

Chapter 4

Policies to Decarbonize the Transport Sector



Abstract This chapter presents a range of policies that support an effective decarbonization of the transport sector, considering both the measures that favor a reduction and/or a modal shift of transport demand, and those that promote the spread of cleaner vehicles. The chapter also provide examples of best practices, i.e., cases in which local, national, or international authorities have attempted and been able to successfully implement these measures. Following analysis of individual policies, the chapter will look to take a more holistic approach to policy implementation. In this context, it will illustrate the governance levels that involve each singular policy, the taxation issue, potentially emerging risks, and the distributional effects deriving from the implementation of these policies.

4.1 Introduction

This chapter discusses the different policies that may be adopted to foster effective decarbonization of the transport sector. The policies are divided into two categories depending on whether they involve passenger or freight transport. Within these categories, each contains two subcategories based on whether the policies discussed:

- favor a reduction and/or a modal shift of transport demand; or,
- promote the spread of cleaner vehicles.

The chapter discusses policies by following a common pattern. First, it explains what the policy consists of and what it aims to achieve. Secondly, it enumerates the measures which characterize the policy. Thirdly, it provides examples of best practices, i.e., cases in which local, national, or international authorities have attempted and been able to successfully implement these measures.

Following analysis of individual policies, the chapter will look to take a more holistic approach to policy implementation. In this context, it will illustrate the governance levels that involve each singular policy, the taxation issue, potentially emerging risks, and the distributional effects deriving from the implementation of these policies.

Horizontal analysis shows clearly that in developing successful policies for the decarbonization of transport policymakers face a multitude of challenges. The first

criterion for the assessment of a policy would naturally be its effectiveness in reducing carbon emission, in itself given the complexity of modern economic systems is not an easy task. Moreover, policymakers must consider the interaction of policies and their broader socioeconomic impacts. Considering effects on the price and efficiency of transport would be prime candidates here. More particularly, the regressive nature of many policies is an area that must be considered and addressed. Finally, many policies are predicated on the development of large-scale, sophisticated digital software and data processing. An investigation into possible side effects of digitalization is outside the scope of this chapter but their existence should be noted nonetheless.

4.2 Passenger Transport—Reduction and Modal Shift of Transport Demand

4.2.1 Promote the Increase in the Average Occupancy of Vehicles with Carpooling (Enabled by Digital Technologies)

Carpooling is a form of flexible transport whereby drivers of private cars offer their empty seats to other individual travellers that have similar itineraries and time schedules. There is little formal legislation controlling carpooling; however, it is common across the developed world that payments between passengers and drivers in a car pool should not result in a profit for the driver otherwise this could violate terms and conditions of their car insurance.

Carpooling schemes can be classified into two categories, which differ depending on travel's length: urban (or short-distance) carpooling and inter-city, inter-state (or long-distance) carpooling.

Starting from early 2000s, new companies launched long-distance carpooling services in Europe. The French BlaBlaCar is one of the most famous companies operating in this sector. This service has rapidly become popular and has been expanded in several countries. Long-distance carpooling is an almost entirely spontaneous phenomenon and therefore proper legislation to regulate it is missing. Similarly, there is no significant political initiative to encourage the spread of inter-city carpooling.

As regards short travels, carpooling options encourage car owners to cut urban congestion by inviting people to share a vehicle. Typically, such schemes are led by workplaces and include information technologies such as online booking. Dedicated infrastructure and specific policies may promote the uptake of urban carpooling. The main measures generally include:

- establishing a lane for high-occupancy vehicles on an access road into city centers;
- establishing park and pool venues on main roads;
- integrating carpooling with public transport;
- offering a trip-matching service for carpooling;
- carrying out the necessary public relations work and raising awareness.

A carpooling scheme has been tested in Rome (CIVITAS Initiative, Roma) in the framework of the European CIVITAS projects. During peak hours, many of the cars circulating in the center of Rome have a single occupant travelling to work. Some companies had carpooling “crews,” but they tended to be formed spontaneously rather than in an organised way. The idea behind this measure was therefore to develop a systematic approach in order to promote collective car use more effectively.

The Sustainable Mobility Department of the public transport operator (ATAC) installed a simulation model designed to manage carpooling services and integrated it with the mobility management system. The model uses origin and destination data and incorporates revealed preferences about trip characteristics and scheduling.

In the first phase of the project, ATAC identified the needs and priorities of companies and individuals as well as the areas to promote carpooling in with the help of computer-based tools. After that, it cooperated with citizens to develop first home-to-work plans to serve as a trial. Finally, ATAC designed and promoted several carpooling schemes across the city.

The three main schemes involved the municipality’s offices, the hospital Policlinico Umberto I and the Ministry of Public Health. Almost 400 car pools were formed and more than 1000 citizens took part in this experiment. Furthermore, the projects included agreements with local garages to provide facilities at special rates.

Stuttgart also provides a successful experience of implementation of carpooling systems (CIVITAS Initiative, upgrading the carpooling system with an events feature). The Pendlernetz Stuttgart carpooling system offers all commuters a chance to find an appropriate car pool, enabling them to travel to work in a more relaxed and environmentally friendly way. It was created in order to improve the mobility of all citizens and visitors to the city and the Stuttgart region. Digital technologies also improved the system: communication on potential car pools via mobile phone text messages to users, geographically referenced route mapping and automatic transfer to the public transport information system contributed to providing an effective carpooling service.

The carpooling system was extended to local events like football matches and concerts. This involved integrating an events data pool into the Pendlernetz Stuttgart system. The new service was aimed in particular at visitors to the home games of the football club VfB Stuttgart. During such events the demand for travel to the same destination (e.g., the stadium) skyrockets. A carpool scheme, therefore, proves even more efficient in such situations.

Other interesting examples in USA relate to urban carpooling. An MIT study developed an algorithm finding that just 3000 four-passenger cars could serve 98% of taxi demand in New York City (NYC), with an average wait time of only 2.7 min. Compared with the 14,000 taxis currently operating in NYC, the cost and emissions savings from carpooling are self-evident. The research does however highlight the benefits and dependency of successful carpooling on sophisticated digital techniques.

Recently, in Abu Dhabi the Department of Transport has for the first time embraced car sharing. They have launched a new online system encouraging motorists to sign up and offer lifts to strangers. Individuals signing up can either look for rides or offer them themselves. Charging for these rides will be illegal outside of sharing the cost of

fuel and other expenses. The opportunity for carpooling has now been incorporated into the official transport website alongside other modes of transport such as cars, ferries, and traditional public transport (Integrated Transport Center). Importantly, the scheme has been launched in combination with the introduction of new toll gates on routes into and out of Abu Dhabi Island. The combination of these two strategies is targeted at reducing the number of cars on the roads (The National, 2019).

Efficient carpooling relies on a well-functioning platform. If carpooling is considered as an attractive option by cities, they should first look to best-case examples, such as those from Rome and Stuttgart to benefit from existing experiences. Trials should then be carefully rolled out, with adaptations made as they are increased in size.

4.2.2 Promote a Shift from Private Cars to Public Transport and Clean Car Sharing (Enabled by Digital Technologies)

This section will first examine policies to bolster a modal shift toward public transport. With this respect, it will describe the experience of the city of Usti nad Labem. After that, the section will focus on the shift toward a more modern transport mode—car sharing—by looking at the development of this new service in both American and European cities.

With the aim of influencing the modal shift in favor of public transportation, it is necessary to advertise the benefits and the services of this transport mode. Public transport promotion aims at supporting its good image, attracting passengers, and strengthening its usage. An effective cooperation between the city and its public transport operator is a prerequisite for a successful promotion campaign.

The basic objectives of public transport (PT) promotion includes:

- Highlighting advantages of public transport compared to individual motor transport;
- Attracting new passengers while keeping the existing ones;
- Improving provision of information about transport services;
- Increasing awareness about public transport and ITS;
- Improving accessibility of services by providing targeted information to passengers; and
- Exploiting new technology to supply favorable services, such as SMS ticket, downloadable public transport maps or timetable.

The city of Usti nad Labem in Czech Republic implemented a public campaign promoting public transport in the city to raise awareness of passengers and build reputation of public transport (CIVITAS Initiative, Public Transport Promotion Campaign).

The authorities produced and distributed relevant information, promotional, and education materials. Further distribution of these materials was transmitted to the PT Company of Ústí nad Labem, which will continue in the initiated activities. By providing clear information, the city and the relative transportation operators should facilitate the accessibility to public transport services for existing or potential users.

The campaign consisted of several events organized to promote local public transport services to residents. During these events, people were able to compare PT services provided in the past and in the present. They participated in knowledge and effort competitions for prizes, discussions, and workshops about PT services. Information materials were distributed during these events and they are available at other public areas and through the PT Company of Usti nad Labem. Two PT vehicles were equipped with free internet connection for passengers and decorated by thematic pictures in order to attract attention and welcome customers.

Local media also played an important role in promoting the campaign activities. Particular attention of the promotion campaign was laid on education of children to utilise PT in the city.

As regards results, the usage of the city public transport in Ústí nad Labem is now relatively high compared to similar cities in the Czech Republic, although improvements of services are still needed.

Shared mobility emerged in major cities in the early 2000s with the arrival of car sharing services from providers such as Zipcar, whereby members could borrow cars on a short-term (hourly) basis. Many of these services are now accessed through smartphone apps, allowing users to locate and unlock vehicles, and making one-way journeys possible.

Several cities have already allowed and pushed private companies to deploy electric vehicles in their urban car sharing networks. Zipcar in Chicago has used electric vehicles in its fleet since 2012. Philadelphia and Portland also are working with Zipcar on their programs. Other examples include Houston's Fleet Share, San Diego's SmartCitySD with Car2go, and BMW's program in San Francisco (Lutsey, Searle, Chambliss, & Bandivadekar, 2015).

In Italy, many communities and regions participated in the founding of their regional car sharing providers. This was pushed forward by the national coordination point for the development of car sharing, the Iniziativa Car Sharing, and its support through the Italian Environment Ministry. In several cities, communities are directly involved in the regional car sharing organization. Political support can be seen in the preferential treatment given to car sharing vehicles in many Italian cities:

- They have unrestricted access to the low emission zones in city centers—established because of poor air quality levels. Regular car traffic may enter only within given time limitations.
- Car sharing vehicles may use reserved bus lanes, bringing them through the worst congestion areas of the city more easily.
- They can park free of charge in the “blue zones” of the city center. Examples of such political support through local transport policy are found in Turin, Venice,

Bologna, Rimini and Modena. In addition, the councils in many Italian cities use car sharing for their employees' business travel.

4.2.3 Promote a Shift from Private Cars to Rail in Long-Distance Travels (E.g., TEN-T)

In order to foster a modal shift from road to rail, customer and market oriented measures as well as enhanced rail systems are required.

