

Transport decarbonisation in Lithuania: Beyond Best Practices national technical report

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Summary

This National Technical Report provides an overview of passenger transportation in Lithuania and highlights key policy initiatives and challenges. It emphasizes the need for improvements in transportation infrastructure and connectivity, moving away from dependence on private cars and better utilisation and promotion of existing alternatives such as public transport, car sharing and walking. Measures such as parking management schemes, including parking charges, and low emission zones are suggested as measures to reduce car traffic. Road charge revenues can be used to develop sustainable mobility infrastructure and support a shift towards public transport. Furthermore, promoting public education, embracing walkability, and prioritizing public transport enhancements are crucial for achieving sustainable transportation goals. By implementing these measures and adapting to changing circumstances, Lithuania can foster a resilient and efficient passenger transportation system that aligns with environmental and societal needs.

Contents

Introduction	1
Passenger transport governance	2
Lithuanian modal split and passenger transport emissions in numbers	9
The main drivers of emissions from passenger transport	12
Best Practices	15
Conclusions	46
References	47

Introduction

Passenger transportation in Lithuania is governed through a combination of direct transportation regulation and more indirect climate-related policies. Long-term transport strategy is dictated through the “Lithuanian Transport and Communication Strategy until 2050”, which cites Lithuania’s key strategic placement as a corridor between the Baltic states, Eastern, and Western Europe, but also notes that transportation infrastructure currently falls short of economic and social needs. There are a series of short- and medium- term policies governing transport, including the “Better Connected Lithuania” initiative, which seek to strengthen the transport sector and improve connectivity.

Lithuania has a high dependence on passenger cars which made up three-quarters of the modal split in 2019, primarily driven by rising incomes, personal attitudes, and insufficient public transport connectivity. Selected best practices for Lithuania include several practices which seek to reduce the use of internal combustion engine (ICE) vehicles, as well as promoting a walkable city, which seeks to implement sustainable neighbourhood design.

Passenger transport governance

Transport in Lithuania is governed through two general legislative pathways: directly through transportation policy, and indirectly through environmental and climate legislation. Transportation policy is generally given on two timelines, the medium- and long-term.

Lithuanian Transport and Communication Strategy until 2050

The long-term vision of transport and communication is presented in the “Lithuanian Transport and Communication Strategy until 2050” (Republic of Lithuania Ministry of Transport, 2020). The Strategy notes Lithuania's place as an important transit corridor between the Baltic Sea region, Eastern Europe, and Western European states, but also the low level of infrastructure development relative to transit and economic needs. The importance of the sector is also reflected in Lithuania's macroeconomic indicators. The share of the transport sector in GDP was 13% making it one of the most important sectors of the country's economy. As of 2019, about 8% of country workforce was employed in the transport and energy storage sector (Ibid.).

Despite the high economic and social importance, Lithuania scores only 4.47 out of 7 possible points according to the European Transport Scoreboard, which measures and ranks EU member state performance in 29 transport sector benchmarks. This is only slightly higher than average in 12 of the 26 EU countries (Ibid.). As a reaction, the Strategy models at least a 127% growth in passenger-car kilometres by 2050 due to increased population and economic growth. Given current infrastructure concerns and significant demand increases, the main vision is building an environmentally and socially friendly transportation system that fosters Lithuania's economy and competitiveness internationally. The transport system should ensure efficient, safe, and convenient mobility both inside and outside the country, and comply with all environmental standards and requirements. The efficiency of the transport system is the basis for competitiveness, which contributes to the sustainable development of the economy and encourages the growth of businesses and creates the necessary conditions for trade and other activities. While the sustainable mobility concept is posited as a key goal, emissions reductions are de-centralised and are stymied by competing policies seeking to increase mobility.

All three analysed scenarios described in the strategy show an expected increase in the number of international as well as local ridership. The optimistic scenario shows an increase in the number of international passengers from 2018 until 2025 by 158%, and by 127% in the case of the pessimistic scenario (Republic of Lithuania Ministry of Transport, 2020). The main drivers for this increase are Lithuania's economic growth and favourable population ageing rate. Change in the local passengers' number also will depend on the economic situation in the country as well as environmental requirements. A growing economy will push the trend towards higher numbers of

passenger car kilometres whereas environmental measures should support wider use of public transportation (see **Figure 1**).

Projected number of cars in Lithuania through 2050

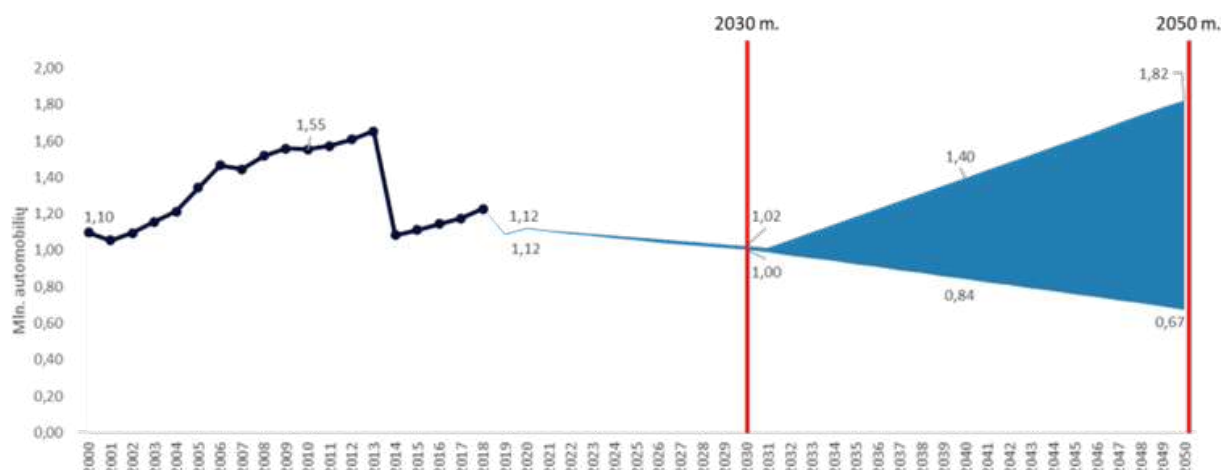


Figure 1 Projected number of cars in Lithuania (Republic of Lithuania Ministry of Transport, 2020).

