, given the growth in alternative or complementary modes of public transport, it is essential that these authorities exercise some institutional control over the new modes while looking to facilitate their adoption. In addition, price transparency should be the rule. Users should be made aware of the true cost of transport and the use to which public money and their own contributions have been put.

c) As noted, municipalities should encourage carpooling and car sharing as possible alternative door to door mobility solutions. In the case of car sharing, cities should preempt special parking areas and the charging infrastructure which accompanies them (Autolib in Paris). Similar solutions are needed for bikes. In this area, cities have the necessary clout to facilitate the establishment of car and bicycle stations and to introduce local incentives; in short to shape the market and make their city more attractive by re-branding its image.

d) As noted, emerging countries were the first to introduce TODs (Transit-oriented developments), building retailing and pedestrian areas around public transport stations (bus and rail) offering park-and-ride facilities. The layouts for new living spaces were first designed in Copenhagen and Stockholm. The success of TODs is dependent on them being fully integrated into urban planning policy and supported by data management tools that focus on densely populated areas.

Examples:

the most successful TODs, i.e. those that have helped reduce urban congestion significantly, are based in Toronto, Vancouver, Singapore and Tokyo.

In Asia, bus-based TODs have been developed in Kaoshiung, Qingdao, Jiaxing and Kuala Lumpur. Bus Rapid Transit (BRT) TODs have also been introduced in Latin America in Curitiba, Santiago and Guatemala City.

e) In the poorest developing countries, «informal» transport remains the rule, with undeclared taxis and mini-buses operating a fairly well-established business model. The most flourishing examples are to be found in Nairobi (Kenya) and Kampala (Uganda), though these practices are widespread in many developing regions. It is interesting to note that as living standards rise, these informal modes of transport tend to disappear. Governments attempt to regulate them, for example, through mandatory seat belts in buses. Some cities pursue a proactive policy of banning them in order to comply with labor and tax laws and modernize their image. In developing countries, two- and three-wheelers are often the only mobility solution available.

Example

«Three-wheel» transportation is known by different names in different countries (Phat-phati or Chandgari in India and Pakistan, or Qingqi in China). It provides up to 15% of jobs in urban areas. Due to the pollution they cause, some local authorities require three-wheelers to switch to natural gas (India, Pakistan) or electric power (China, India, etc.).

In the final analysis, individual safety concerns in urban environments are a key factor in increasing the attractiveness of public transport. Designing a proper land transport safety policy requires an understanding of public freedoms, applicable laws and the specificities of each transport sector.

f) The rise of Intelligent Transport Systems (ITS) and the advances in driver assistance applications have spurred the development of semi-autonomous or fully autonomous vehicles. To support this innovation, public authorities need to change the regulatory framework by introducing specific standards and regulations that facilitate experimentation in open environments. Global marketing of these solutions requires an international approach.



4/COORDINATING THE ORGANIZATION OF LAST-MILE LOGISTICS

The issue of urban goods delivery has often been neglected, particularly due to the overall inconsistency of regulations governing traffic, parking, delivery hours, etc. The right to conduct trials, i.e. to test demonstrators in real conditions, is not set in law, which slows down the introduction of virtuous mechanisms of innovation.

As with public transport, urban delivery should be governed at an institutional level. Local authorities must factor in all aspects of urban logistics related to people and goods under a single logistics system.

It is important to consider six measures:

- a)** First, goods distribution in urban areas requires efficient interfaces between long-distance transport and transport used for distribution over short distances in town. Initially that means enabling the development of logistics centers around urban conglomerations (Urban Distribution Centers or UDCs). Second, it is necessary to create pooled urban delivery centers in cities to facilitate delivery in areas with regulated access. To get as close as possible to residents and develop optimum coverage, some leading e-commerce and logistics providers currently rely on a network of neighborhood retailers.
- b)** The organization of urban services must be rethought as must delivery hours (by day for some types of vehicle, but above all at night), shop and warehouse opening hours, etc. This, of course, has repercussions for labor and social legislation and requires decisions at national or ministerial level.
- c)** To drive this change and promote very low emission vehicles, local authorities must intensify the retrofitting of their fleets.

It should be noted that postal services are often front runners in this process. For example, the Universal Postal Union ((UPU) encourages various countries to move in this direction by organizing field training and best practice sharing. In the United States, these initiatives are being pursued by players such as Amazon who have not shied away from entering into agreements with delivery centers used by drugstores and mass retailers.

d) The public space can be altered to facilitate deliveries. For example, Barcelona has adopted a local urban delivery charter. Certain areas, designated «exclusive zones», allow access to a limited number of transport companies only (a solution also being rolled out in London to complement the ULEZ).

e) With communication platforms such as cell phones and the Internet growing exponentially, local authorities should use IT systems to provide operators with maximum information on the traffic situation, keeping them informed in real time of traffic jams in the city.

Cities that have successfully introduced ITS technology to manage traffic include Hong Kong, Guangzhou, New York City, Los Angeles and Chicago.

f) In terms of administrative organization, a national authority for coordinating urban logistics might be useful in harmonizing national regulations (to avoid local differences from town to town), creating a link between several regions with a high concentration of logistics nodes, contributing to refinancing load loss (under the terms laid down by the urban distribution center's management), and ultimately encouraging cities to sign up to an inter-municipal logistics charter. Steps should be taken to coordinate co-modal distribution with other types of infrastructure such as rail or inland waterway where cities have, or are close to, a river.

Example: the Paris Logistics Charter, signed in 2002, is a code of conduct agreed upon by all logistics players setting out the access arrangements for delivery trucks. Interestingly, many mass distribution brands have quickly adopted alternative (rail/waterway) delivery modes to rationalize costs and to improve energy efficiency.


5/ ENCOURAGING PRIVATE FUNDING

To facilitate dialog with private players, the various public stakeholders need to adopt a coordinated approach and encourage private initiatives with sound business models (for example, if they allow for advertising, or generate income by using urban land for a new purpose).

As guardians of a public transport service and user fares, public authorities need to safeguard the common interest by ensuring a certain level of service quality from the private partners.



Table showing the different forms of public-private partnerships in use today

Integration with	PUBLIC  PRIVATE			
Type of operation	Traditional public procurement	Publically financed operations	Privately financed operations	Entirely privately owned
New Infrastructure	Distinct design and construction bids	Private sector provides design and construction under single bid	Private sector provides design, construction and finance	Private sector controls the entire process
Existing Infrastructure	Managed by a government agency	Operating and maintenance contract	Operating and maintenance contract	---

Inter-ministerial coordination should be strengthened at national level to ensure consistency of government investment policies and encourage private investment in support of new and innovative urban mobility priorities. To this end, a newly-created body would prepare government decisions relating to agreements between the state and financial institutions. The new entity would also coordinate the drafting of specifications for calls for projects. Finally, it would oversee appraisal of investment projects, issue opinions and recommendations, evaluate investments and prepare an annual report on program implementation.

By convening public and private players, this action would further promote the development of trans-national centers of excellence, competitiveness clusters and public-private cooperation networks. As an additional measure, private players could usefully be offered incentives to propose new, «clean» urban mobility initiatives under traditional state-province plans, or national funding contracts for local authorities. This action should be backed by a training program for local authority staff in

1/ the development of urban mobility strategies at local level in close cooperation with the private players best meeting the specifications;

2/ green public procurement contracts for example, should be offered where several local authorities jointly order a certain number of clean vehicles and use a (public) demand aggregator. In addition to PPPs, close attention should be paid to the role of one-off semi-public companies in developed countries. These companies are useful for governance purposes when conducting local public programs as they combine the benefits of direct management, whereby the local authority retains control of its public service, with the advantages of delegated management, whereby the skills and innovative abilities of a private provider are brought to bear on the project. For developing countries, micro credit offers a solution in that it encourages the adoption of a particular mobility mode through the ownership and use of two-wheelers, for example.

*Example:
micro-credit scheme in Pudukkottai, India
to promote the use of bicycles by women.*

At the international level, depending on the requirements and as part of a concerted dialog, the World Bank could provide support for stakeholders in urban mobility projects under joint financing agreements with the Global Environment Facility (GEF) and regional banks (e.g. Asian Development Bank, European Investment Bank, etc.).

