THE ASSESSMENT OF ALTERNATIVE FUELS INFRASTRUCTURE IN THE DANUBE REGION AND THE DEVELOPMENT PATHWAY TO INTEROPERABILITY

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INTRODUCTION

Alternative fuels relate to the three major challenges in the transport sector: excessive greenhouse gas emissions, energy security considerations of the fuels, and traffic congestion management. Some alternative fuel technologies are already economically competitive and commonly used; therefore, supporting them so as to be able to overcome the above stated challenges is not justified.

Most importantly though, alternative fuel technologies in passenger vehicles, in some aspects of public transportation and almost in the entire freight transport sector are not commonly available and they are hindered by obstacles that are either real or perceived. First, alternative fuel vehicles (AFVs) generally cost more than vehicles equipped with gasoline or diesel engine, but the actual cost difference is further aggravated by generally held cost perceptions: technological conservatism, the lack of knowledge and first-hand experience with the new technologies characterise many consumers. As a result of these perceptions, the investment of purchasing AFVs are seen as more risky, thereby decreasing the attractiveness of these technologies. This issue highlights the difficulty of decarbonising the transport sector as not only technological advancements need to take place, but a socio-technical transition towards low-carbon technologies need to happen.

SUPPORT MEASURES FOR ALTERNATIVE FUELLED VEHICLES
There exists a three level hierarchy through which support measures are most effective:

LEVEL 1: measures that decrease the fixed cost of purchasing alternative fuelled vehicles. These could come in the form of direct subsidies or tax breaks that decrease the purchase price and generally fall into national jurisdiction.

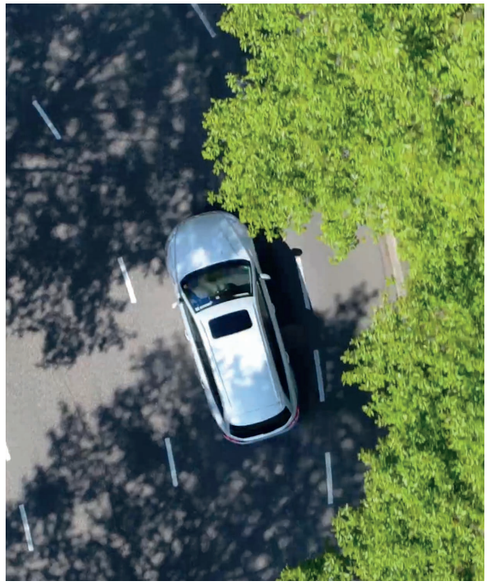
LEVEL 2: removal of the infrastructural bottlenecks that disable the circulation of alternatively-fuelled vehicles. Measures in this area should be internationally coordinated, and could come in the form of tax breaks for the installation of charging or filling stations, direct subsidies by financing the installation of the elements of the infrastructure, or even the reduction of the operating costs of the infrastructure elements.

LEVEL 3: measures that allow the users of AFVs to incur further benefits through the usage of their vehicles (level 3). These could come in the form of reducing the costs of the fuels, allowing AFVs to access restricted areas for general traffic or discounted parking rates, and therefore should also fall into national jurisdiction.