Measures to increase the capacity of the rail system include¹:

- Investing in high-speed rail.
- Improving timetable planning: “e.g. double track—bundling of trains with the same average speed in the timetable channels and daytime operation of faster freight trains (Islam, Ricci, & Nelldal, 2016).”
- Exploiting trains with higher capacity.
- Differentiating track access charges to avoid overloaded links.

The EU has elaborated the 4th Railway Package (European Commission, Mobility and Transport), a set of six legislative texts designed to complete the single market for rail services (Single European Railway Area). Its overarching goal is to revitalize the rail sector and make it more competitive vis-à-vis other modes of transport. This package comprises two “pillars”: the market and the technical pillar.

The market pillar includes a set of rules that allow railway undertakings from one Member State to provide passenger services in any other EU Country. It also guarantees impartiality, prevents discrimination, and introduces the principle of mandatory tendering for public service contracts in rail. As a result of these measures, the passenger rail sector will become more competitive. Increased competitiveness will stimulate operators to be more responsive to customer needs, provide better quality services and improve their cost-effectiveness. At the same time, the principle of mandatory tendering for public service will lead to savings of public money.

The second pillar, the technical one, provides a legislative framework enabling a considerable cut of the operational costs and administrative burden. In so doing, it boosts the competitiveness of the railway sector. In particular, it will:

- “Save firms from having to file costly multiple applications in the case of operations beyond one single Member State. ERA will issue vehicle authorizations for placing on the market and safety certificates for railway undertakings, valid throughout the EU. So far, railway undertakings and manufacturers needed to be certified separately by each relevant national safety authority.
- Create a “One stop shop” which will act as a single entry point for all such applications, using easy, transparent and consistent procedures.

¹For further details on this topic see Islam et al. (2016).

- Ensure that European Rail Traffic Management System (ERTMS) equipment is interoperable.
- Reduce the large number of remaining national rules, which create a risk of insufficient transparency and disguised discrimination of new operators (European Union Agency for Railway, The 4th Railway Package—What does it mean for me?).”

In China, the central government is aiming to integrate AI technologies and its national railway to monitor and maintain its operations. Due to its limited expertise and experience, China Railway cooperated with the technology company Tencent and the automotive group Geely to install in-cabin WiFi on its trains. Incorporating social capital is seen as a move to rapidly develop China Railway’s services.

China has also invested enormous physical capital into the development of the world’s largest high-speed rail service. Work began in August 2008 with a line built connecting Beijing and Tianjin in just 30 min. Since then, China has put into operation over 25,000 km of dedicated HSR lines. These projects have been overseen by the 2004 Medium- and Long-Term Railway Plan covering freight and passenger transportation till 2020. Strong commitments from top levels of governance have been key for the success of HSR. There have been clear positive network externalities as HSR has sprawled across Chinese landmass. For instances until 2012, the Zhengzhou-Xi’an line was an isolated service until 2012. Following its connection to the Beijing–Guangzhou HSR in 2013, passenger volume increased by 43% (World Bank Group, 2019a). Extensive planning in China has driven an increase in passengers travelling via rail.

A clear priority for neighboring countries or states with land borders should be greater coordination between train services and investment in order to better stimulate the development of more efficient and high-speed rail. In terms of high-speed rail, lessons can be learned from the relatively successful story in China so far. A key criterion has been the investment of large amounts of capital. Countries should look for effective strategies of sharing this investment burden with the private sector.

4.2.4 Develop Cross Border Corridors for Connected and Automated Mobility (CAM)

New digital technologies have been increasingly applied to the transport sector. Smarter and more connected vehicles are currently under development. These new generation vehicles and infrastructure perform more efficiently by collecting large amounts of data. In particular, they are able to interact with other smart systems and optimize their performance, thus reducing energy consumption and maintenance costs.

This development involves different modes of transport (IEA, 2017a). In road transport, digitalization enables coordinated fleet operations as well as other operations such as the possibility to check the status of battery charging for electric

vehicle. In aviation, modern sensors applied on new commercial aircraft and big data analytic systems enhance route planning and help rationalize fuel consumption. Maritime transport also benefits from improved communication systems that ships use to exchange information with port authorities. By doing so, operators prevent congestion in ports.

Automated mobility has also made concrete steps forward. By replacing human control, automated cars can improve safety while optimizing speed and gasoline (or energy) consumption. Major progress is also expected in the passenger railway and aviation.

Given the huge amount of data that need to be processed, the development of connected and automated mobility will be favored and enabled by the deployment of the 5G technology. To this end, the EU is establishing a collaborative network of cross-border corridors between Member States.

As part of the European Commission's 5G Public Private Partnership, the EU supports three 5G cross-border corridor projects for large-scale testing of connected and automated mobility (European Commission, 5G Public Private Partnership, the Next Generation of Broadband Infrastructure). The three projects, launched in November 2018, trial 5G technology applied to CAM over more than one thousand kilometers of highways across four borders:

- 5G-CARMEN (5G Carmen): 600 km of roads across an important north–south corridor from Bologna to Munich via the Brenner Pass.
- 5GCROCO (5G Croco): over highways between Metz, Merzig and Luxembourg, crossing the borders of France, Germany, and Luxembourg.
- 5G-Mobix (5G PPP): along two cross-border corridors between Spain and Portugal, a short corridor between Greece and Turkey, and six national urban sites in Versailles (France), Berlin and Stuttgart (Germany), Eindhoven-Helmond (Netherlands) and Espoo (Finland).

China is seeing the growth of Intelligent and Connected Vehicles (ICVs) which are able to achieve the exchange and sharing of information while being aware of complex surroundings. Through intelligent decision-making such vehicles may carry out driving operations independently of human beings. The Chinese Government has taken concrete steps to foster the creation of an intelligent transport eco-system. In 2017, a National Innovation Platform for the Acceleration of ICV Development was established. This platform looks to address obstacles in the development of ICVs as well as ensure the effective implementation of national strategies (GIZ, 2018).

In Shenzhen, the municipal government is participating in a public–private partnership called the Greater Bay Area Intelligent Vehicle Eco-Partnership (GIVE). The objective is to accelerate the formation of this ICV ecosystem around Hong Kong, Macau, and Guangdong province. Over 100 members from business and academia have joined as of 2018 (Ibid.).

R&D efforts should be continued and encouraged in order to develop more efficient connected and automated solutions.

4.2.5 Congestion Charging Policies

A congestion charge is a charge for driving a vehicle in an urban area, often limited to working hours. Devised as a way to internalize external costs, this initiative would be beneficial for two reasons. First, the congestion charge pushes up the cost of using private cars, thereby prompting users to choose other options. Reducing traffic in usually congested urban areas makes districts more enjoyable and attractive for potential new pedestrians or cyclists. Secondly, pricing congested road or areas raises money to build new cycle paths or make streets more suitable for walking.

Congestion charging schemes can be classified into four types (CURACAO, What Are The Key Features And Examples Of Scheme Design):

- Point based charges (e.g., tolls to cross a bridge or to enter a section of motorway).
- Cordon based pricing: A charge is levied for crossing a cordon, and may vary with time of day, direction of travel, vehicle type, and location on the cordon. There could be a number of cordons with different prices.
- Area license based pricing: A charge is levied for driving within an area during a period of time. The price may vary with time and vehicle type.
- Distance or time based pricing: Price is based upon the distance or time a vehicle travels along a congested route or in a specified area, and may vary with time, vehicle type, and location.

Congestion charging initiatives have been implemented in major cities. In London, this has resulted in a significant decrease (−21%) of congestion in the interested areas. As a consequence, the city reallocated more road space to sustainable transport modes. Walking and cycling also become safer as congestion drops: With this respect, a survey shows a significant fall in bicycle accidents in London (Guardian, 2015). CO₂ emission reductions of 12% were recorded, while a 12% reduction was also recorded in local air pollution, specifically PM10 (Joint Research Center, 2019, p. 451).

Similarly, in Milan private vehicles entering the charging zone have decreased by 29% since the establishment of the Area C, a combination of a congestion charge with a low-emission zone that cannot be entered by the most polluting vehicles. This congestion reduction has led to a 35% reduction in CO₂ emissions (Ibid.). At the same time, this initiative promoted a shift toward environmental friendly transport modes as the number of bike users significantly grew in the next three years (Polinomia srl, 2016).

In 1998, Singapore transitioned from a manual, labor-intensive pricing system to the current system of Electronic Road Pricing, becoming the first city in the world to do so. The system uses entry points to charge drivers entering the city center. Rates of entry vary depending on the time of day and between points of entry. All resident cars use in-vehicle stored-value smart cards while visitors must rent or purchase an in-vehicle unit. The novelty of such an electronic system is that, unlike a simple toll system, it directly charges drivers for the congestion they are causing through a variable price mechanism that increases during times and in areas of heaviest road usage (Menon & Guttikunda, 2010).

Cities should adopt more stringent congestion charging policies. The benefits must be carefully explained and discussed with the general public to avoid backlashes. A focus on discussing the health benefits that will arise through the reduction of local air pollution should be a fundamental mechanism through which to generate widespread support for higher levels of congestion charging. Particularly, older and heavily emitting vehicles should be targeted as a priority. Automatic and Electronic Road Pricing should be the preferred design, with Singapore providing a case study on best implementation.

4.2.6 Parking Management Policy in City Centers

At city level, one opportunity to reduce congestion and promote a modal shift of transport demand is the parking management policy. That is, local authorities could consider introducing or raising parking fees in certain districts. Through these kinds of policies, the costs connected to the use of private vehicles would increase. Higher, even though indirect, costs would discourage citizens from driving private means of transportation. The reduction in the private car usage should entail a rise in the public transport use (if this is present and efficient) or cycling (if bicycle paths are in place).

In 2012, Nottingham adopted a parking management policy to tackle problems associated with traffic congestion. In particular, the city introduced a Workplace Parking Levy (WPL) (Nottingham City Council). This refers to a charge on employers who provide workplace parking. WPL has provided funds that the city has invested in new transport infrastructure (such as the extensions to the existing tram system) and the redevelopment of Nottingham Station.

In India, New Delhi is currently undergoing an extensive overhaul of their parking management policy. Measures are aimed at curtailing the use of private vehicles, giving more space to pedestrians, and encouraging alternative, greener modes of transport (The Hindu, 2019). Policies include on-street parking charged at twice the value of off-street parking as well as exponentially increasing parking fees with time spent parked. Moreover, within each parking facility civic agencies shall identify and provide areas for electric vehicle charging and battery swapping facilities.