To avoid poor coordination between projects linking different territories, a strategy along the lines of the European Transport Networks (ETN) could be implemented to develop major infrastructure projects across regions or countries. The ETN is an integrated transport system combining road and road/railway transport, waterway transport, sea ports and the railway network (high speed trains, in particular). Intelligent transport management systems and satellite navigation also fall into this category.

At the international level, governments can and should do more by way of deeper cooperation in the definition and/or harmonization of common standards. The development of international cooperation and exchange platforms or programs, such as the CIVITAS European program, should be stepped up.

CIVITAS : a network of some 200 towns that have been cooperating since 2002 on more than 650 locally implemented schemes. Since inception, the network has been supported by the European Commission, which has allocated a €200 million budget to it. We are now entering the CIVITAS MORE II phase the aim of which is to promote collaboration among new European and non-European cities through March 2015.

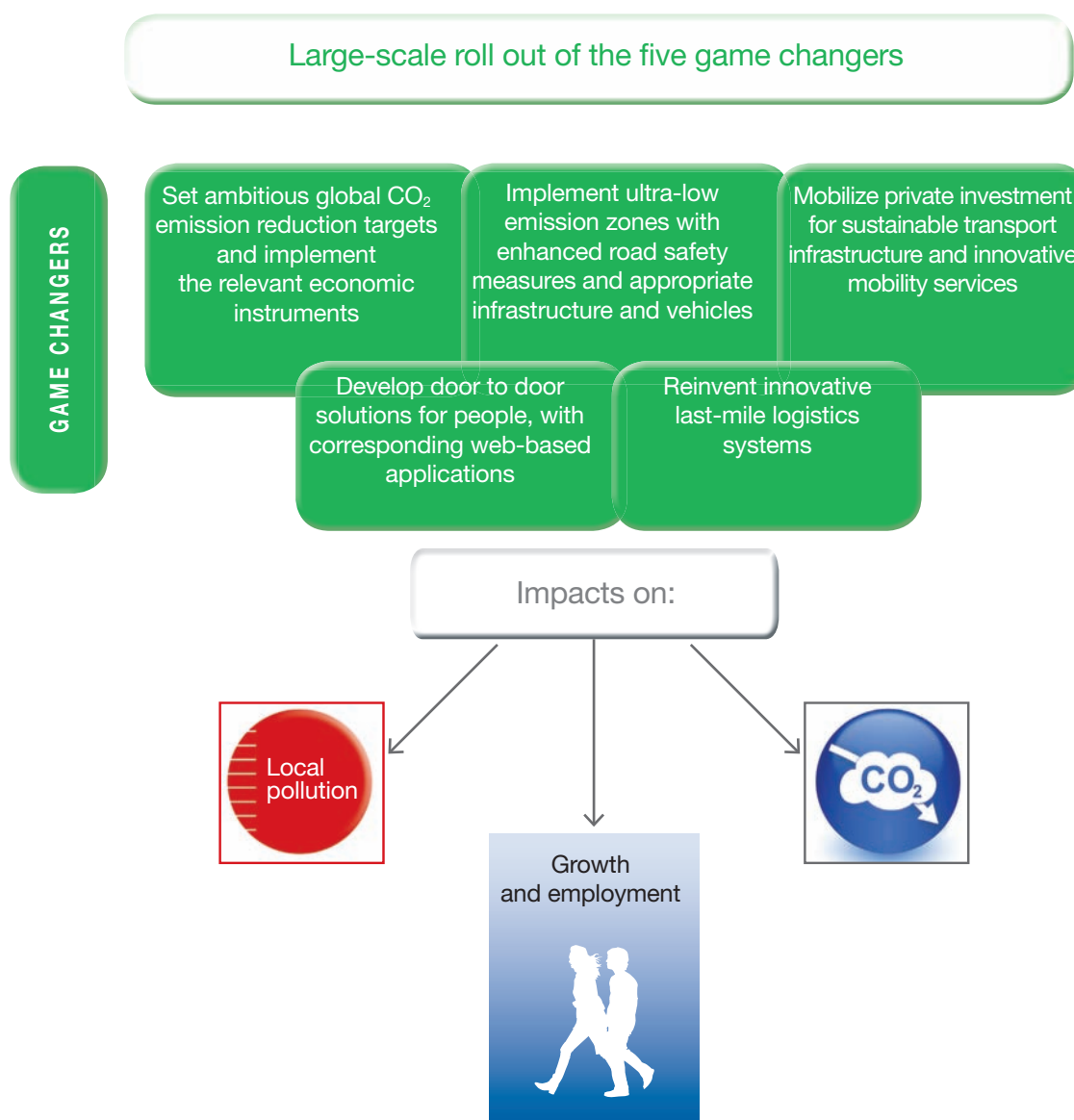
In conclusion, public policy promoting innovation can make a decisive contribution towards addressing global challenges by working in tandem with a mix of technological and economic initiatives.

These will shape tomorrow's urban mobility, provided they are integrated (i.e. they take into account all aspects of urban policy), coordinated between national and local levels and pursue the same objectives. Some forward-looking cities have taken the lead by anticipating the new mobility challenges, «breaking down walls» between the governing departments, setting up new mobility management authorities with their own skills and resources, and not shying away from seeking solutions beyond their jurisdiction.



5 Rolling out the **five game changers** on a massive **scale**

The weight of transport in local pollution is well known and the impact of corrective actions can be easily estimated. We worked with the International Energy Agency (IEA) on its CO₂ emission quantification model, assisted by the strategy consultants Oliver Wyman and the Climate Economics Chair of Paris Dauphine. In a study on growth carried out in parallel with NERA Economic Consulting, whose economic experts are recognized for their work by many government agencies, we sought to assess – based on business-as-usual projections – the potential macro-economic effects of our game changers.





Accordingly, in this chapter, we propose the first step of an environmental and economic quantification process that would bring on board new partners as its accuracy and knowledge base increase. Results so far are very encouraging.

Action on a city scale appears to be key for enacting all our game changers. We thus propose a method along with a set of ground rules for effectively implementing our proposals.