CONTEXT OF REGIONAL GREEN CONNECTIVITY

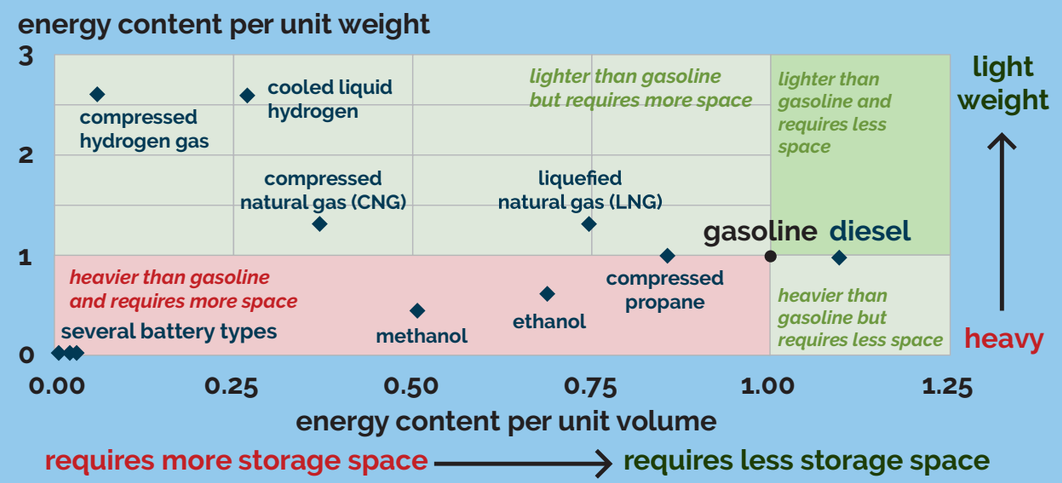
The Danube Region connects countries that are not only highly heterogeneous in terms of their economic performance, the Region consists of countries with ultimately different transportation sectors. Clean connectivity and interoperability in the region thus means connecting countries with highly diverging characteristics in passenger and freight transport. In Austria for instance, almost 80% of the passenger kilometres travelled have been completed by passenger cars, but in the case of Moldova and Ukraine the share just exceeds 40%. In these latter countries the prominence of railway and other forms of public transportation is much bigger, an increasing trend that is observable as moving West to East within the region.

Even if there is little difference between the modal split of passenger transportation, such as in the case of Hungary and Austria, the characteristics of the passenger vehicle stock can be markedly different. Austria is characterised by a renewing passenger vehicle fleet, where 37.4% of the cars were younger than 6 years, whereas in Hungary this figure was only 11.1% in 2015. This divergence even among neighbouring countries suggests that the way in which the alternative fuels market will unfold in each respective country of the Danube Region will indeed be rather different, both timing and technology wise. Therefore, interoperability to be achieved at the regional level will require some level of cooperation and coordination, to overcome these differences.



Realistically, the Danube Region has two options with regards to alternative fuels, electric mobility and natural gas. First generation liquid biofuels only provide for a short term solution, without any kind of beneficial technological lock in effect that could ensure long term emission reduction, and wide-scale support for these fuels will likely be withdrawn post 2020 in the EU. Hydrogen, on the other hand, provides for a true alternative and with the potential of being virtually carbon-free in many subsectors of transportation; however, many EU countries do not seem to be committed as of yet to develop hydrogen supply chains on a large scale. Thus, in giving overall recommendations at the regional scale, the report only considers electricity and natural gas as alternative fuels.

FIGURE 1: ENERGY DENSITY COMPARISON OF SEVERAL TRANSPORTATION FUELS (INDEXED TO GASOLINE =1)[1]



[1] *U.S. Energy Information Administration. 2013. Few transportation fuels surpass the energy densities of gasoline and diesel.*

TABLE 1: APPLICATION POTENTIAL OF ALTERNATIVE FUELS ACROSS THE MULTIPLE VEHICLE CATEGORIES

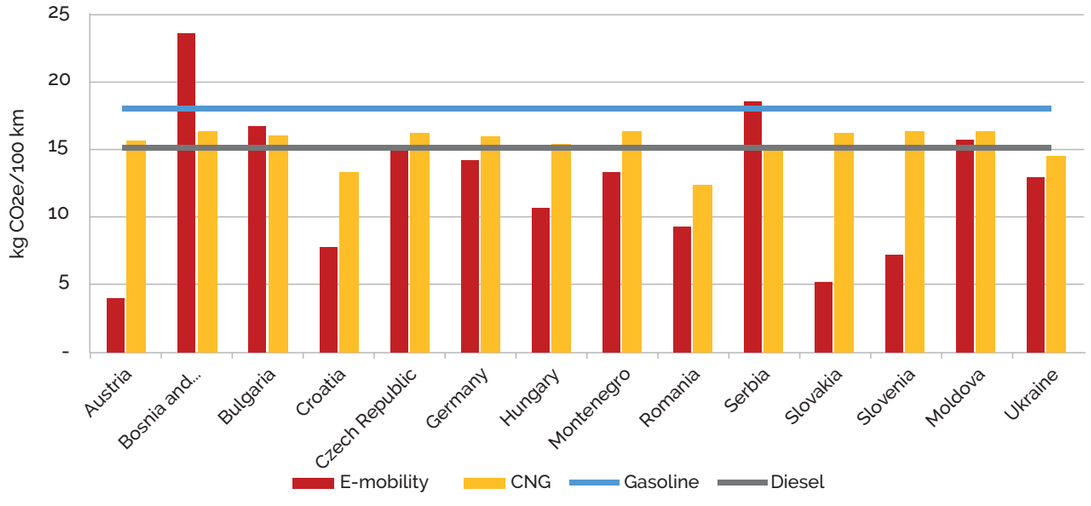
Vehicle category	1st gen liquid biofuels	Plug-in hybrid vehicles	Battery electric vehicles	CNG	LNG	Hydrogen	Sum
M1	5	5	4	5	1	5	25
M2	5	1	4	5	1	3	19
M3	5	1	3	4	4	3	17
N1	5	4	4	5	1	4	24
N2	5	1	2	4	4	3	19
N3	5	1	1	3	5	3	18
Sum	30	13	18	26	17	21	