Draft rules of the New Delhi Parking plan (dated 12/06/19) detail that on-street spaces need to be utilized for the convenience of primarily pedestrians/cyclists, then mass public transport followed by emergency vehicles (Government of National Capital Territory of Delhi Transport Department, 2019). Civic agencies shall endeavor to use additional parking revenue for local development works related to the safety of pedestrians and road safety. If successfully implemented, the new parking management policy will engender a significant shift in population behavior away from individual car driving in one of the world's most populous cities.

4.2.7 *Promote Cycling and Walking Zones*

In many urban areas around the world, people still opt for traditional private cars because of the absence of alternative options. In this context, promoting cycling and walking zones would boost the modal shift of transport and ease traffic. That is, municipalities should make their urban spaces safer and walking or cycling friendly. To this end, they should prioritize the development or expansion of relevant infrastructure like cycle tracks and sidewalks. But also lower car speed limits and introduce car-free days.

As regards the promotion of cycling zones, Copenhagen's experience is surely among the best practices. In 2011, it developed its bicycle strategy (City of Copenhagen, 2011). The measures of the strategy included:

- Dedicating more space to cyclists: widening some tracks and building alternative routes to move some of the bicycle traffic away from the congested routes;
- Developing campaigns focused on more considerate behavior in traffic;
- Improving travel times by bicycle, for instance by prioritizing ambitious short cuts like tunnels and bridges over water, railways and large roads;
- Strengthening partnerships with companies, shopping districts, public transport providers, and neighboring municipalities to promote the use of bikes;
- Combining bicycles with public transport. Integrating bike sharing system with buses, trains and metro;
- Inviting bids for new bike sharing systems;
- Investing in new bicycle parking.

The adoption of this strategy has resulted in significant improvements. A 2017 report enumerates major achievements: 41% of all trips to work and study to/from Copenhagen was by bike and 62% of Copenhageners chose to bike to work and study in Copenhagen (City of Copenhagen, 2017). In total, 1.4 million km was cycled in the city on an average weekday which is an increase of 22% since 2006. In the same period, cyclists' feeling of safety has increased by 43% while the relative risk of having a serious bicycle accident has been reduced by 23%.

A case study in New Zealand has highlighted the potential of cycling and walking interventions to reduce carbon emissions (Keall et al., 2018). In 2010, New Plymouth and Hastings were selected by the New Zealand government as walking and cycling Model Communities. Total investment into the projects was \$13.1 million of which 85% was spent on infrastructural changes (i.e., improved walkways and cycle lanes) and 15% on information and education (e.g., campaigns to increase cycling and walking uptake).

Based upon these interventions, a quasi-experimental study revealed that the average vehicle kilometers driven was reduced by 1.6% as an average of the two cities relative to control cities, similar in all characteristics other than not having enjoyed the investment. An estimated 1% reduction in annual CO₂ emissions follows as a result of this reduction in kilometers driven.

4.2.8 *Promote Multimodality*

As of today, most transportation systems in the world favor the choice of uni-modal solutions by users. This is explained by the fact that the concept of multimodality (or intermodality) is new and not yet widespread. Multimodality refers to seamless trip-making across multiple transport modes (e.g., walking, cycling, bus, urban rail, and cars) (IEA, 2017a, p. 40).

Most urban areas still lack effective schemes to integrate long and short-distance transportation means. Similarly, cities do not rely on frameworks to connect private vehicles on the one side and public or shared mobility services on the other. As a result, end users find single transport mode journeys more practical than multimodal solutions.

Multimodality can provide a large variety of benefits. It may contribute to resolve problems related to congested roads and offer cleaner and safer mobility opportunities. In fact, multimodality exploits the strengths of different transport modes, such as speed, cost, reliability, and convenience. By taking advantage from the combination of several mobility options, it provides transport solutions which are better suited to the needs of the user.

Measures aiming to develop efficient multimodal platforms include:

- Setting targets: what area must be connected to other areas;
- Defining the spatial scale: regional, national, or local level;
- Identifying transportation means to be connected: trains, private cars, buses, bikes, etc.;
- Setting a suitable, legal framework to facilitate the introduction of digital systems for passenger ticketing, real-time information sharing and reservation;
- Defining an investment plan to smooth interchanges at bus and train stations or other terminals;
- Involving private shared mobility providers and stakeholders interested in developing an interface to provide access to mobility options via a single ticketing and payment channel;
- Managing and regulating the charges for the use of interchange terminals.

The EU has been covering these themes and supporting projects aiming to promote multimodality. In particular, the project CLOSER identified new transportation patterns based on the idea of multimodal mobility to connect long and short-distance networks (European Commission, Project CLOSER). More recently, the EU has co-financed the CIVITAS projects that inter alia focus on topics like park and ride, public transport and bicycles, and the improvement of interchange terminals to promote intermodal urban transport chains at city level. For example, the city of Turku in Finland is improving the interconnectivity of its public transport system, bike sharing services, and private vehicles through the development of a participation platform using ICT and social networks (mobile apps, social media) (CIVITAS Initiative, Turku).

In the USA, collaboration between Uber and Rapid transit agencies such as the Metropolitan Atlanta Rapid Transit Authority (MARTA) aims to address this problem (Metro-magazine, 2015). MARTA app users are linked directly to the Uber app while in transit in order to help them reach their final destination. In turn, Uber drivers have information about when the bus or train will arrive so that they are already waiting at the station when passengers arrive.

Multimodal forms of transport are essential to combating passenger problems of the “last mile.” That is, public transport is often very useful in transporting passengers from one city center to another or from one pre-defined station within a city to another but passengers face the difficult task of how to commute the “last mile” to their personal destination. In such a circumstance, they face an incentive to simply drive the whole route.

4.2.9 Limit the Number of License Plates to Be Registered Each Month

In large and highly polluted urban areas, improving alternative transportation options has not been successful in promoting a modal shift. Neither have policies adopted to discourage, through fiscal or non-fiscal means, users from driving their cars. In such cases, local authorities have considered a strict limitation in the number of license plates to be registered each month.

One of the most extreme examples is Beijing where tackling problems related to air pollution and traffic congestion are priorities. To this end, since 2011, the municipal government has devised a lottery to restrict the number of cars registered each year (Bloomberg, 2019b). This policy is so strict that just one new plate for every 2000 applicants is awarded bimonthly. In fact, over the last years, the annual new vehicle quota has fallen to 100,000, from 240,000 in 2013.

Also, the local authority requires each licensed gasoline-fueled car to be idle one day a week (the day is determined by its license-plate number).

Following the implementation of these restrictions, car sharing and ride-hailing companies such as Didi Chuxing and Shouqi Limousine & Chauffeur acquired considerable share in the transportation market. The strong impact of these policies has even changed the consumer attitude from necessarily owning a car to booking a car on demand.

Placing an explicit limitation on car registrations is a reasonably extreme measure. However, it is likely to become more necessary in the future unless governments begin to quickly and effectively adopt many of the other policies detailed in this chapter.

4.3 Clean (Automated and Connected) Vehicles for Passengers

4.3.1 Emissions Standards

One of the most common policies designed to cut CO₂ emissions in the transport sector consists of setting emission standards. This kind of policy generally identifies a certain level of emissions (measured in CO₂ grams per kilometer) for newly registered vehicles. In the event in which these targets are not met the legislation usually stipulates financial penalties. For example, if the average CO₂ emissions of a certain manufacturer's fleet exceed the target defined by the authorities in a given year, the manufacturer has to pay an excess emissions premium for each car registered. Also, emission standards provisions are often accompanied by directives on fuel quality, which require a reduction of the greenhouse gas intensity of transport fuels.

In China, the corporate average fuel consumption limit for passenger cars is dropping from 8.2 l/100 km in 2010 to 5.0 l/100 km in 2020, and then 4.0 l/100 km in 2025 (Lubrizol, 2019). According to estimations (Ibid.), in 2020, there will be a saving of around 160 billion liters of fuel (over a trillion RMB) and 370 million tons of CO₂ every year.

In 2017, the EU average emissions level of the new cars registered was 118.5 grams of CO₂ per kilometer (g/km) (European Commission, reducing CO₂ emissions from passenger cars). From 2021, phased in from 2020, the EU fleet-wide average emission target for new cars will be 95 g CO₂/km.

Within its Mid-Century Strategy for Deep Decarbonization, the USA also established fuel economy and GHG emissions standards for both light- and heavy-duty vehicles, which have reduced transportation GHG emissions significantly in recent years (US Mid-Century Strategy for DEEP DECARBONISATION). However, on April 2, 2018 the Trump Administration announced its intent to revise through rulemaking the federal standards that regulate fuel economy and greenhouse gas emissions from new passenger cars and light trucks.

Emissions standards are, by definition, an effective tool for reducing emissions associated with road transport. Governments should communicate clear plans for progressively increasing the stringency of emissions standards over time.

4.3.2 Country-Level Bans on Commercialization of Petrol/Diesel Cars

In order to meet emission reduction targets, governments have increasingly considered policies to promote the use of zero emission vehicles. Aiming to boost the commercialization of cars and vans powered by clean energy, some countries have

committed themselves to end the sale of new conventional petrol and diesel vehicles in the future. In so doing, they expect almost every car and van in circulation 10–15 years after the introduction of the ban to be zero emission.

With respect to this policy, European countries seem to be at the forefront. Denmark has proposed a ban on the sale of new cars with internal combustion engines from 2030 and hybrid from 2035 (Reuters, 2018). Prior to Denmark, France and the UK had pledged to stop supplying fossil fuel-powered vehicles by 2040. The UK government has subsequently proposed to bring this target forward to 2035 (BBC, 2020). The Dutch Government has proposed a plan to ban all petrol and diesel vehicles by 2030, so that all new cars in the country must be emission-free (Wiredbugs).

India has recently announced that its commercialization of petrol and diesel cars will cease in 2030. China has also joined the initiative and announced that its ban will cover the commercialization of internal combustion engine cars and commence in 2040.

Country-level bans can be viewed as an effective way to shift the incentives for car manufacturers toward producing non-petrol or diesel vehicles. Bans are in that sense very attractive but must be accompanied by more intermediary measures to help guide developments toward a longer-term target. Bans will only serve to penalize the population if there are not already feasible transportation alternatives in place.

4.3.3 Public Investments in Clean Vehicles R&D

Driven by climate change and air pollution concerns, research and development of electric and other clean vehicles have become a crucial tendency in the transportation sector.

China is the country which has allocated most financial resources to clean vehicles R&D.

China began R&D for electric vehicle under the National High-Tech Development Program “863 Program” (Report on National R&D Programmes on the Fully Electric Vehicle). The national 863 Program was introduced during the 10th Five-Year Plan (2001–2005), where also the goal to commercialize and industrialize electric vehicles was introduced. This goal was refined in the 11th Five-Year Plan (2006–2010).