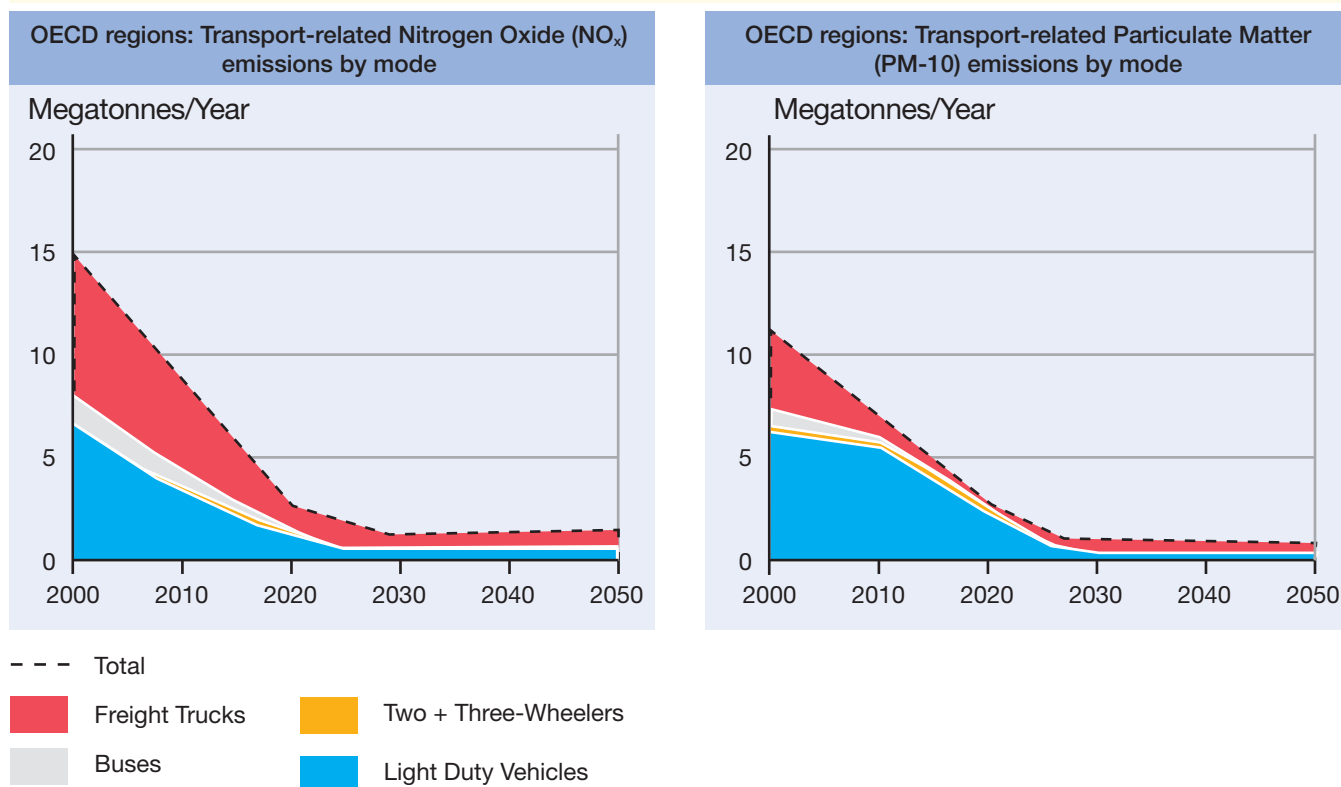
1/REDUCING LOCAL POLLUTION

The transport sector accounts for a mere 5% of SO_x (sulfur oxides) due to the desulphurization of fuels in most countries. On the other hand, it accounts for more than 20% of particulate matter (PM) and 50% of NO_x (nitrogen oxides) emissions, leaving ample room for reduction and improvement.

Two groups: OECD and non-OECD countries

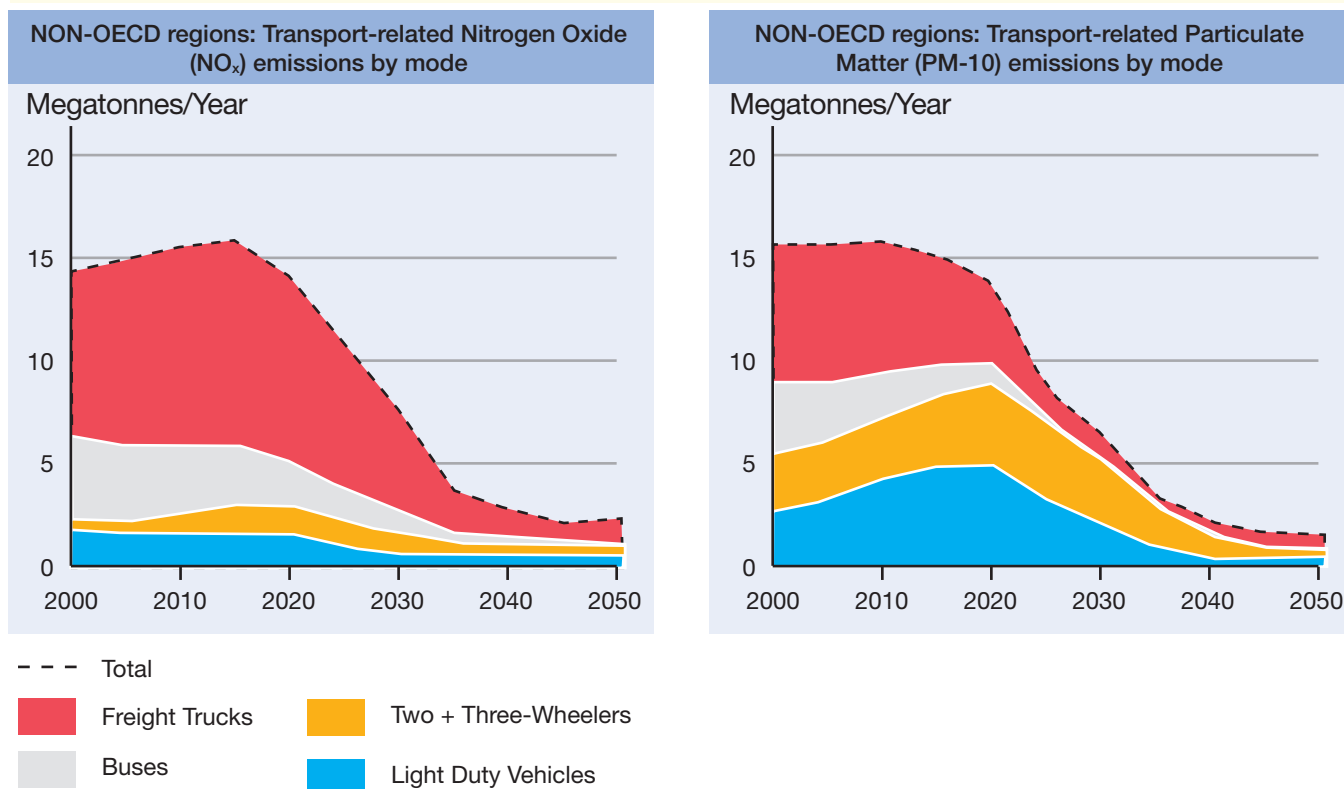
The figures below, drawn from the Mobility 2030 report published by the WBCSD and prepared by the IEA shows forecasts to 2050 for two major transport pollutants (NO_x and PM) in both OECD and non-OECD countries.

OECD countries



OECD countries have been pursuing pollutant reduction policies regarding both pollutants for several decades through the adoption of increasingly stringent (EURO) standards and the deployment of specific technologies (particulate filters, catalytic converters, etc.) These policies have borne fruit for a number of years already but, in the absence of new initiatives, a fully satisfying situation will not be achieved until 2030.

Non-OECD countries



Non-OECD countries are lagging behind by about fifteen years (and some have yet to desulfurize their fuel). The growing size of their motorized fleet and their rapid urbanization call for urgent measures.

Two game-changing measures – one regulatory, the other technological – are essential to reduce local pollution, and in particular PM and NO_x, whose damaging impact on health is a cause for public concern.

Creating ultra-low emission zones (ULEZs) will drastically reduce local pollution in densely populated urban areas. CO₂ emission reduction initiatives will further cut local pollution. Mobilizing private investment will contribute to the development of more sustainable and efficient infrastructure. Door to door solutions, along with last-mile logistics, will promote soft or electric modes. Fast implementation of the measures developed in this Green Paper is therefore key to accelerate action on air quality improvement.

Fully eliminating urban pollution, however, will require an overall strategy tackling transport, housing (heating, cooking, air conditioning), industry and major construction projects.