PROSPECTS FOR INTEROPERABILITY AT THE REGIONAL LEVEL

There are environmental, economic and business environment considerations that influence how cooperation in alternative fuel technologies should unfold in the Region. From an environmental perspective, the most important consideration is that the well-to-wheel emission intensity of the alternative fuels differ greatly across the countries. Considering an average passenger car and its real-life fuel consumption suggests that e-mobility is superior to the generally less carbon-intensive diesel fuel in 9 of the 14 countries within the region. In 3 instances e-mobility provides inferior climate performance compared to diesel and in 2 instances even gasoline provides for lower emission levels than electricity.

Electricity proves to be of inferior climate performance if the electricity mix of the country is dominated by fossil fuels, especially coal. CNG (compressed natural gas) is superior to gasoline in all instances; however, the carbon dioxide savings are questionable relative to diesel, though they are advantageous in respect of their lower particulate matter and nitrogen oxide emissions. Countries that lack natural gas production (Slovenia, Moldova, Bosnia and Herzegovina) perform worse in CNG's climate competitiveness; therefore, the inferior carbon dioxide emissions also couple with a greater level of energy insecurity within these countries. Overall, the wide scale usage of electric passenger vehicles provides for the lowest carbon emissions in the Region in this transport segment.

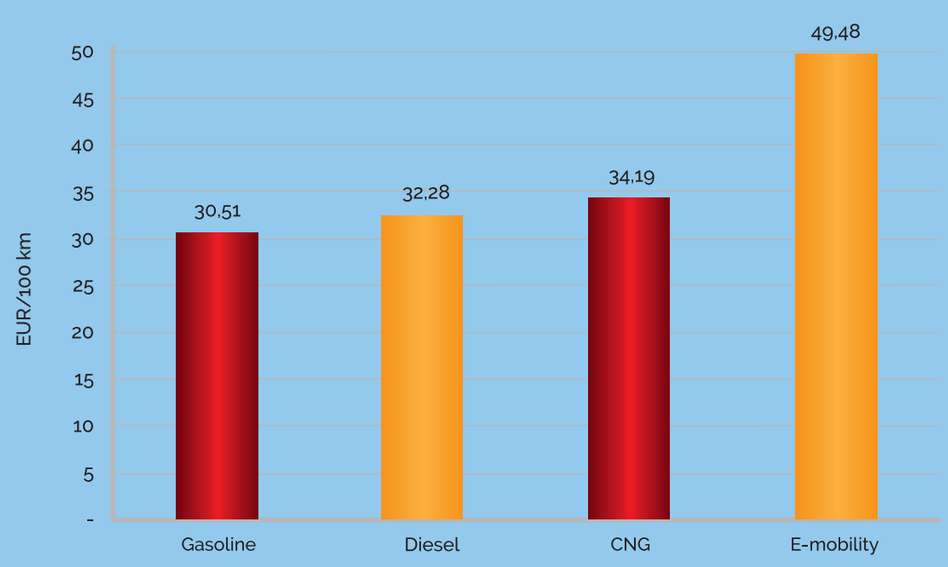
FIGURE 2: WELL-TO-WHEEL EMISSIONS OF FUELS IN DANUBE REGION COUNTRIES [2]



[2] *Source: Eurostat, ENTSO-E, European Commission*

The market development potential of AFVs in the region also depends on the economic competitiveness of the fuels. Gasoline vehicles are the most cost efficient per 100 km, considering the fixed costs of purchasing the vehicle as well and diesel vehicles follow closely. On the other hand, in some countries CNG competes effectively with diesel, having lower overall costs in the Czech Republic and Germany, as a result of the beneficial excise duty rates applied in these two countries. The cost of e-mobility however is far greater compared to all other drivetrains considering the parameters of the analysis, even though e-mobility enjoys subsidies in many countries of the region that reduce the higher fixed costs of purchasing electric vehicles. Despite studies that point to the fact that the cost advantage or disadvantage of alternative fuels is not currently a decisive factor in purchasing such vehicles, many countries in the Danube Region are indeed price sensitive when it comes to transportation, exemplified by the size of the import second hand vehicles market compared to new vehicle purchases.