The main objectives of the “863 Program” are to fund technological research and innovation in areas of strategic importance to the nation’s economic and social development. In particular, it is engaged in the funding of electric vehicle related activities. To this end, in 2001, the “863 ElectricDrive Fuel Cell Vehicle Project” received an initial investment of RMB 800 million (approximately equivalent to 103 million Euros).

This strong public engagement has resulted in significant development of EV technology, which, in turn, has reduced EV production costs, in particular by reducing battery costs, further nurturing the development of the EV market.

The EU too has made concrete steps by adopting the strategic action plan for batteries. In particular, the European Commission:

- In collaboration with Member States makes available, research and innovation funds (H202018) for battery-related innovation projects, according to pre-identified short- and longer-term research priorities across the batteries value chain.
- Launches calls for proposals for an additional total amount of EUR 110 million for battery-related research and innovation projects (in addition to EUR 250 million already allocated to batteries under Horizon 2020; and EUR 270 million to be allocated in support of smart grids and energy storage projects as announced in the Clean Energy for all European package).
- Supports the creation of a new European Technology and Innovation Platform to advance on battery research priorities, define long-term visions, and elaborate a strategic research agenda and road-maps.
- Prepares the launch of a large-scale Future Emerging Technologies Flagship research initiative, which could support long-term research in advanced battery technologies for the 2025+ timeframe.
- Optimises solutions for integration of stationary storage and electric vehicles in the grid within Horizon 2020 smart grid and storage projects²³ as well as Smart Cities and Communities' projects.

Alongside penalties and bans for the use of polluting vehicles, it is very important for governments to play a role in driving forward research into the cleaner technologies that will one day offer a replacement. The benefits from R&D and innovation in clean vehicles are likely to be far-ranging. Government schemes should look to effectively unlock private investment at the same time as providing some public funds.

4.3.4 Public Investments in Clean Vehicles Infrastructure (E.g., EVs Charging Network)

A successful strategy aiming to expand the electric vehicle ownership requires considerable investment in relevant infrastructure. Drivers must have confidence in the performance and connectedness of charging and fueling networks before they will purchase or use a zero-emissions vehicle (ZEV). With this respect, local, state, and utility stakeholders need to cooperate to stimulate the accessibility and ease of use of all types of charging infrastructure, both public and private ones.

The State of California has invested much effort on the development of an effective charging infrastructure. In January 2018, the Californian government signed an Executive Order, setting ambitious targets of 200 hydrogen fueling stations and 250,000 electric vehicle chargers to support 1.5 million ZEVs on California roads by 2025, on the path to 5 million ZEVs by 2030 (Governor Edmund G. Brown Jr, 2018).

The initiative is designed to focus multistakeholder efforts on deploying charging and fueling infrastructure as well as making ZEVs increasingly affordable to own and operate.

In particular, the California Public Utilities Commission has approved roughly \$1 billion in programs to incentivize residential, workplace, and public charging from Pacific Gas & Electric, Southern California Edison and San Diego Gas & Electric (Greentech Media, 2018).

The intent of the government is also to help expand private investment in zero-emission vehicle infrastructure, particularly in low income and disadvantaged communities. With this in mind, the 2018 Executive Order serves inter alia the purpose to develop a concise document mapping the relationships between existing and planned ZEV infrastructure investments. Moreover, it identifies the need to create a platform for stakeholder engagement, feedback, and information sharing.

The Chinese central government is also aggressively pursuing the development of EV charging networks. As of January 2019, there were roughly 2.6 million EVs on the road in China. There were 808,000 eV chargers, of these roughly 330,000 were public and 480,000 were home chargers. Charging infrastructure is growing rapidly throughout China, with major cities (Beijing, Shanghai, Guangdong Province) having taken the lead on this front. The majority of provinces in China added over 1000 new charging posts in 2018 alone. Highway corridors have also been created for EV charging between Beijing and Shanghai as well as other major cities (Center on Global Energy Policy, 2019).

Central government policies are clear on the drive for larger infrastructure. In September 2015, the State Council issued the “Guidance on Accelerating the Construction of Electric Vehicle Charging Infrastructure.” This guidance called for a charging infrastructure sufficient for 5 million EVs to be developed by 2020. Furthermore, 10% of parking spaces in large public buildings must be available for EV charging (Ibid.).

There is a pivotal role for governments to play in providing the public good of charging networks. Incentives are reduced for both manufacturers to design, and consumers to purchase, clean vehicles without clear plans for an effective network in place. A structured plan would provide the necessary certainty to companies that investing in ZEVs will be worthwhile.

4.3.5 Clean Vehicles Production Quotas for Carmakers

Quotas usually refer to restrictive practices. For example, they may be used to limit imports thereby benefiting local producers. However, quotas may also serve the purpose to stimulate production instead of restricting it. More precisely, they may be devised to encourage the production of certain goods and curb output of others. In the context of the transportation sector, the goal of this strategy is to promote a shift. In fact, authorities may apply quotas on EVs production or import to car manufacturers. In other words, car industry corporations are obliged to reach a certain level of

EVs as a percentage of their total vehicle production or import. By encouraging the commercialization of electric cars, this kind of quota clearly boosts a shift toward cleaner vehicles.

The State of California adopted a quota policy to meet its health based air quality standards and greenhouse gas emission reduction goals. Some years later, China introduced a slightly modified version of California's program (International Council on Clean Transportation, 2018). The Chinese regulation was formally introduced in 2018 and applies only to passenger cars. It establishes New Energy Vehicle (NEV) credits, which need to be achieved by producing or importing enough new energy passenger cars. Higher performance vehicles get more credits. At the same time, the rule allows manufacturers to use surplus NEV credits to offset corporate average fuel consumption credit deficits.

The Chinese government specified EV targets for car manufacturers: 10% of the conventional passenger vehicle market in 2019 and 12% in 2020. Failure to meet these credit targets after adopting all possible compliance pathways will lead to Ministry's denial of type approval for new models that do not meet their specific fuel consumption standards until those deficits are fully offset.

Clean vehicle quotas can be an effective tool for encouraging production; however, governments should be careful not to create perverse incentives toward particular models and technologies. Any quota should remain as technologically neutral as is possible.

4.3.6 Public Procurement for Clean Vehicles

The market for clean vehicles may also be stimulated by direct purchase from the public administration. Although the means of transport used by the public services account for just a small share of the total vehicles in circulation, this measure may still impact on the deployment of low or zero emission transportation.

Authorities at regional or state level may commit themselves to purchase environmental friendly automobiles to raise the demand for this kind of vehicles. Also, and more importantly, they can promote clean mobility solutions in public procurement tenders by defining targets that cities and other authorities at local level have to meet.

The European Commission proposed a directive which sets minimum procurement targets for each category of vehicle and for each Member State (European Parliament, 2019a). The scope of the directive is broadened to include forms of procurement other than purchase, namely vehicle lease, rent or hire-purchase, and to public service contracts for passenger transport by road and rail, special-purpose road transport passenger services, non-scheduled passenger transport and hire of buses and coaches with driver.

The proposal sets minimum procurement targets for each category of vehicle and for each Member State. For light-duty vehicles, Member States must reach a share ranging from 16 to 35%, which is the same for the 2025 and for the 2030 deadlines.

For buses, individual Member State targets range from 29 to 50% (2025) and from 43 to 75% (2030), and for trucks from 6 to 10% (2025) and from 7 to 15% (2030).

Furthermore, the proposal introduces reporting and monitoring obligations for the Member States and aligns the Commission's and Member States' reporting obligations. It provides for intermediate reporting in 2023 and full reporting in 2026 on the implementation of the targets for 2025, and further reporting every three years thereafter.

In China, individual provinces have embarked upon their own public procurement of electric vehicles, backed by the central government with an ambition for China to establish a position as a world leader in battery technology. In 2017, Shenzhen became the first city in the world to realize the full electrification of its public bus fleet with a total of 16,359 electric buses. This was thanks to a combination of subsidies from central and local government. As of January 2019, 99% of taxis are also electric (The Guardian, 2018; Institute for Transportation and Development Policy).

The lessons learned from China and in particular Shenzhen are that public procurement can play a very effective role in stimulating the clean vehicle industry.

4.3.7 Subsidies and Other Special Provisions (E.g., Grants, Tax Credits, Tax Exemptions)

Clean vehicle commercialization can be boosted by fiscal incentives. Consumer purchasing incentives for EVs, just as subsidies on other goods, promote EV sale by reducing the final cost for consumers. Several states across the USA cover part of the EV costs. Equally common are subsidies for home chargers and public chargers in the form of tax credits, rebates, and grants.

Some states offer the same subsidies to all types of electric vehicles, some provide a different amount to plug-in hybrid EVs (PHEVs) and battery EVs (BEVs), and others offer the benefit only to BEVs (Lutsey et al., 2015). "Examples are California's Clean Vehicle Rebate Project, which offered \$2500 for BEV and \$1500 for PHEV purchases in 2013; Colorado's motor vehicle credit that offers up to \$6000 based on battery capacity and purchase year; Massachusetts' MOR-EV rebates of up to \$2500 for plug-in vehicle purchases; and Georgia's income tax credit for ZEV purchases and leases of 20% of the vehicle cost, up to \$5000. Georgia's program is set to expire in mid-2015" (Lutsey et al., 2015, p. 15).

In some cases, income tax credits are accompanied by state sales tax exemptions for electric vehicle purchases and related services. Examples include Washington's retail sales tax exemption for alternative fuel vehicles; Maryland's excise tax credit of up to \$3000 based on battery capacity for purchase or lease of a plug-in vehicle, and the district of Columbia's excise tax exemption for high fuel economy vehicles.

Aside from federal and state vehicle purchasing support, several cities have contributed to promoting electric vehicle purchases by offering additional financial support. Furthermore, utilities may offer a multitude of incentive programs for customers

who own electric vehicles. Some utilities offer discounted rates for electric vehicle charging, and many offer time-of-use rates, which allow charging at much lower cost during off-peak hours.

It is important, in areas such as subsidies, that governments follow a clear and coherent plan. Stop-and-start subsidy programs, such as those typically experienced for household renewable energy subsidies, will not be effective in facilitating the development of a strong zero-emission vehicle industry that can survive when subsidies are eventually removed.

4.3.8 Non-fiscal Incentives (E.g., Parking Benefits)

Beside subsidies, non-fiscal incentives have played a significant role in promoting low emissions vehicles over the last years. The most common measures concern parking benefits and unrestricted access to high-occupancy vehicle (HOV) or carpool lanes for electric vehicle drivers.