2/REDUCING CO₂ EMISSIONS

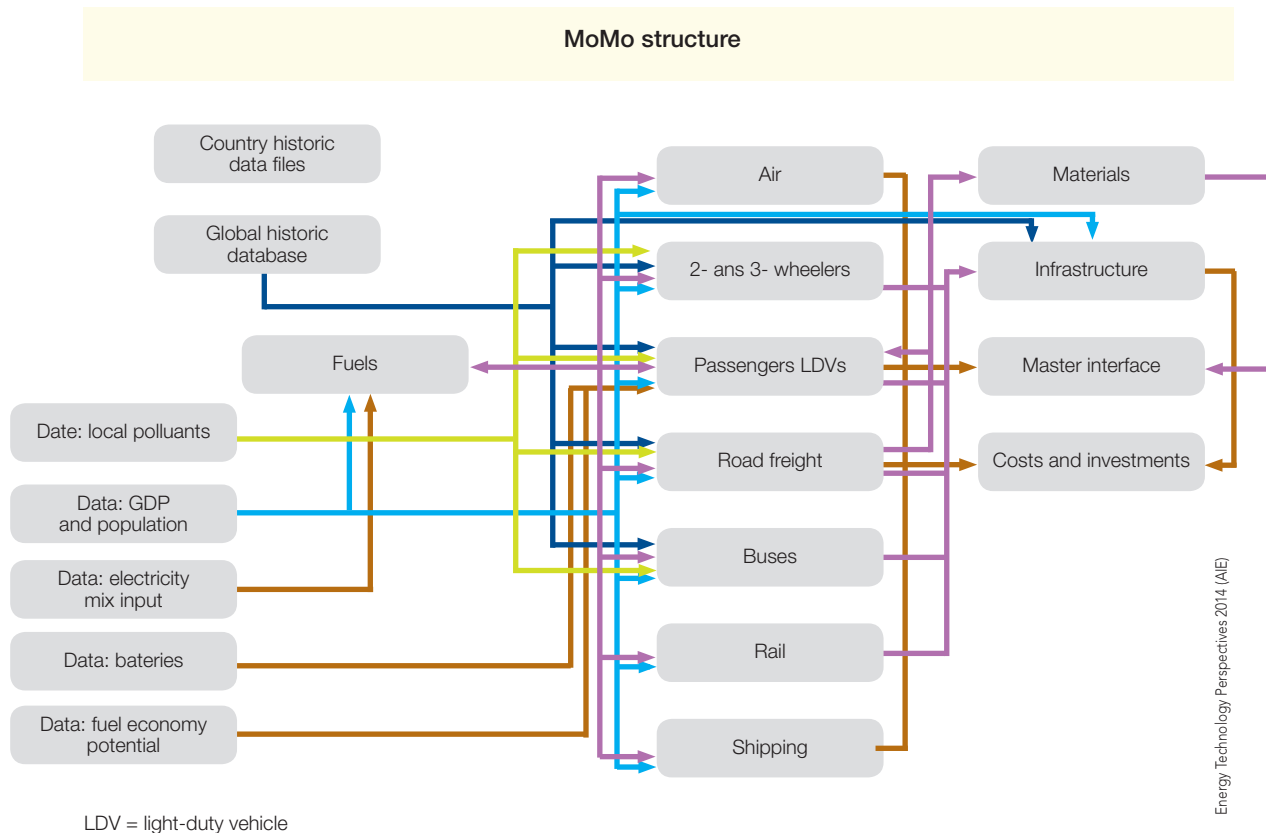
2.1 The IEA's two reference scenarios: 4°C and 2°C

The 2°C scenario is «deductive». It is based on a predetermined outcome consistent with the goal of limiting the rise in global mean temperature to 2°C above preindustrial levels by 2100. This scenario also identifies the solutions that would help ensure a secure and economically viable energy system in the long term. Its target: cutting CO₂ emissions by more than half by 2050 and ensuring that they continue to fall thereafter.

The 4°C scenario on the other hand is «inductive». It is founded on measures public authorities consider “realistic”. The outcome of this scenario is a 4°C rise in global temperature by 2100 compared with preindustrial levels, with major geographical disparities.

Transport's share in the 4°C and 2° C scenarios

The «transport» scenarios are drawn from the IEA's reference scenarios (4°C and 2°C) presented above. They model the evolution of CO₂ emissions from transport. In terms of total CO₂ emissions worldwide, the transport sector accounts for almost 24%, with road transport alone accounting for slightly more than 17%. To model mobility, the IEA used MoMo, a mobility model which covers all transport modes and is structured as follows:



Key point

MoMo covers all transport modes and includes modules on local air pollutants and on the costs of fuels, vehicles and infrastructure as well as analysis on the material needs for new vehicles.

Under the 2°C scenario and despite an overall reduction in emissions, based on IEA CO₂ data and International Transport Forum (ITF) transport data, transport's share of direct emissions¹ will increase by 35% between 2011 and 2050.

Under the 4°C scenario, its share will rise by 30%. We observe that transport's share is larger in 2050 under the 2°C scenario because the IEA anticipates technological breakthroughs in the energy sector that will have a greater impact on CO₂ emissions.

¹ - Direct emissions: the emissions calculation considers that the emissions factor for biofuels is zero, as opposed to the "well-to-wheel" method, that takes into account the fuel's biogenic carbon which is transformed into CO₂ during combustion.

The 4°C scenario is used by us as a benchmark against which to measure the impact of «shocks» produced by our game changers.

The effect of the game changers has been defined by Michelin Challenge Bibendum (MCB) experts by taking into account all the characteristic values of the transport sector in the IEA's 4°C and 2° C scenarios. MCB experts have also assessed the estimated speed of implementation of the game changers.

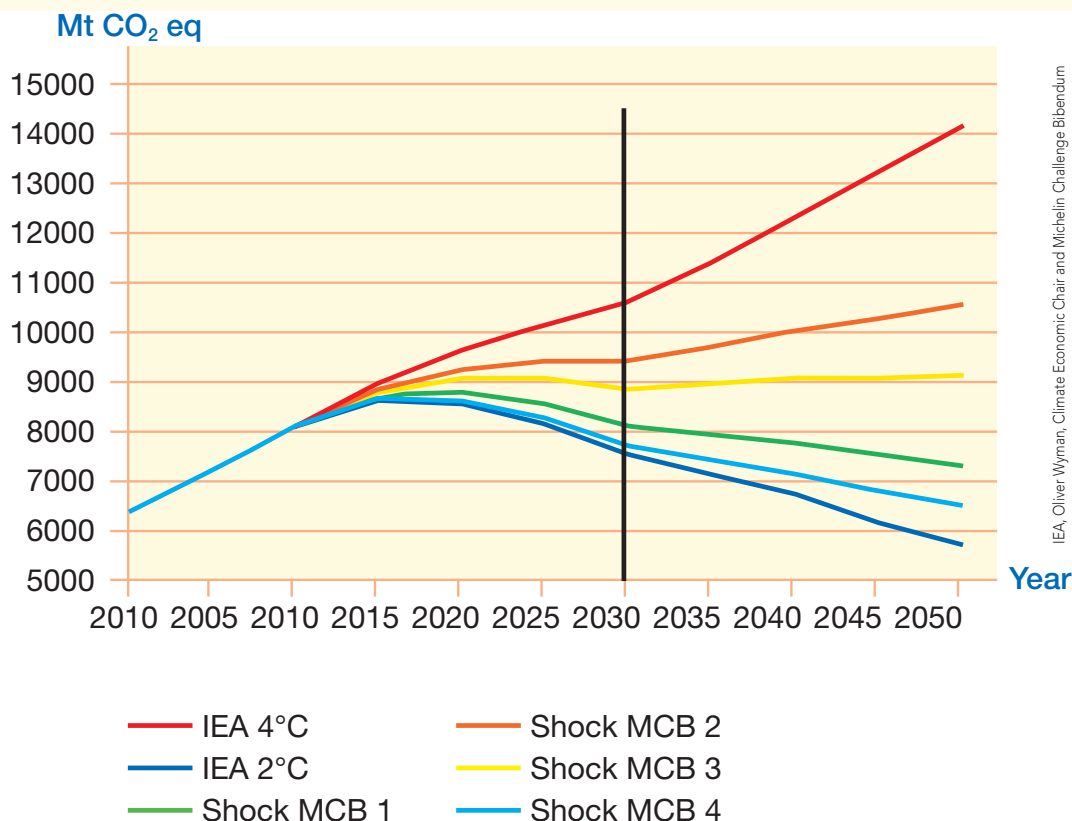
We have developed four different assumption sets with Oliver Wyman Consulting and the IEA («MCB shock 1» to «MCB shock 4»). They take into account all game changers in this Green Paper, allocating different weightings to them.

2.2 Outcomes and interpretations

Two of the four assumption sets – «MCB Shock 1» and «MCB Shock 4» – have outcomes very close to those of the 2°C scenario. Both favor the phased introduction of CO₂ pricing towards the level recommended by the IEA in its 2°C scenario (i.e. US\$130 in 2040 versus US\$150 in Sweden today). That is why the monetary valuation of CO₂ is a particularly powerful lever for making massive cuts to CO₂ emissions.

The study confirms that our game changer recommendations are synergistic. Their combined effects are inevitably more powerful than the impact of any one lever. Further simulations will make it possible to examine even more ambitious scenarios.

Chart comparing CO₂ trajectories in the IEA's 4°C and 2°C scenarios with the four assumption sets (MCB shocks 1 to 4)



The outcomes of the four assumption sets based on the five game changers described in this report confirm that, in all cases, our game changer scenarios significantly reduce CO₂ emissions versus the IEA's 4°C reference scenario, other things being equal.