FIGURE 3: COST OF PURCHASING AND OPERATING AN AVERAGE M1 CATEGORY PASSENGER CAR IN THE DANUBE REGION STATES GIVEN CURRENT FUEL COSTS [3]



[3] *European Oil Bulletin, Eurostat and CNG retailers*

To promote alternative mobility at the regional level, the current business environment will need to change, and the differences in the availability of AFVs must be reduced.
Considering one of the most popular M1 category vehicle (VW Golf) that can be equipped with electronic, CNG, gasoline and diesel drivetrains as well, in 2 countries the model is not at all supplied, in 8 countries the CNG version is not available while in 5 countries the electric model cannot be purchased, with similar marketing trends in the case of other manufacturers and models. This trend exemplifies car manufacturers' commitment towards e-mobility, which is partially fuelled by the support policies of countries that almost exclusively favour electric mobility.

Overall, therefore, from an environmental perspective e-mobility performs better than natural gas as an alternative transport fuel in the passenger car sector at the Danube Region level. In terms of the economic aspect, CNG may approach the costs of gasoline and diesel vehicles in some countries, but it is generally more expensive, while e-mobility is currently significantly more costly to consumers despite the available support measures and subsidies, thereby also calling for more supportive measures. The current business environment is more favourable to electric mobility, as the majority of the car manufacturers see the future of mobility in electric vehicles, which is also reflected in the propulsion technologies of the AFVs offered for sale in the Danube Region - a market dominated by electric and hybrid vehicles.

While the emphasis in passenger transportation should be placed on e-mobility because of its overall climate benefits, the report argues that both LNG (liquefied natural gas) and CNG have their role to play in the future of the Danube Region transport sector. CNG is already a popular fuel in many non-EU member states, it is therefore expected that the commodity will continue to play an important role in the transport sector. In the long term however, the report proposes that CNG should mainly be used in the public transportation sector, an application area in which the fuel is already highly competitive, contributing with its lower NOx and PM emissions to the lower pollution levels in urban areas. LNG, on the other hand, is the only viable alternative in the freight transport sector; however, its environmental performance should be evaluated considering the significant changes in recent years in the global market of the commodity.

SUGGESTED EVOLUTION OF TRANSPORT POLICIES TARGETING ALTERNATIVE FUELS IN THE DANUBE REGION

FIGURE ES1: TEN-T NETWORKS IN THE WESTERN BALKANS

Developing alternative fuel technologies and vehicles are meaningless without an appropriate filling and recharging infrastructure that allows for these vehicles to circulate without significant limitations in their performance and mileage.

It is the network of these individual infrastructure elements that create the basis for interoperability across cities and countries.

The question of interoperability is a key aspect of European transport policy and it is through the TEN-T (Trans-European Transport Network) core and comprehensive networks that the EU wishes to enhance and allow for the seamless connection of its member states. In recent years though, the TEN-T networks have been indicatively extended into third countries as well (Figure ES1), recognising that through the increased mobility of employees, tourism and road haulage the EU and neighbouring countries together form a transport system. Thus, the core TEN-T network now indicatively penetrates Serbia, while the comprehensive network connects Bosnia and Herzegovina, Montenegro, Moldova and Ukraine to the core European transport routes. In the past, interoperability was preoccupied with physically connecting countries; however, the need to decarbonise the transport sector will require that the TEN-T routes are equipped with alternative fuels infrastructure in the spirit of interoperability.