Two US states provide free parking for electric vehicles. Hawaii offers free parking for electric vehicles at eligible parking locations that are metered (Slowik & Lutsey, 2017, p. 5). In Nevada, local authorities with public metered parking areas are required to launch programs for alternative fuel vehicles to park in these areas without paying a fee.

Cities also commit to provide parking benefits, New York City (NYC) and Denver being two examples. NYC demands that 25% of new parking be electric vehicle ready. Denver set a rule that calls for new lots with at least 100 spaces to have at least one designated for electric vehicles (Lutsey et al., 2015, p. 11).

As for the other measure, ten states offer unrestricted access to HOV or carpool lanes for electric vehicle drivers. California and Florida also exempt electric vehicles from toll charges on high occupancy toll (HOT) lanes, sometimes called “express lanes” but essentially HOV lanes that single occupancy vehicle drivers can access by paying a toll. Access to HOV and HOT lanes reduces the time that electric vehicle drivers spend on the road during peak traffic hours.

In China, the registration lottery for new cars is significantly more lenient and accessible for those who purchase an electric car compared with those who purchase a gasoline or diesel powered vehicle. Stringent restrictions and years long waiting lists for registrations of gasoline/diesel vehicles are targeted at encouraging reduced demand for driving alongside shifting some of this demand toward electric vehicles. Registered cars in Beijing must also lie idle for one day of the week determined by license plate number.

Governments therefore have many options, both fiscal and non-fiscal, for promoting the spread of low emissions vehicles. Most effective strategies should involve a combination of both.

4.3.9 City-Level Bans on Circulation of Petrol/Diesel Cars

As a part of a drive to clean up air pollution, some local authorities have considered significantly reducing CO₂ emissions by banning petrol or diesel cars from driving in the city.

To this end, the city of Amsterdam has drafted a strategy divided into three steps (Guardian, 2019). From 2020, diesel cars that are 15 years or older will be banned from going within the A10 ring road around the Dutch capital. From 2022, public buses and coaches that emit exhaust fumes will no longer enter the city center. The city council plans to ban cars and motorbikes running on petrol or diesel from driving in Amsterdam from 2030 completely. At the same time, the city is investing in charging stations and new infrastructure to promote the uptake of zero-emission vehicles and encourage citizens to switch their transport mode.

Meanwhile, Madrid has also begun to restrict car access to the city center. By 2020, all older diesel and gas-powered cars will not be allowed to enter the center at all. Hybrid vehicles with an “eco-label” will be permitted to enter.

Since January 1, 2018, Brussels has been a low-emission zone. Older diesel vehicles are now banned from the city center. The ban will be gradually extended to other diesel vehicles by 2025. The same applies to petrol vehicles: some grades are already banned while petrol vehicles up to the EURO 2 standard will be banned from 2025 (Brussels Capital Region).

In December 2016, mayors from Paris, Madrid, Athens, and Mexico City simultaneously announced plans to ban diesel cars and roads from their roads by 2025. It is not yet clear whether diesel vehicles in the four cities will be subject to a total ban, or which areas of the cities will be covered (The Guardian, 2016).

4.4 Freight Transport—Switch from Road to Rail

Freight transport represents almost one third of total transport emissions. This major impact is due to the large use of road transport which is responsible for the greatest part of the entire sector emissions. In fact, not only goods shipment by road accounts for the largest part of total freight sector, but it causes considerably more pollution than other transportation systems, such as railway. Therefore a switch from road to rail would have a significant, positive impact on the environment. Policies to support such a switch include the measures described below.

4.4.1 Subsidies

An increase of the modal share of rail freight can largely absorb the expected growth in freight transport and minimize its climate impact on the environment. A shift

toward cleaner shipment schemes may be conducted by modernizing the rail freight industry, enhancing efficiency and standardization, improving cost-effectiveness and accelerating technological innovation. These aims may, in turn, be achieved through government financial support to rail freight operators. Benefiting from subsidy policies, operators will be expected to pass on their savings to their freight shipping customers via lowered rates.

In 2018, the German government announced that it had adopted an aid scheme to support a shift from road freight transport to rail transport (European Commission, State Aid). The scheme has a yearly budget of €350 million and will run until 2023.

In particular, the newly introduced policy provides that rail freight operators will be compensated for up to 45% of their track access charges, i.e., the charges that railway undertakings have to pay for the use of the rail network. By lowering operational costs faced by rail freight operators, this aid scheme makes rail transport more competitive in the shipment sector. Customers have, thus, incentive to shift their preferences from trucks toward a cleaner transportation system.

This kind of policy not only will benefit environment—as carbon emissions will be significantly reduced: it will also positively impact on congestion as medium and heavy freight vehicles' presence on the roads would decline.

In South Africa, the Department for Environmental Affairs in 2014 commissioned a report into the possibilities of a freight shift from road to rail. Since deregulation of the railways in the 1980s, the freight modal share by rail has been decreasing. The conclusion of the report was that such a shift is highlighted as one of the most favorable measures in reducing greenhouse gas emissions. One concern of the report was that rail freight is less labor intensive than road freight and so the transition could be associated with job losses (Department of Environmental Affairs RSA, 2014).

The Department of Transport has since released a Draft White Paper in which it details plans for rail to serve as the national land transport backbone by 2050 (Department of Transport RSA, 2017). Interventions will be two-pronged: infrastructure investment interventions to enhance rail's competitiveness, and enabling interventions to adjust institutional arrangements to ensure that rail functions effectively in delivering its share of national transport. It is recognized that funding of freight rail is inadequate and the government should ensure that additional sources are tapped. The government will limit its funding contribution to rail infrastructure only. This will consist of capital grants from national government as well as capital grants or long term investment instruments from provinces.

4.4.2 Cross-Border International Railway Connections

As of today, international goods shipment is mainly carried out by road. One reason explaining the lower use of rail is the lack of developed international infrastructure connections and service provisions. In order to promote a shift toward more environmentally friendly freight transport schemes, national authorities should coordinate

themselves or with supranational institutions to improve cross-border international railway connections.

With this aim in mind, policies should consider the following measures:

- Implementing a stable long-term planning and financing framework for cross-border railway projects;
- Fostering coordination of national or supranational statistical offices to collect data and produce reports regarding the development of cross-border missing links;
- Funding cross-border infrastructure projects;
- Creating a platform to coordinate cross-border projects;
- Involving people at local level. Special attention must be given to resident’s concerns about environmental impact and citizen’s questions about the use of public money;
- Making information on cross-border rail connections available to potential customers operating in the freight segment;
- Providing a common, transparent and solid regulatory framework for infrastructure managing;
- Equalizing diverging, national taxes, administrative costs, and infrastructure access charges.

In order to develop a Europe-wide infrastructure network, the EU has established the Trans-European Transport Network (TEN-T), a policy which includes the implementation of cross-border railway lines.

The ultimate objective of TEN-T (European Commission, TEN-T) is to close gaps, remove bottlenecks and eliminate technical barriers that exist between the transport networks of EU Member States, strengthening the social, economic and territorial cohesion of the Union and contributing to the creation of a single European transport area (European Commission, Mobility and Transport).

The implementation of this policy is crucial to promote an effective modal shift in freight transport. This modal shift would result in an improvement of air quality. Preliminary estimates show a potential, significant impact on air pollution: the development of cross-border railway infrastructure, together with other measures carried out in the TEN-T framework, will boost the reduction in GHG emissions by about 7 million tons between 2015 and 2030 (European Commission—DG for Mobility and Transport, 2017).

In the USA in 1980, rail freight transportation accounted for just 20% of intercity freight miles down from 70% in the 1930s. The 1980 Staggers Rail Act deregulated many aspects of rail infrastructure development and service provision, allowing much greater flexibility in price setting and service levels. A stable environment encouraged investment, and between 1982 and 2009 the rail industry invested \$510 billion in capital improvements. Technological standardization across the North American rail network played a crucial role in enabling long-haul freight transportation to be economical by rail. Since 1980, both the volume and productivity of US freight rail transportation have been steadily increasing (World Bank Group, 2019b).

While maintaining focus on improving national rail policy, governments must also recognize the importance of developing cross-border solutions if they are to develop

an environment in which more significant volumes of freight transportation can be carried out via rail. Key policy considerations should revolve around stimulating coordination, standardization, and transparency for investors.

4.4.3 High-Speed Train

An effective policy designed to promote a modal shift toward greener transport modes may not only rely on the widening of the existing infrastructure. In fact, the enhancement of the service quality must accompany projects concerning the rail network extension. With this respect, investments on high-speed rail play a major role.

As of today, high-speed lines are generally utilized for passenger trains. This is due to the fact that the related infrastructure mostly reaches city centers which are generally destinations for passenger but not freight transport. Nevertheless, due to the current e-commerce boom, the demand for express delivery of goods, and thus high-speed freight transport, is fast increasing.

As a consequence of these new trends, there has been a growing interest from governments to improve freight rail which resulted in investments in high-speed infrastructure. In this context, Italy has been acting as a frontrunner. In 2018, the first national high-speed railway service became operational (RailFreight.com, 2018a). Operated by Mercitalia—the freight arm of Italian State Railway—this line will connect the terminal of Maddaloni-Marcianise in Caserta, the natural logistic gateway to Southern Italy, with the Bologna Interport, one of the most important logistics hubs in Northern Italy in three hours and thirty minutes. The goods will travel on board a high-speed train at an average speed of 180 kmph. The ETR 500 train has a load capacity equivalent to 18 tractor-trailers. According to the Italian service operator, “Mercitalia fast” is the world’s first high-speed rail transport service for goods.

Although Mercitalia offers the first high-speed freight service in Italy, it is followed by another service planned to be launched in the same country (RailFreight.com, 2018b). In 2019, the Italian company Interporto Servizi Cargo (ISC) will offer a high-speed rail freight service between Florence and Bologna. Mercitalia and ISC will use the same high-speed railway line, but at different time slots.

Japan built its first high-speed rail link in 1964 connecting Tokyo to Osaka. Since then, Japan’s regional structure with large metropolitan centers located a few hundred miles apart and a high demand for travel has favored the development of high-speed rail. The rail network has been significantly expanded geographically with current top speeds reaching 188 mph (302 km/h). The network has evolved to serve both freight and passengers; however, the HSR service is dominated by passenger services (Abalate & Bel, 2012).

Meanwhile, China currently owns the world’s largest HSR system with more than 20,000 km of track in service. This network is also largely passenger dominated with HSR freight not as common. Surging demand for express delivery is slowly driving a shift. In 2013, China Railway Corporation implemented the first freight reform since

its establishment by adding HSR freight. In 2014, China Railway Express began to provide HSR freight service in more than 100 cities. In October 2016, China Railway High-speed express service was launched offering customers door-to-door small parcel express services. The main good delivered were parcels, medicines, and emergency goods. This growth in express delivery may drive future development in larger-scale freight transport (Gao, Jiang, & Larson, 2017).