3/THE IMPACT ON GROWTH AND EMPLOYMENT

3.1 NewERA Global Model, the general equilibrium model by NERA Economic Consulting

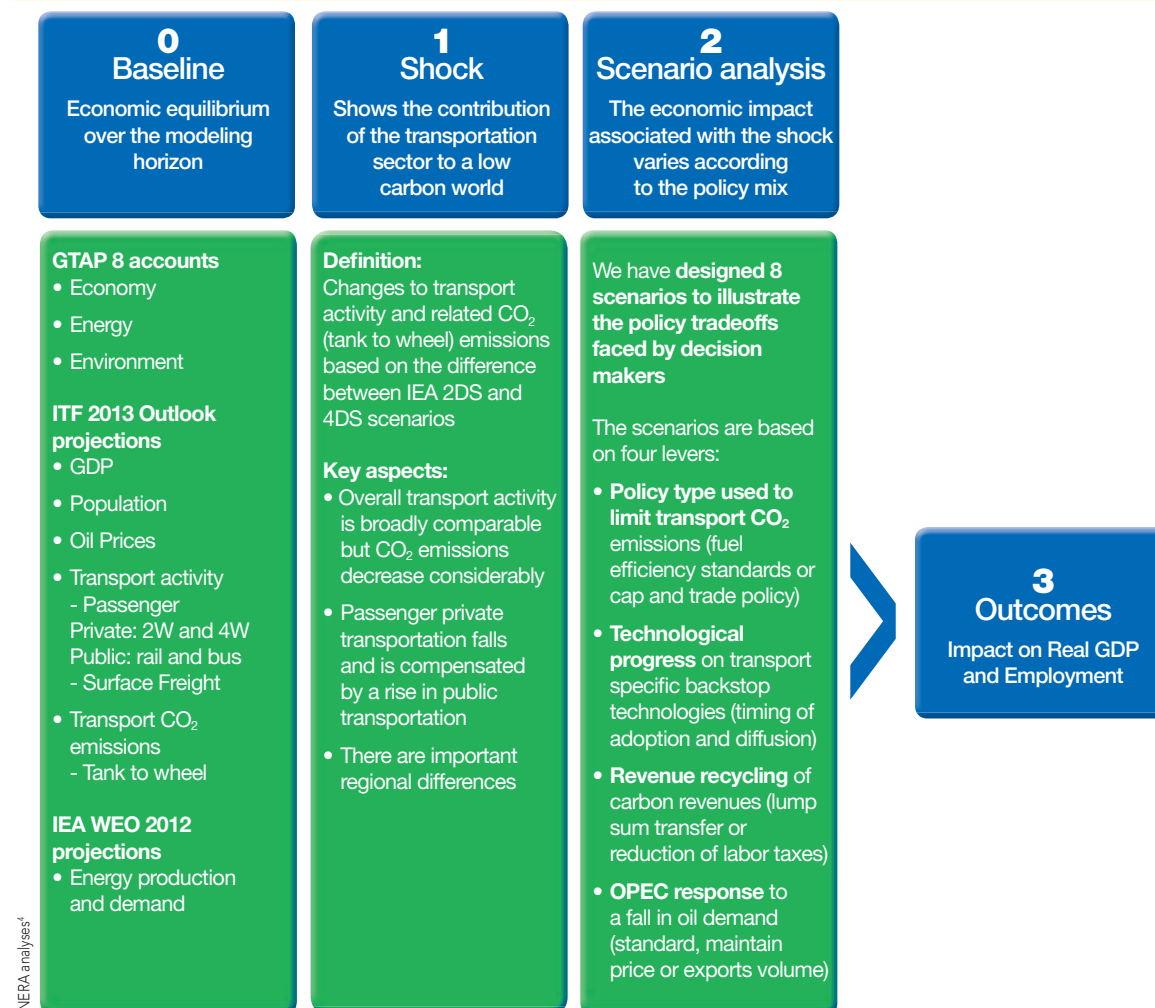
NERA Economic Consulting uses NewERA Global², its proprietary Computable General Equilibrium (CGE) model, to guide decision makers on the long term economic impacts of policy trade-offs. Briefly, general equilibrium model simulates complex relationship between economic sectors and between regions and allows to study impacts of different and wide ranging policies such as environmental policy.

NERA's studies are based on an economic shock to the transport sector (i.e. a close but non-identical shock as the one resulting from our game changers) consistent with the difference between the IEA's 2°C and 4°C scenarios³.

Specifically, shock modeling involves substantial improvements in the environmental performance of the transport sector (passenger and freight land transport) measured as «tank-to-wheel» CO₂ emissions per unit of transport.

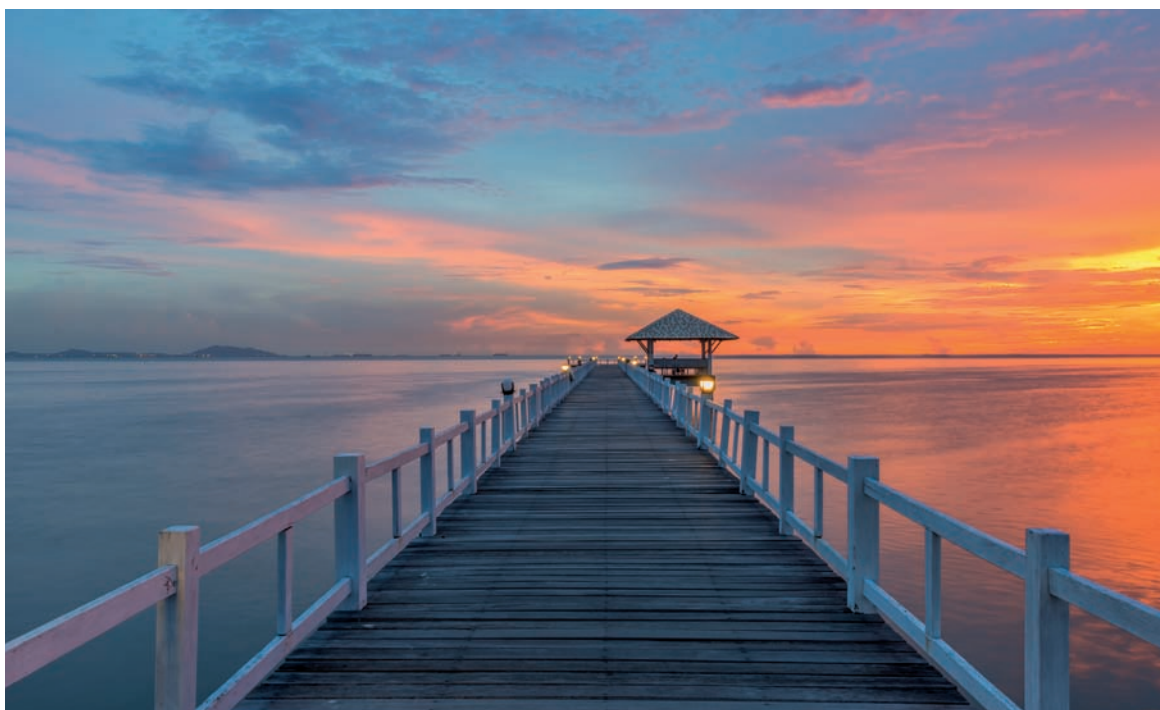
The following figure summarizes the key features of NERA's approach.

Summary of approach adopted



To illustrate the differential impact of various public policies, NERA modeled the aforementioned «economic shock» by combining different scenarios with regard to:

- 1/ the emergence of innovative technologies to limit CO₂ emissions;
- 2/ the choice of policy instruments;
- 3/ the method of redistributing auction revenues from an economy-wide cap-and-trade program;
- 4/ the reaction of OPEC countries to a significant fall in the demand of oil⁵.



2 - NewERA Global is a forward-looking, global computable general equilibrium model based on assumptions of full utilization of the factors of production. The model simulates the interactions between industry, households and government. It covers all sectors of production in the economy and models bilateral trade. Productive investment decisions are based on perfect anticipation of future public policy choices and the future of the economy at large, resulting in optimum levels of saving and investment. The NewERA model is particularly well suited for analyzing economic and energy policies as well as environmental regulations.

3 - Policies to address climate change also tend to limit the risks of major environmental damage and the resulting costs. In line with most available CGE models, NERA has not modeled this aspect, though we expect its probable impact up to 2030 to be limited.