The question of interoperability with AFVs in the Danube Region is effectively a question of how to integrate non-EU countries to the alternative transport infrastructure that will develop on the back of the 2014/94/EU Directive in EU countries until 2025. Of the options available to the international policy arena to promote interoperability and the usage of AFVs, it is level 2 policies coordinated at the Danube Region level that are the most appropriate to remove infrastructural bottlenecks in the region. Due to the economic reality though, it is likely and already evident that EU countries will be the flagbearers for shifting towards more sustainable transport practices. It therefore should not be expected that non-EU countries develop their own infrastructure, international assistance is required in the area.

Considering the present legal framework that govern the TEN-T network, there are two obstacles that stand in the way of international efforts to remove infrastructural bottlenecks of alternative fuels in the Danube Region. First of all, the present regulation by no means requires that the comprehensive network is equipped with alternative fuel charging or refuelling infrastructure, but the non-EU Danube Region states are mainly penetrated by the comprehensive network. Most importantly however, projects that seek the development of sustainable transport practices in third countries are not yet eligible for funding from the EU, the Union may cooperate - giving non-financial assistance - only to promote the interoperability between the trans-European transport network and networks of third countries. As a result, the current legislation leaves little room to provide for EU-financed projects that aim to develop the alternative fuel infrastructure in third countries. These regulations will need to be amended if interoperability of AFVs is to be achieved at the regional level.

To identify routes that are crucial to be equipped with alternative fuels infrastructure, we propose to not only indicatively extend the TEN-T core network, but these indicative segments should become a firm part of the TEN-T network and thus be equipped with the required electric charging and potentially LNG infrastructure. For Ukraine and Moldova, where the most important road networks are indicatively part of the comprehensive TEN-T network, we propose that at least the capitals of these countries should be accessed via roads that are equipped with electric chargers (routes highlighted in yellow in Figure ES2). Reaching Kiev from the Slovakian and Hungarian border requires 10-12 100 kW fast chargers within Ukraine, while to reach Chisinau 2-3 100 kW fast chargers are required in Moldova, if the route connects onto the Sebes-Iasi core network in Romania. Given the current share of transiting freight through Ukraine and Moldova, the development of the LNG infrastructure is at present not a priority and the servicing of the SSLNG infrastructure in these countries would also be too costly given the distance from current sources of LNG.

FIGURE ES2: INDICATIVE MAP OF THE COMPREHENSIVE TEN-T NETWORK EXTENDED INTO UKRAINE AND MOLDOVA

In the case of Serbia, the requirement is to have at least 12-15 100 kW fast charging points along the core and comprehensive parts of the TEN-T network. To allow for the transiting freight transport the report proposes to have at least 2 LNG filling stations deployed in Serbia, in the vicinity of Belgrade and Nis. These Serbian LNG stations could serve as key infrastructure elements in the extension of the Blue LNG corridors through Hungary, Slovakia, Austria, the Czech Republic to reach Germany and therein connect onto the already existing WE Blue, SoNor and Med-Blue Corridors (Figure ES3). We estimate that with the installation of 8 additional LNG stations in these countries, a SE-NW LNG corridor can be established, connecting Turkey to Germany.

In Bosnia and Herzegovina, the requirement is to have at least 7-10 fast chargers. With these electric charging infrastructure developments in mind, it also should be remembered that while the interoperability with electric transport in both Serbia and Bosnia Herzegovina may be accomplished, but at the expense of higher carbon emissions, given the generation mix of the two countries at present. Finally, the report proposes that 5-7 fast charging points in Montenegro is adequate to reach interoperability with electric vehicles. The amount of freight transiting through Montenegro and Bosnia and Herzegovina does not justify the installation of an LNG filling station at present.

Based on market information and the projects that so far have received funding under the Connecting Europe Facility, it is estimated that the installation cost of a 100 kW fast electric charger is EUR 50,000, while the deployment of an LNG filling station can be accomplished from EUR 1,000,000 at most. With regards the timing of the proposed developments, it is suggested that funds are earmarked in the next EU budgeting cycle (2021-2027) that specifically target the development of the alternative fuels infrastructure in the Danube Region countries. We estimate that to install the minimum infrastructure needed for the interoperability of electric and LNG powered vehicles within the Danube Region would cost EUR 10,350,000 (Table ES1). We also propose that these developments in neighbouring countries should take place by 2025 so that non-EU states will not lag behind alternative transport development, thereby also allowing the growing alternative fleet of EU countries to circulate in an ever larger part of Europe.