HSR travel in China is however still primarily designed for passenger traffic. HSR freight service mainly uses the vacant space in high-speed passenger trains. The operation time, section, and schedule are constrained by passenger traffic. Moreover, HSR passenger stations do not have sufficient freight operation conditions such as warehouses and stacking areas. The conditions in China are thus ripe for a burgeoning future of HSR freight transport but this has not yet been fully realized (Ibid.).

An obvious lesson is that any developments in HSR have so far been aimed at passengers while freight has been largely neglected. Under certain circumstances, there may be significant gains to be realized from stimulating a shift into HSR freight transportation. In countries that have already invested heavily into passenger HSR, there are likely to be substantial cross-benefits from a strategy that focuses upon utilizing HSR for both passengers and freight. Countries who have not yet significantly invested should consider optimal policies for combining passenger and freight HSR.

4.5 Cleaner and More Efficient Freight Transport

4.5.1 *IMO Regulations to Reduce Sulfur Oxides Emissions from Ships*

Beside policies aiming to promote a modal shift in the freight transport, significant efforts must also be devoted to making goods shipment systems more sustainable.

In the framework of the International Maritime Organization (IMO), governments have agreed on a regulation to limit air pollutants emissions from ships significantly. Ships are responsible for Sulphur oxides (SO_x) emissions, which are produced when crude oil is combusted in their engine. SO_x is known to be harmful to human health, causing respiratory issues and lung diseases.

The rationale behind the recently adopted regulation consists in a ceiling imposed to the sulphur content in fuel oil. Currently, for ships operating outside designated emission control areas, the limit for sulphur content of ships' fuel oil is 3.50% m/m (mass by mass). By contrast, under the new IMO's regulation, we are going to witness a substantial cut: from 3.50 to 0.50% m/m. The new limit is going to apply from January 1, 2020 (International Maritime Organization). Moreover a stricter, already in force ceiling of 0.10% m/m applies to four emission control areas: the Baltic Sea area; the North Sea area; the North American area; and the US Caribbean Sea area.

4.5.2 Encouraging the Use of LNG as a Marine Fuel (E.g., Rotterdam)

Research shows that the use of LNG as a marine fuel to replace current oil-based fuels has a significant, positive impact in terms of reduction of greenhouse gas emissions (Port of Rotterdam). Supporting the employment of LNG would thus contribute to making maritime transport more sustainable.

To this end, port authorities could commit themselves to the following initiatives:

- Providing land for LNG bunkering terminals, the construction of quay walls, jetties, or other possible basic infrastructure for maritime access;
- Playing a proactive coordinating role in conducting feasibility studies on LNG bunkering in cooperation with various stakeholders (i.e., local government, competent authorities, private actors, etc.);
- Adopting incentive policies to attract investments;
- Setting a differential port tariff on ships fueled by LNG or other clean fuels.

The Port of Rotterdam is at the forefront with respect to these practices. In particular, it has established a strategic partnership both with private stakeholders and another port in the region (Gothenburg) to develop LNG infrastructure and the associated safety and technical standards. In December 2018, Cees Boon, Senior Policy Advisor at the Harbormaster Policy Department of the Port of Rotterdam declared that by 2020, nine licenses will have been granted to LNG bunker providers to operate at the port (International Association of Ports and Harbors). Moreover, the Dutch authorities have considered a ban on dirty shipping fuel: the upcoming regulations (Bloomberg, 2019a) will bar most ships from using high-sulfur fuel oil which is essentially a by-product for refineries, thereby boosting the demand for LNG.

Policies carried out by the Dutch Port over the last years have proved successful. In 2018, the sale of bunker oil in the Rotterdam bunker port fell from 9.9 to 9.5 million m³ (Safety4Sea, 2019). On the other hand, the throughput of LNG as bunker fuel increased considerably from 1500 to 9500 tons.

The government of South Korea has announced plans worth 2.48 billion USD to develop LNG bunkering facilities in the country (Maritime Executive, 2019). Singapore, as the world's largest bunkering hub, is also committed to the development of LNG as an alternate marine fuel. The Maritime and Port Authority (MPA) of Singapore is undertaking a variety of measures: co-funding of LNG vessels, waiving of craft dues of LNG-fueled craft, 10% port dues concessions for qualifying LNG vessels, and a pilot program testing the operational protocols of Singapore's LNG capabilities (Maritime and Port Authority of Singapore).

More particularly, the Singapore MPA will waive five years of craft dues for new LNG-fueled harbour crafts registering between Oct 1, 2017 and 31 Dec 31, 2019. An additional 10% of concessions in port dues will be granted to qualifying vessels that engage LNG-fueled harbor craft for their port operations. As of January 1, 2020, the sulfur content used aboard any ship docking in Singapore shall not exceed

0.50%/m therefore indirectly increasing the demand for LNG fuel (Maritime and Port Authority of Singapore, 2019).

In October 2016, a Memorandum of Understanding was signed between Antwerp, Japan, Norway, Rotterdam, Singapore, and a range of other LNG-supporting port areas with the goal of deepening LNG bunkering cooperation and information sharing and promoting the adoption of LNG as a marine fuel (Maritime and Port Authority of Singapore).

Regulations on sulfur emissions are therefore an attractive strategy to directly reduce the release of harmful pollutants and indirectly stimulate the use of cleaner alternatives. Such regulation will be most effective when countries work together under international organizations, such as the IMO.

4.5.3 Supporting Truck Automation

Like passenger transport, the road freight sector is undergoing a process of automation enabled by new digital technologies. Digitalization has already paved the way for systemic improvements in the freight transport, the introduction of Global Positioning System (GPS) being a glaring example. Yet, new generation technologies have the potential to transform shipment activities fully, leading to the deployment of completely digitalized “driverless” trucks, automatized, and operated remotely.

Although vehicle automation has predominantly been associated to the passenger sector, there are good chances for this technology to penetrate the freight segment too for two reasons. First, automatized trucks would entail a considerable, operational cost reduction, since driver-based expenses would fall. Second, implementing this new technology in trucks would be easier as trucks mostly travel on highways. In fact, highways constitute a relatively predictable and stable driving environment compared with urban areas.

A successful process of gradual automation of road transport requires actions to be implemented both at local and international level. Local authorities are responsible for the so-called systemic improvements which include inter alia effective road maintenance. Beside the systemic improvements, authorities should set up an efficient environment in which a huge amount of digital data and information can be exchanged. With this in mind, we refer to the Sect. 1.4 “Develop cross border corridors for connected and automated mobility,” which examines the EU’s effort to establish a collaborative network of cross-border corridors between its Member States. This effort aims at developing the 5G technology to ensure an adapt environment for data processing.

In the USA, truck platooning refers to the concept of automated trucks driving sequentially and due to information sharing able to drive closer to each other than would be possible with human drivers. Such truck platooning has the potential to reduce fuel consumption by up to 10% while improving safety. Truck platooning has been successfully demonstrated on test vehicles by several developers in the USA. Regulatory proceedings are seen as the most prohibitive factor to more widespread

technological roll-out. Some federal oversight is provided by organizations such as the National Highway Traffic Safety Administration (NHTSA) but a large proportion of relevant legislation is decided at the state level (New York Department of Transportation, 2018).

4.5.4 Modernizing Truck Regulation

The relationship between the gross vehicle weight of a truck and its fuel consumption is not one to one. An increase in a truck's size and payload leads to a smaller proportionate increase in fuel consumption. In other words, larger trucks with heavier payloads haul each unit of freight with less fuel than smaller trucks, all else remaining equal.

Several countries have restrictions on truck size and weight. These have been put in place mainly to limit wear and tear on roadways and bridges and to address safety concerns.

There is some momentum for revising constraints in favor of frameworks that permit so-called high-capacity vehicles without compromising infrastructure durability or safety. Political authorities could consider to introduce the so-called performance-based standards to replace current limits on vehicle weights and dimensions with design criteria that ensure that vehicles operate as desired on roadways. In particular, these standards do not impose restrictions based solely on the physical attributes of a vehicle, such as its weight and dimension; by contrast they introduce specific performance criteria in common operational settings.

Over the last decade, Australia has tested performance-based standards with the purpose to abandon the traditional truck regulation which hinges upon physical attributes like weight. The Australian standards mandate that vehicles are able to meet specific performance criteria, such as on low-speed support paths, gradeability, and rearward assistance (IEA, 2017b).

For countries adopting these kinds of standards, it is crucial to limit the risks of counterproductive, modal shift from rail to road transport. In fact, performance-based standards increase flexibility and reduce costs connected to goods shipment operated by trucks, which, as previously mentioned, largely contributes to CO₂ emissions. Given this risk, authorities should make sure that the introduction of standards designed on performance is accompanied by the adoption of measures promoting the switch from road to cleaner transport modes.

4.5.5 Promoting Alternative Fuels for Trucks

Efforts to make road freight transport cleaner include the switch to less polluting fuels. With respect to passenger cars, this switch has barely been applied due to the parallel, significant surge of electric vehicles. By contrast, truck electrification

proceeds at a slower pace as batteries required by this kind of vehicles are still costly and bulky. As electric trucks hardly gain market share, fossil fuels greener than petrol or diesel, such as natural gas, are considered as a promising solution to embark on a decarbonization (or at least carbon reducing) process.

Measures to promote a fuel switch involve taxation and investments on infrastructure. For example, some countries levy lower rates of duty on natural gas than on gasoline or diesel. In the UK, the fuel duty on compressed and liquid natural gas and biomethane is 50% below that on diesel (The Oxford Institute for Energy Studies, 2019, p. 10). Also, governments encourage investments on refueling stations through subsidies to operators. In Europe a number of companies have built facilities part-funded by the EU's "Connecting Europe Facility for Transport" program (European Commission, Innovation and Networks Executive Agency). Uniper is planning eight NGV refueling stations in Germany, three in Belgium and three in France; while, in 2018, Liquind 24/7 GmbH announced (LNG World News, 2018) it would be investing €16 million in ten LNG stations following a grant of over €3 million.

The growing economy of Shenzhen, China, has raised the prominence of environmental issues. In an attempt to promote alternative fuels for transport, Shenzhen has the largest number and the biggest terminals in China. Once all terminals have become fully operational, the supply capacity of LNG will exceed 11 million tons/year accounting for around 55% of the Guangdong province (Hu, Huang, Cai, & Chen, 2017).

4.5.6 Supporting Digitalization of Railways

The rapid development involving digital technologies can pave the way for digitalizing key services linked to rail transport, thereby improving the efficiency of freight transport operated by rail. In fact, digitalization enables operators to modernize freight information exchange, enhance online traffic monitoring and detect imminent defects or breakdowns to prevent accidents. Also, digital innovations offer new solutions such as smart infrastructure and automated train control systems, favoring train automation. Higher level of automation means that trains are increasingly driven by computers which optimize their speed and control the braking systems. As a consequence, line capacity will improve.