4 - OPEC could respond to a drop in global oil demand by either attempting to maintain its exports or maintain world crude prices. NERA's analysis investigates these two extreme responses as well as a middle of the road response.

5 - Based on its experience, NERA has chosen a relevant policy mix to illustrate how these instruments and market conditions affect economic outcomes. A comprehensive analysis of the policy instruments available and the uncertainty surrounding market conditions is beyond the scope of this study.

3.2 Outcomes and interpretations

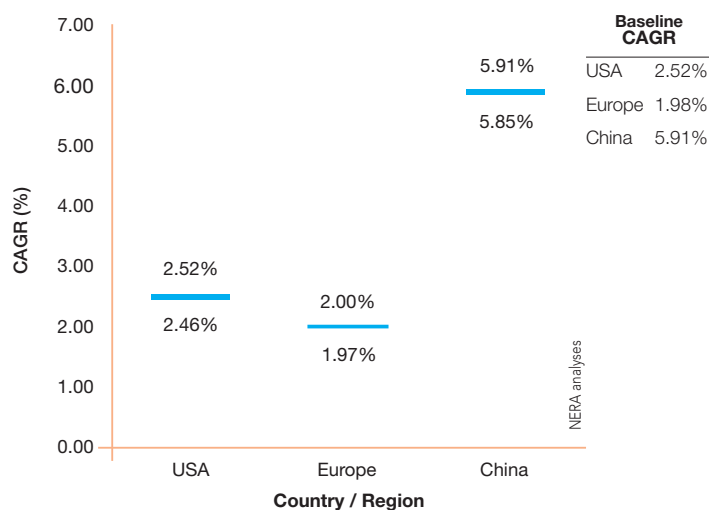
Outcomes

NERA Economic Consulting has assessed the impact on the global economy of CO₂ emissions reduction in the transport sector. The tentative outcomes of this first analysis for the United States, Europe and China are set out below.

The first finding is that GDP in these scenarios grows during all the periods under review. The projected growth is only slightly below estimated growth in the baseline for the 2015-2030 period, for the reasons stated below. The “shocks” thus induced in the model would not stunt growth, as some people might have feared, despite the magnitude of the recommended changes. Further possibilities do exist and other more favorable combinations can still be tested.

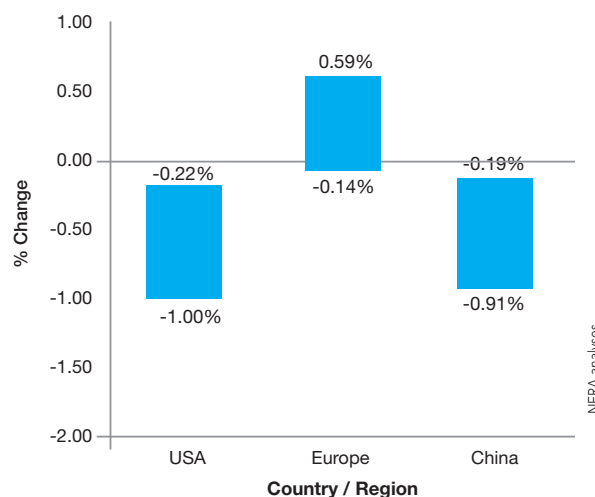
Impact on GDP growth

GDP annual growth rate over the period 2015-2030 (CAGR), min-max range of all scenarios and baseline



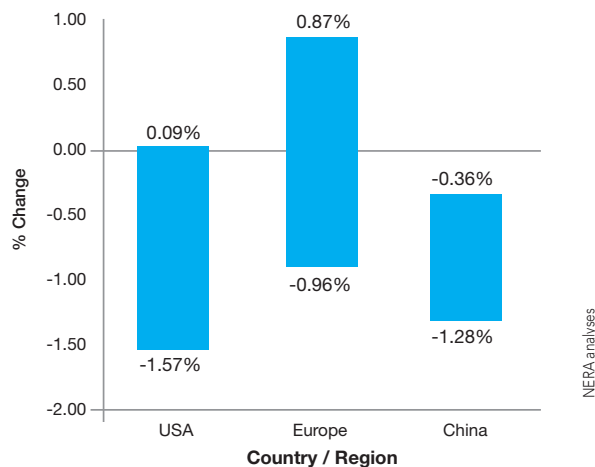
Impact on GDP

% change relative to baseline in 2030, min-max range of all scenarios



Impact on Employment

% change relative to baseline in 2030, min-max range of all scenarios



NERA's analyses make a distinction between the impacts on the gross domestic product of the United States, Europe and China. In all the scenarios modeling the impact of the economic shocks, US and China's GDP fall short of their baseline levels. The impact on European GDP depends on the scenario used.

Second, it should be stressed that while the impacts measured relative to the baseline are relatively small for the 2015-2030 period, in absolute terms there is a substantial difference between an undiscounted cumulative negative impact of USD 2,400 billion⁶ and an undiscounted cumulative positive impact of USD 1,100 billion⁷, depending on the scenarios and geographical areas involved. These aspects highlight the key role of decision-makers in shaping the most cost-effective policy mix.

On the jobs front, the impact of simulated shocks relative to the baseline is generally negative for the United States and China and varies for Europe depending on the scenario considered.

Interpretation

Impact on GDP

The perceptible differences between regions (depending on the scenario) mainly stem from three factors:

1. The decarbonization of the transport sector results in a slump in oil demand and prices and a significant improvement in the trade balance of oil importing countries. China and Europe, both heavily dependent on oil, benefit from this effect.
2. The transport sector's relative share of each region's economy and the impact on fuel prices caused by its conversion to low-carbon fuels determine the economic costs of transition to more environmentally friendly transport modes. The US, with its large transport sector consisting mostly of private vehicles and relatively lower fuel prices, is the region most negatively impacted by this transition.
3. As China has the highest CO₂ reduction challenge, the cost of switching to a more environmentally friendly transport sector has a negative impact on GDP, thereby offsetting the positive impact of improvement in the country's trade balance referred to in 1 above.

Impact on employment

The need to improve the transport sector's environmental efficiency comes with adjustment costs that increase the marginal production cost for companies. The implied reduction in labor demand leads to a drop in employment⁸. Europe, however, can produce a positive impact on employment under a scenario whereby it recycles the income from CO₂ pricing to ease labor taxes, as we will discuss in greater detail below. Also, all three regions enjoy a «wealth effect» associated with the reduction in the price of imported oil, which boosts consumption despite the decline in employment.

Finally, although we do not present the figures here, the transformation under way in the transport sector leads to a drop in consumption and economic activity in the oil exporting countries as a result of falling revenues from oil exports⁹.

The key role of decision makers in the formulation of public policies

As noted, the impacts measured relative to the baseline represent substantial amounts in absolute terms, underlining the need for the most cost-effective policy mix and rapid implementation (see chapter on Targeted public policies). In two scenarios analyzed, the impact on GDP and employment of the conversion of the transport sector is enhanced by the implementation of relevant policies¹⁰.

6 -In 2012 USD.

7 -In 2012 USD.

8 -The quantification of simulated shocks and their impact on employment should be used with caution, since labor market modeling on CGE models is too narrow to capture the specific characteristics of each country and period.