FIGURE ES3: PROPOSED LNG BLUE CORRIDORS WITHIN THE DANUBE REGION

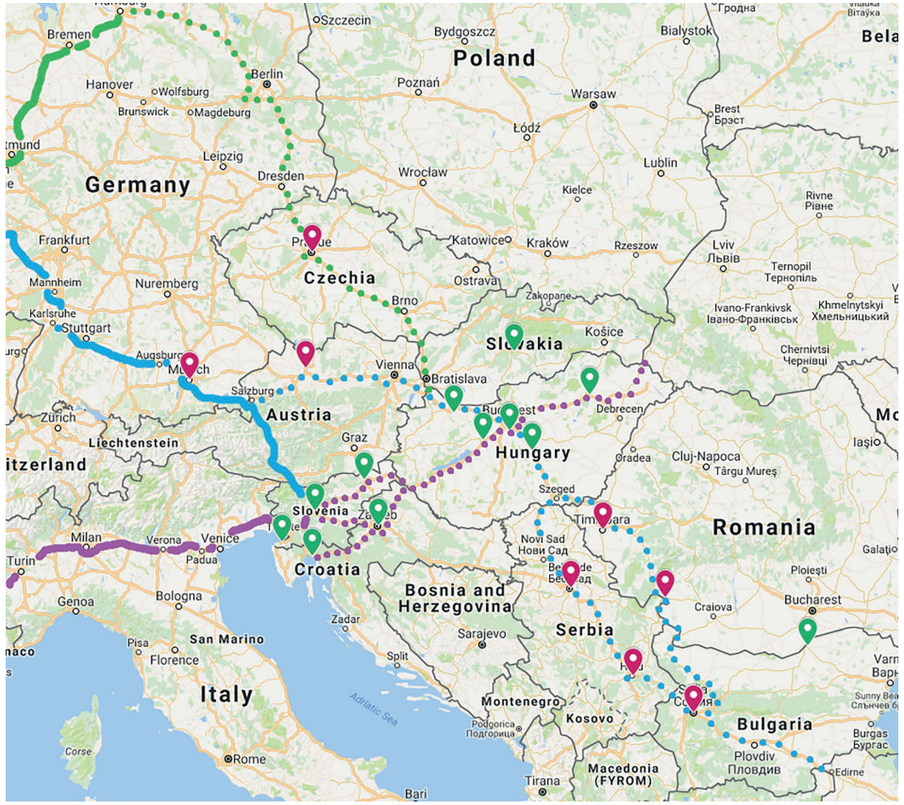


TABLE ES1:
PROPOSED INFRASTRUCTURE DEVELOPMENTS TO ACHIEVE INTEROPERABILITY OF ELECTRIC AND NATURAL GAS VEHICLES IN THE DANUBE REGION

	No. of electric charging points	No. of LNG filling stations	Cost of electrification	Cost of gasification
Ukraine	10-12	0	EUR 600,000	n/a
Moldova	2-3	0	EUR 150,000	n/a
Serbia	12-15	2	EUR 750,000	EUR 2,000,000
Bosnia and Herzegovina	7-10	0	EUR 500,000	n/a
Montenegro	5-7	0	EUR 350,000	n/a
Bulgaria	Dealt through Directive 2014/94/EU and national alternative fuels framework policies.	1	n/a	EUR 1,000,000
Romania		2	n/a	EUR 2,000,000
Germany		1	n/a	EUR 1,000,000
Austria		1	n/a	EUR 1,000,000
Czech Republic		1	n/a	EUR 1,000,000
SUM	36-47	8	EUR 2,350,000	EUR 8,000,000

With the advancement of electricity and natural gas as a transport fuel though, energy policies and strategies of countries can become inseparable from strives for sustainability in the electricity sector, or the energy security issues that characterise the supplies of natural gas. Consequently, the report proposes that under the auspices of the Energy Community, non-EU member states of the Danube region shall prepare a report by 2020 that similarly to the national policy frameworks in relation to Directive 2014/94/EU determines and sets non-binding targets with regards to the alternative fuel sector development also providing the platform to formalise support for level 1 policies. This is essential, as the report revealed that the commonly held assumption that the alternative fuels infrastructure development will incentivize vehicle usage is unsupported; therefore, these national policy frameworks would be ideal platforms to formalise level 1 support measures for obtaining vehicles, which could effectively complement the level 2 policies formulated at the international level.

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