The digitalization of railways entails considerable benefits in terms of safety, punctuality, and energy consumption. In other words, it makes freight transport more efficient and environmentally sustainable at the same time.

In order to boost the process of rail digitalization, the European Commission included the digital agenda to its 2020 strategy (European Commission, Europe, 2020 Strategy). Furthermore, in 2015, it established the digital transport and logistic forum (European Commission, Digitalization of Transport and Logistics), a collaborative platform, where Member States, public entities, and organizations exchange knowledge and coordinate policies and technical recommendations for the European

Commission, in the fields of transport and logistics digitalization across all modes of transport. This group put forward proposals such as “encouraging the use and acceptance of e-freight information by state authorities and business operators in all transport modes, including rail, and to propose interoperable IT solutions to exchange this information” (European Parliament, 2019b, p. 4).

On the funding front, the EU legislator bodies are evaluating the 2021–2027 Digital Europe program (European Commission, 2018) in the multiannual financial framework. This program is meant to strengthen the EU’s high-performance computing and data processing capacities, reinforce core artificial intelligence capacities and expand the best use of digital technologies in key sectors such as transport.

Digitalization of railways should be a policy priority given the substantial and far-reaching benefits. Alongside environmental benefits there are also significant efficiency benefits to be exploited. Much funding for digitalization will still be allocated toward R&D; however, certain strategies, such as those relating to the exchange of information, can already be implemented in practice.

4.6 Transport Policies and Governance Levels

		City level	Country level	International level
Passenger Transport	Carpooling	X		
	Car sharing	X	X	
	Public transport promotion	X	X	
	Supporting connected and automated mobility		X	X
	Congestion charging	X		
	Parking management	X		
	Cycling and walking zones promotion	X		
	Multimodality	X		
	License plates limitation	X	X	
	Emission standards		X	X
Bans on diesel and petrol vehicle commercialization		X		

(continued)

(continued)

		City level	Country level	International level
	Public investments in clean vehicles R&D		X	X
	Public investments in clean vehicles infrastructure	X	X	
	Clean vehicles production quotas		X	
	Public procurement for clean vehicles		X	X
	Subsidies	X	X	
	Non-fiscal incentives	X	X	
	Bans on diesel and petrol vehicle circulation	X		
Freight Transport	Subsidies to freight transport on railways		X	X
	Support to high-speed train		X	X
	IMO regulation			X
	Promotion of alternative fuels	X	X	
	Truck regulation		X	
	Digitalization of railways			X

4.7 Taxation

Taxation plays an essential role when considering policies to decarbonize the transportation sector. Providing a comprehensive, global overview of taxes linked to the automotive industry is complex for two reasons. First, a large variety of heterogeneous taxes are levied on the motor vehicle segment. Direct taxation includes taxes on vehicle acquisition (VAT, sales tax, registration tax), ownership (annual circulation tax, road tax) and motoring (fuel tax). This is complemented by indirect taxation, of which parking fees are an example.

Secondly, tax systems vary considerably from country to country. In fact, some national governments prefer to levy all the types of taxes on vehicle acquisition while adopting only few on ownership. By contrast, some others put greater emphasis on

taxes on vehicles ownership. Certain others have significantly increased fuel taxes and, at the same time abolished some of those on vehicle ownership. Furthermore, governments can adopt the same tax, but charge different rates or complement it with other fiscal measures. For example, Germany applies VAT at 19% on the sales of new vehicles while Greece at 24%; Italy, instead, applies a 22% VAT but has introduced a bonus/malus scheme based on CO₂ emissions. Besides the levels of CO₂ emissions, other criteria contribute to differentiating rates at which taxes on motor vehicles are applied: engine's attributes (such as size, power or age), cylinder capacity, fuel type, and vehicle's attribute (weight, age, or number of axles). In sum, the tax framework is strictly dependent on national politics.

In this section, fuel taxation is first explored through cross-country comparison on the magnitude of excise taxes. Cross-country comparisons of vehicle acquisition and ownership taxes are harder to compare cross-country but insights into the EU, USA, and Chinese taxation systems are offered.

4.7.1 Fuel Taxation

The OECD has carried out some cross-country analysis with regards to fuel taxation. Figure 4.1 shows the average effective road energy tax on both diesel and gasoline. There is an apparent and significant heterogeneity between countries. The data presented are the average effective fuel taxes for both diesel and gasoline for road use by country. Significant differences in the pricing of diesel and gasoline are highlighted.

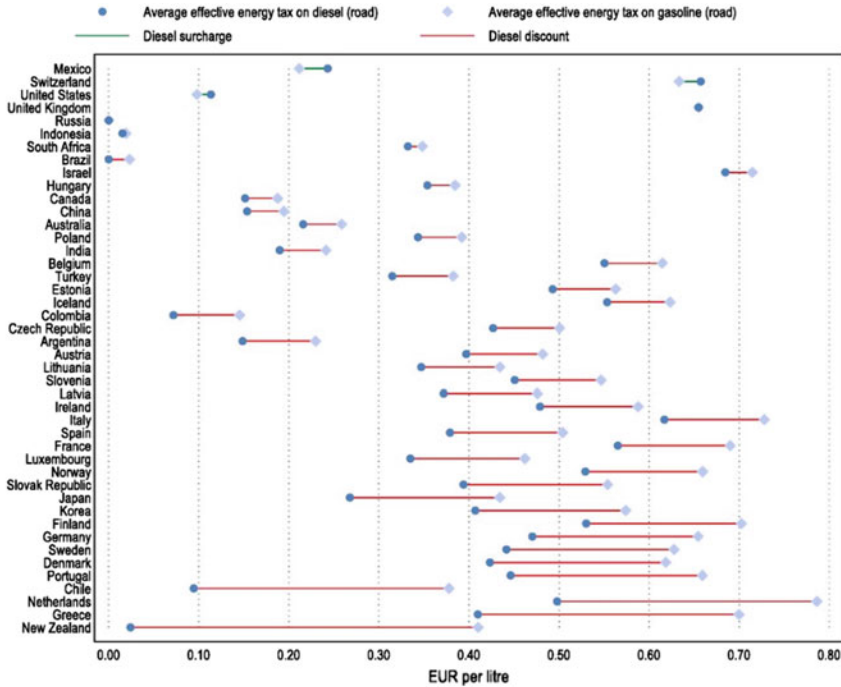
4.7.2 Acquisition and Ownership Taxation

EU Taxation

The European Automobile Manufacturers' Association (ACEA) published its annual Tax Guide which presents an overview of the specific taxation on motor vehicles in Europe. The Guide (ACEA Tax Guide, 2019) provides a summary of the taxes on acquisition and ownership of motor vehicles in all EU Member States.

Taxes on acquisition within Europe comprise of a VAT paid on initial purchase as well as a registration tax. The lowest VAT rate is 18% in Malta, while the highest is 27% in Hungary. Croatia, Denmark, and Sweden also have a notably high VAT rate at 25%.

Registration taxes across Europe vary significantly in terms of how they are computed. Typical variables used are CO₂ emissions, cylinder capacity, vehicle purchase price, and other emissions standards. For example, CO₂ emissions are used to compute payments in Austria, Belgium, Croatia, France, and Portugal among others. Cylinder capacity is taken into account for Belgium, Cyprus, Hungary, Poland, and



Note: Average tax rates are calculated based on the tax rates applicable on 1 July 2018 and energy use data for 2016 that was adapted from IEA (2018^[1]), *World Energy Statistics and Balances*. New Zealand is a special case because diesel vehicles pay distance-based road-user charges, which are not included in TEU because they affect different behavioural margins than energy taxes.

Fig. 4.1 Global overview of fuel excise taxes (OECD). Source OECD (2019)

Portugal. The purchase price or value is considered by Croatia, Denmark, Finland, Greece, Ireland, and Malta among others.

The UK imposes a flat 55 GBP registration fee for all types while Sweden is the only EU country without a registration tax. In France, the registration tax varies by region and includes an additional CO₂ component. In Germany registration fees are 26.3 EUR. In Italy, the registration fee is based on vehicle type and horsepower, as well as CO₂ emissions. In Spain, registration fee is based on CO₂ emissions.

Taxes on ownership differ for passenger cars and commercial vehicles. For passenger cars, engine power and CO₂ emissions are two commonly used metrics. For commercial vehicles, gross vehicle weight and number of axles are two commonly used metrics (i.e., the size of the vehicle is the important factor in determining tax).

Engine power determines part or all of the passenger cars ownership tax in Austria, Bulgaria, Croatia, Czech Republic, and Hungary. CO₂ emissions are considered in Cyprus, Finland, Greece, Ireland, Luxembourg, and Malta among others. In France, the fiscal power and CO₂ emissions are considered. In Italy, power, emissions and fuel type are all important. Estonia, Lithuania, Poland, and Slovenia have no ownership taxes on passenger cars.

Gross vehicle weight is used in calculating commercial vehicles ownership tax for Czech Republic, Estonia, Finland, Italy, Lithuania, the Netherlands, and Poland.

For Germany, as well as weight and pollution, noise category is also taken into account. In Luxembourg, the suspension type is a component in price setting alongside weight and axles. The UK considers dead weight and environmental characteristics. Spain considers only payload in determining tax. Slovenia has no ownership tax on commercial vehicles.

China Taxation

Taxation in China can be grouped into two primary categories:

- Taxes to be paid by the vehicle manufacturer
- Taxes to be paid by the vehicle owner

Zongwei, Yue, Han, and Fuquan (2017) provide an overview of the general structure of China's taxation system as it is applied to automobiles, detailing which taxes are due at which stage of a motor vehicle's life cycle and whom they must be paid to.

Unlike within the EU, VAT is charged throughout the production life cycle of the motor vehicle rather than simply at point of sale. The first phase of VAT is therefore paid by manufacturers and indirectly passed through to consumers.

There are four phases of taxation in the Chinese system: producing, purchasing, retaining, and using. A variety of taxes are paid by automakers in the producing phase. These include a circulation tax which varies between 1 and 40% depending on engine. VAT is paid, split between central and local governments. Surtaxes are levied on urban maintenance and construction and education. An estate property tax and city and town land use tax must also be paid.

The rest of the taxes for stages purchasing, retaining, and using are all paid directly by consumers. Consumers pay a 10% tax of the vehicle price when purchasing to the central government. Local government's then charge VVT which is a local tax varying by engine displacement and applied for the retaining of an automobile.