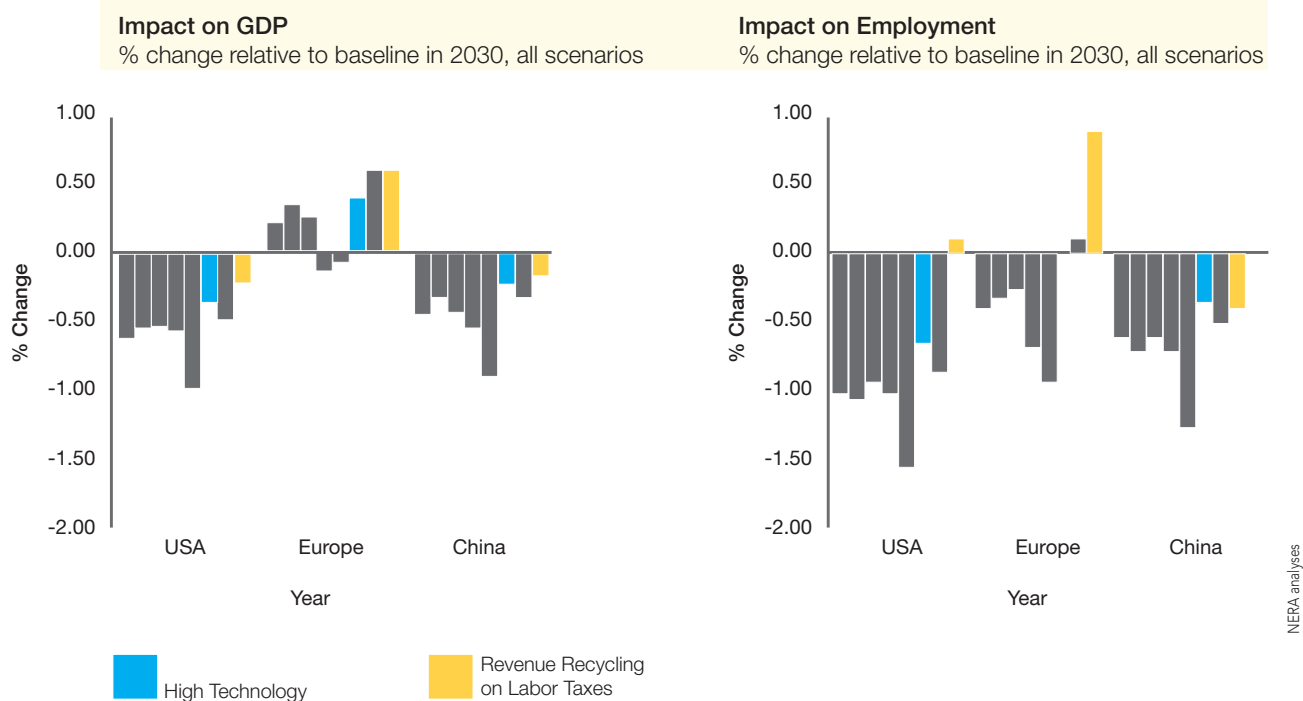
9 -This effect is especially pronounced here because the simulated shocks focus on the transport sector – a sector heavily dependent on oil and with limited substitution options in the baseline.

10 -This analysis ignores scenarios with a positive impact falling outside the sphere of public action in the regions under study. For instance, a scenario whereby OPEC decides to maintain its volume of oil exports at the baseline level would be relatively positive for both GDP and employment, but decision-makers in the regions under review have little influence in this matter.

- The «High Technology» scenario assumes the emergence and rapid deployment of innovative low-carbon technologies in the transport sector (in blue in the figure below). This scenario also assumes the establishment of a CO₂ allowances market, marked by redistribution of the resulting income in the form of fixed household subsidies and OPEC's middle of the road response to a drop in oil demand.

- The «Revenue Recycling on Labor Taxes» scenario sees decision-makers using the income generated by CO₂ pricing to reduce labor taxes and therefore mitigate their distortive effects on the economy¹¹ (in yellow in the figure below)¹².

This scenario assumes an average pace of technological innovation, coupled with the middle of the road OPEC response to a drop in oil demand.



NERA's study serves to identify the action plans available to decision-makers to optimize the macroeconomic impacts of the transition to a low-carbon transport sector.

These findings are in line with the results of several studies of the impact of climate change mitigation policies, such as those published by OECD¹³ and the *Stern Review*¹⁴.

11 - This approach seeks to produce two positive effects on the economy: reduced pollution and reutilization of environmental taxes to cut other taxes – such as labor tax – that have a distortive impact on the economy. This process is usually called «double dividend».

12 - This policy has been applied only in OECD countries. For that reason, its shock mitigation effect on employment in China is weaker than that observed for the USA and Europe.

13 - OECD (2012), OECD Environmental Outlook to 2050, OECD Publishing; Chateau, J., A. Saint-Martin and T. Manfredi (2011), "Employment Impacts of Climate Change Mitigation Policies in OECD: A General-Equilibrium Perspective", OECD Environment Working Papers, No. 32, OECD Publishing.

14 - Stern, Nicholas (2007), *The Economics of Climate Change: The Stern Review*, Cambridge University Press.

4/ QUANTIFYING THE COMBINED IMPACT OF THE GAME CHANGERS

This first analysis shows that the impact on growth and employment of the simulated shock can be positively affected so long as they promote innovative technologies and mechanisms for the redistribution of income from CO₂ pricing.

The winning scenarios proposed by the NERA simulations study are consistent with the predictable impact of our game changers, as they identify similar dynamics.

CO₂ pricing, recycling the resulting income into the economy (especially to support employment during the tricky transition period) and rapid expansion of innovative low-carbon technologies lie at the heart of our proposed game changers. They are underpinned by improved investment capacity and openness to private capital.

The focus in the next stage of our joint work will be on optimized alignment of the analyses undertaken and possibly on measurement of the combined effects of our five game changers.

Our goal in the coming months is to fine tune assessment of the impact of our game changers with the help of our partners. We hope that this will strengthen our convictions and ability to persuade the various stakeholders.

CONCLUSION

Reducing local pollution from transport requires the development of new technologies.

The study of CO₂ emissions reduction carried out with the IEA shows that the outcomes for the transport sector in the 4°C reference scenario can be significantly improved. In two assumption sets, we close in on the emission levels in the 2°C scenario if we act quickly and decisively to introduce CO₂ pricing.

Finally, NERA's analysis of GDP and employment highlights two scenarios capable of optimizing the impact of simulated shocks. The first involves fast deployment of innovative technologies.

The second involves introducing a mechanism for the redistribution of income from CO₂ pricing to ease labor taxes.



AS A NEXT STEP AND BEYOND, LAYING THE GROUNDWORK FOR AN INNOVATIVE URBAN MOBILITY ECOSYSTEM

As a result of these learnings, we offer cities a simple framework to develop the vision expressed in this Green Paper.

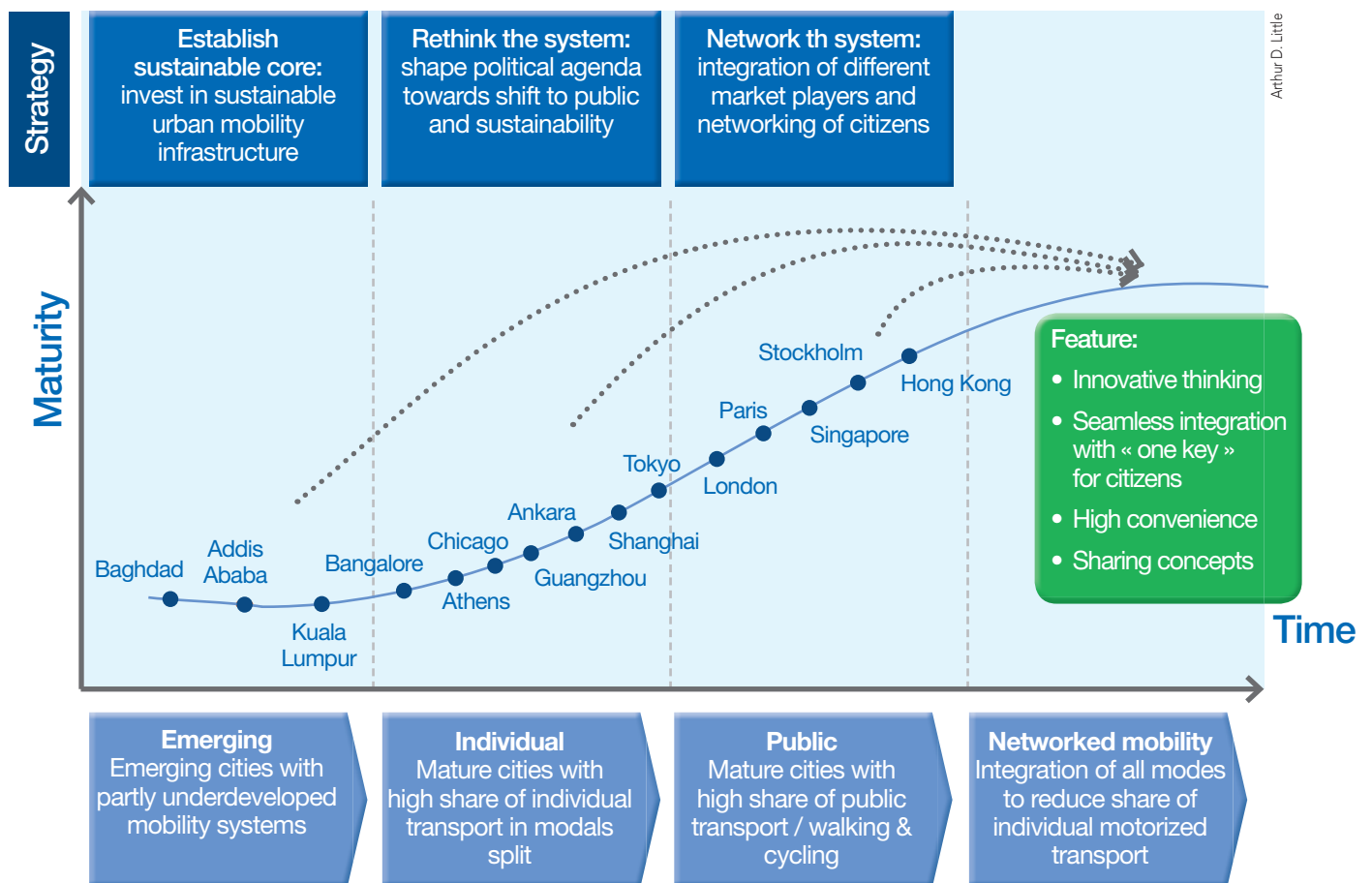
An analysis of mobility maturity and performance in 84 cities around the world, conducted by Arthur D. Little in collaboration with UITP, reveals three pathways to progress:

- **emerging cities** can invent their own sustainable mobility solutions. By capturing emerging transport infrastructure and technologies, they have the opportunity of becoming the test-bed for the urban mobility systems of tomorrow;

- **«individualistic» cities**, with a high proportion of private vehicles must re-engineer their system towards more common and sustainable solutions;

- **«public» cities**, with a high proportion of public transport (and where walking and cycling are practiced) must integrate their mobility system by connecting mobility solutions and interacting with their citizens.

The solution for the future is an interconnected multimodal network, tailored to the city's growth project and balancing economic development and well-being.



Four key dimensions

The stakeholders in urban sustainable mobility ecosystems should focus on four key dimensions:

- **A visionary strategy and ecosystem.**

Cities should develop a political vision and objectives based on the strategic alignment of all key public and private urban mobility stakeholders. This alignment will ensure a balance between visionary ideas and project feasibility.

- **Mobility supply management.**

Cities should extend their transport offering for citizens, shifting from “delivering transport” to “delivering solutions”. They should enter into partnerships and alliances with third parties, delivering user-friendly multimodal solutions that meet everyone’s needs.

- **Mobility demand management.**

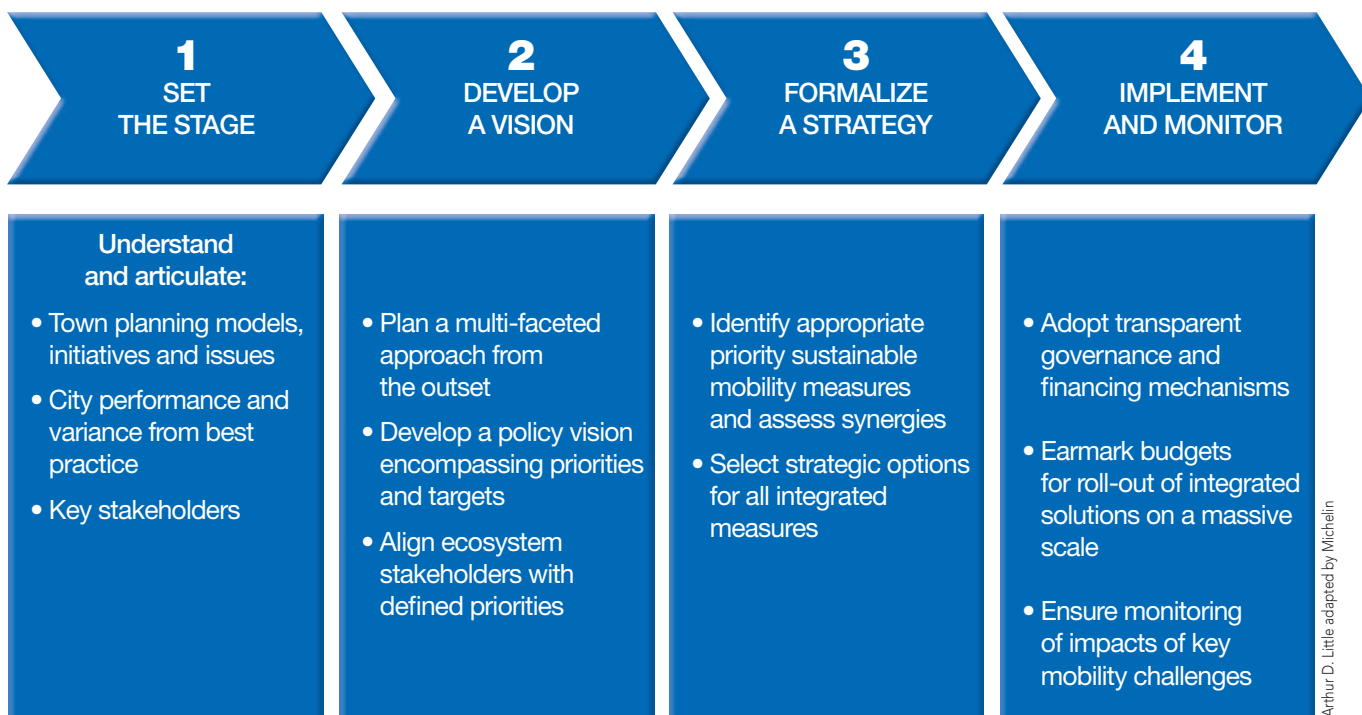
Cities should define ways (incentives/penalties) to encourage people to match their behavior to the mobility mode adopted. Measures do exist, some of which are tried and tested.

- **Public transport funding.**

To ensure the financial viability of public transport and its operators, assessments must be made in three areas: opportunities to derive additional revenues from aggregation of third party services; growth in passenger numbers; and revenue collection from indirect beneficiaries of public transport (see chapter on «New economic instruments»).

All four dimensions have to be carefully weighed by cities at the trial stage, all too often by-passed when it should in fact form part of a formal assessment process, by factoring in the specific context of the country and the city. The final outcome will be influenced by the performance of the weakest link.

A strict implementation process must be followed for each innovative mobility ecosystem under consideration:



Arthur D. Little adapted by Michelin

And now, let's act!

The Chengdu event will provide an opportunity to pursue these issues, enrich this Green Paper through debate, further the quantitative measurement of the impacts of the proposed solutions and, above all, set up joint action plans with the support of all the partners present.

We believe that the material presented in this document provides both a pertinent response to the urgencies we currently face and a vision for a sustainable future.

Neither the status quo nor the incremental progress made on tackling pollution is acceptable anymore. The action now required must be strong, socially equitable and support sustainable economic activity, in a world increasingly thirsty of mobility.

Achieving strong consensus on the priorities to address and the common initiatives to be launched would prove a valuable contribution to the well-being of a hope-filled civil society.

Let's dare to do the right thing, with our hearts and our minds!



Editors: Erik Grab & Patrick Oliva

Authors: Olivier Dario, Antoine Féral, Patrice Person, Matthieu van der Elst with Hugo Bois

Publication: Sylvie Gillet

Coordination: Delphine Deflandre


Translators: Govind Bhinder/Feat, Hui Hong 洪晖, Xuan Liu 刘璇, Laurence Ullman

Proofreaders/Reviewers: Jennifer Bravinder, Michael Fanning, Luc-Michel Gorre, Jean-François Mathieu, Johnson/Zhen Zhang 张震

Digital community: Virginie Stellmacher, Bluenove with Alexandre Echaliér

Graphic design: Tréma Clermont-Ferrand (with IdeaSound for the chinese version)

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