The final stage of taxation comes from using an automobile. Circulation taxes are paid on both gasoline and diesel. These are approximately \$0.25/L for gasoline and \$0.2/L for diesel. VAT, UMCS, and ES are all paid to the central government. UMCS and ES are surtaxes of VAT on refined oil.

USA Taxation

In the USA, most vehicle taxes are imposed at the state rather than federal level. One exception is the "gas guzzler tax." This tax was established through the Energy Tax Act of 1978 and applies to the sale of new vehicles whose fuel economy fails to meet certain statutory requirements. Its purpose is to discourage the purchase of fuel-inefficient vehicles.

The tax code has also recently been utilized to promote the purchase of electric vehicles and plug-in hybrid vehicles through providing tax credits to purchasers.

Such vehicles purchased in or after 2010 may be eligible for a federal income tax credit. The minimum credit amount is \$2500 rising to \$7500 depending on traction battery capacity and the gross vehicle weight rating.

The credit is applied until the manufacturer has produced 200,000 eligible vehicles counted from January 1, 2010. The IRS announces when a manufacturer exceeds this production figure and will announce the phase out schedule (for the tax credit). As of October 2019, tax credits have been phased out for both Tesla and General Motors.

Most US states impose a sales tax on vehicle purchases. This is a tax on consumption, displayed as a percentage of the sale price. All US states impose vehicle registration fees. These fees are imposed on all vehicles regardless of age and are generally collected annually (ACEA Tax Guide, 2019).

4.8 Risks Linked to Digitalization

Digitalization plays a key role in several of the policies examined. On the one hand, modern digital technologies enhance public transport efficiency, make carpooling and car sharing services more accessible to users, support multimodality and pave the way for smart cities and grids which, in turn, represent the essential prerequisite for automated and interconnected vehicles. On the other hand, increasing levels of digitalization, which we notice *inter alia* in the spread of the so called Internet of things² (IoT), entail potential risks in terms of security.

As digitalization growingly pervades our everyday life, potential targets of cyber-attacks evolve and become more numerous. Cyber-attacks have predominantly targeted IT systems operating in computers and smartphones. Yet, as our everyday objects are increasingly connected to digital networks, they become vulnerable to intrusions from hackers.

This threat involves all sectors, including transport. As one possibility, one could imagine the consequences deriving from a cyber-attack targeting a software which regulates automated cars and trucks. Hackers could stop vehicles' circulation or, in worse cases, trigger accidents.

Aside from security risks, digitalization presents privacy concerns. Privacy issues arise because the functioning of digital technology requires large amounts of personal data. For example, every time we buy bus tickets online, book a car sharing trip or use bike sharing services we provide operators with personal data. We share our starting point and our destination. Also, in the case we carry out the same trip regularly, we share important information regarding our daily routine (where we live, places that we and our relatives frequent, time at which we move, routes we follow). Such data could be used for commercial data mining. That is, customers might be exposed to intrusive targeted marketing techniques or even criminal activities.

²With this expression we refer to the situation “where everyday objects are connected to networks to provide a range of services or applications in areas such as cars, home automation and smart grids.” IEA (2017a).

It is highly likely that automated and interconnected vehicles will require even more detailed personal data. Therefore, the privacy-linked concerns are set to rise in the future.

Authorities have stepped up efforts to address challenges posed by digitalization. In order to face the cyber security issues, the EU adopted the Network Information Security Directive (Directive (EU) 2016/1148) in 2016, requiring Member States to develop a national strategy. This directive established a co-operation group to facilitate strategic cooperation between the Member States regarding the security of network and information systems. As regards privacy, a new regulation, GDPR (Regulation (EU) 2016/679) was drafted to protect personal data. The GDPR states that “consent should be given by a clear affirmative act establishing a freely given, specific, informed and unambiguous indication of the data subject’s agreement to the processing of personal data.” Moreover, it sets rules regarding data breach notifications.

4.9 Distributional Effects of Policies

This final section sheds light on the potential distributional effects deriving from policies to foster the decarbonization of the transportation sector. Specifically, it discusses the social risks linked to fiscal measures pursued to discourage the use of conventional internal combustion engine vehicles as well as potential solutions. Such measures include the introduction of a carbon (or fuel) tax and the reduction of fossil fuel subsidies.

Although environmentally friendly, these measures, as any other fiscal measure, entail wealth distribution which, in turn, may result in social protests. Carbon pricing and similar fiscal initiatives particularly involve major hazards, as they have serious repercussions on a large part of the population, including low-income classes. The case of France will help identify key aspects of this issue.

The French carbon tax was introduced in 2014 at a rate of €7/tCO_{2e}.³ Within four years, it rose sixfold, thus reaching the rate of €44.6/tCO_{2e}. Spurred by the necessity to comply with the Paris agreement requirements, as well as the desire to step up efforts toward an effective ecological transition, the French government proposed a further reform in 2018. The new carbon tax was set on a rising price trajectory toward €86.2/tCO₂ in 2022 and accompanied by an increase in fuel prices.

This proposal soon triggered serious social turmoil. Strongly opposing these measures, the “yellow vests” movement spontaneously emerged and spread throughout the country. Demonstrations were not only motivated by direct and indirect increase in fuel prices, but also (and mainly) by a perceived discrimination. In the yellow vests’ opinion, higher fuel costs predominantly affect workers from the countryside. In fact, these people massively consume fuel because, on average, they drive

³Unless otherwise stated, all data related to France carbon tax refer to World Bank Group, State and Trends of Carbon Pricing (2019c).

longer distances than workers in cities. Beside the geographical (countryside-city) discrimination, this proposal gave rise to lower-income people's concerns, as they cannot necessarily afford modern, cleaner vehicles. Their concern is that they will have to carry the tax burden alone, since wealthier people gradually shift toward new generation, lower CO₂ emitting cars.

As a consequence of large scale protests, the French government decided to modify (and partially withdraw) its plan: the tax rate in 2019 will remain at the 2018 rate of €44.6/tCO₂. As the yellow vests' riot is still continuing at the time of writing despite nation-wide consultations, a new attempt to increase the carbon tax in the near-term is highly unlikely.

Aside from the French case, there are examples where governments successfully introduced plans to support an ecological transition without neglecting dangerous social implications. Carbon pricing or reforms to reduce fossil fuel subsidies were implemented together with cash transfers (or other similar measures) to most vulnerable social classes with the purpose to mitigate inequalities. Such combined plans were able to bring benefits on two different fronts.

In 2008, British Columbia, Canada unilaterally introduced a broad-based carbon tax applying to carbon emitted from the combustion of all greenhouse gases, with few exemptions granted. The tax began at 10 Canadian Dollars (CAD)/tCO₂ and rose to 30 CAD/tCO₂ by 2012. The tax was implemented in a revenue neutral manner with measures designed to ensure equitable effects. Revenue from the tax was used to reduce the bottom two personal income tax rates and the low-income climate refundable tax credit was introduced returning annually up to \$100 per adult and \$30 per child. Furthermore, all residents received a one-time \$100 dividend aimed at contributing toward lifestyle restructuring away from carbon emitting sources (British Columbia, 2008). The combination of these measures ensured the political survival of the tax through attempts to alleviate some of the worst distributional consequences.

Recently, Jordan and Iran have embarked on a process to lower fossil fuel subsidies while, in parallel, developing benefit programs to counter poverty effects. In 2012, the government of Jordan "used various social safety net measures to protect vulnerable groups, including cash transfers to low-income households, a targeted food subsidy program, and increasing the public sector wages for lower income households" (World Bank Group, 2019c, p. 78). Similarly, "Iran implemented electronic cash transfers that accounted for 50% of projected savings from fossil fuel subsidies reforms" (Ibid.).

In sum, the experiences in France, British Columbia, Jordan, and Iran show two essential aspects related to the topic of this chapter. First, fiscal policies to foster decarbonisation are likely to bring about distributional effects. Given the nature of the policies, these distributional effects tend to disadvantage lower-income classes. Second, measures increasing carbon or fossil fuel prices do not necessarily imply growing inequality. If complementary fiscal programs are implemented, two key aims can be achieved at the same time, thereby benefiting both environment and population.

4.10 Conclusions and Key Take-Aways

This chapter has looked to offer a broad overview of the policies available to ensure effective decarbonization of transport sectors. There are a wide range of policies that can be implemented. Individual countries will have particular and specific advantages/disadvantages with regards to the implementation of each individual measure. There is therefore no perfect policy combination for ensuring effective decarbonization of the transport sector but the aforementioned policies are the key areas in which countries have tried, are trying, and must continue to try to invoke positive climatic change.

One common theme emerging from the chapter is of the wide range of positive externalities associated with decarbonization policies. These policies primarily have an impact on reducing carbon emissions however so many are found to impact society in a multitude of other positive ways. For instance, measures aimed at a reduction of road transport demand lead to cleaner cities in terms of air pollution, while developments in automated technologies lead to wide-ranging efficiency benefits. Meanwhile, measures such as the digitalization of railways and promotion of multimodality not only reduce carbon demand but can ensure a smoother and more enjoyable transit experience for passengers.

In terms of precise policy implementation, there is no one-size-fits-all strategy. In order to implement successful decarbonization policy mixes, this chapter has shown that policymakers must pursue a range of subsidies, fines, regulatory measures and standards, bans, R&D investments, management strategies as well as cross-border cooperation.

One area stands out in which governments should look to adopt an effective policy mix. Certain policies are aimed at directly reducing the occurrence of polluting activity, e.g., emission regulations and city- or country-level bans. These policies, by design, will be effective. However, governments should be careful at the same time to pursue policies that will provide alternatives for citizens to switch too once the status quo is banned. R&D and subsidies for promising but not yet developed technologies should be followed in order to develop zero emissions technologies. Meanwhile, the provision of infrastructure, such as ZEVs charging networks, is pivotal in order to encourage private investment to follow. There is a careful balance to be struck between forcing citizens to change behavior and at the same time providing suitable alternatives.

At the same time, measures to promote and inform the general public of the benefits of action are fundamentally important. Government policies should be transparent, for example, information campaigns can explain how any revenue accruing is to be used such that decarbonization policies do not become confused with governments simply trying to raise revenues.

Beyond promoting awareness of the benefits of climate policy, it is of paramount importance to recognize and confront the potential realities of significant socioeconomic consequences. Whether it is measures to subsidize new technologies, accessible mainly by higher-income classes (e.g., EVs) or taxes on fuel consumption (where the incidence is often largest on lower-income classes) such policy measures

are often regressive. In order to combat regressive effects and ensure broad population participation and enjoyment of the energy transition within the transport sector, governments must consider this issue of the utmost importance. Distribution of revenues in a progressive manner is a good start, but furthermore governments must look to assess the regressive impacts of individual policies and factor these into any decision-making process.

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