For the transport sector until 2050 the main vision is an environmentally and socially friendly transportation system which fosters the economy and increases competitiveness. The transport system should ensure efficient, safe, and convenient mobility both, inside and outside the country, and follow all environmental standards and requirements. The efficiency of the transport system is the basis for competitiveness, which contributes to the sustainable development of the economy and encourages the growth of businesses and creates the necessary conditions for trade and other activities.

Despite the described integrated sustainable mobility concept, objectives and measures for environmental and transport sectors remain disintegrated. Therefore in some cases, goals compete between each other, and the achievements in the environmental sector are sometimes offset by a further increase of activities in the transport sector.

National Energy and Climate Plan

With regards to environment and climate policy which affects transportation, the key guiding document is the "National Energy and Climate Action Plan of the Republic of Lithuania for 2021-2030", (NECP) which provides a list of 32 measures to achieve the required reduction of GHG emissions (Republic of Lithuania, 2019). Lithuania targets 'climate-neutrality' by 2050, but transportation continues to account for over 50% of all remaining emissions. The NECP focuses on delivering emissions reductions through the promotion of electric and other "low-emission" vehicles, incentivising switching to less emissions-intensive fuels, improving passenger transport efficiency through improved infrastructure, and building sustainable habits in the population. Lithuania expects the most significant GHG emissions reductions to come from measures related to vehicle

pollution, particularly through the introduction of additional levies on high emitting vehicles (Republic of Lithuania, 2019).

Lithuania's NECP sets a 2030 target of 15% for use of renewables in transport, reporting a 2017 level of 4.3% (Ibid.). The NECP also targets a transport emissions reductions rate of -3.6% annually through 2030, or a total change of -9% below a 2005 baseline by 2030. This is equivalent to reductions of roughly a third and is expected to be one of the most challenging sectors (Republic of Lithuania, 2019, p. 26).

Much of the transport policy outlined in the NECP is centred around transitioning towards a more efficient vehicle fleet that uses EVs and alternative fuels rather than diesel, which currently dominates (Ibid.). The NECP outlines plans to incentivise generation and consumption of biofuels including biomethane and biogas, as well as increasing production of compressed natural gas (CNG) (Republic of Lithuania, 2019).

Lithuania anticipates production and supply of biomethane gas for the transport sector to reach 81.5 ktoe by 2030 (Ibid.). Fuel targets include the purchasing of commercial CNG vehicles (such as buses) and the delivery of 92.72 million m³ biomethane gas in 2030.

Other fuel consumption measures include promoting "economic and ecological driving skills" (Republic of Lithuania, 2019, p. 58) to reduce fuel consumption in private vehicles. Additionally, Lithuania's NECP outlines plans to re-organise traffic flows in urban areas, re-consider spatial planning practices, and support flexible work – all in a bid to reduce fuel consumption in urban and suburban areas.

The NECP addresses concerns about tailpipe emissions, foreseeing policies that promote purchases of vehicles that comply with higher EURO standards, as well as restricting access to certain urban areas for internal combustion engine (ICE) vehicles. Lithuania's NECP supports green procurement programmes for road and water transport, including support for construction of new, more efficient cargo and passenger ships and fleet vehicles which conform to higher EURO standards. Other initiatives include establishing a vehicle pollution charge, scaling vehicle registration fees based on tailpipe emission levels, and introducing a sticker scheme to help with rapid identification of vehicle groups.

Looking to support the integration of EVs into the fleet, Lithuanian government proposed a policy to support EV purchases through tax concessions and purchase allotments depending on vehicle type. Other policies include supporting the development of EV charging infrastructure through installation mandates for new construction and other financial incentives as well as support for zero-carbon taxi and ride-share services (Republic of Lithuania, 2019).

The NECP indicates that Lithuania will move forward "improving access to and use of public transport" (Republic of Lithuania, 2019, p. 67). This includes revising transport routes or introducing new routes that take into account changing societal needs, as well

as introducing free public transport in a stepwise fashion beginning with young children, then students, then the elderly.

The NECP lists several alternate measures to address emissions from transport which were considered but not accounted in emissions reduction calculations as they are considered alternatives to other options. This includes alternate fuel and blending guidelines as well as alternatives for waterways development around Klaipeda (Republic of Lithuania, 2019).

Total financial flows for the policies outlined in the transportation section of Lithuania's NECP are expected to require nearly EUR 2.8bn in public funding and EUR 1bn in private funding. Public funding is expected to come primarily from the 2021-2027 EU funds, state and municipal budgets, LIFE IP, the Climate Change Programme, and the ERDF (Republic of Lithuania, 2019).

National Transport Development Programme for 2022-2030

The main document describing medium-term transport sector priorities is the "National Transport Development Programme for 2022-2030" (Republic of Lithuania, 2022). Following the National Transport Development Programme for 2014-2022, and as part of the overall National Development Programme (NDP) the Programme addresses several key NDP objectives:

Objective 5.3: Improving connectivity within the country and with the EU

Objective 5.4: Improving digital connectivity and increasing an efficient use of transport infrastructure

Objective 6.1: Increasing share of RE and alternative fuels in the transport sector, increasing sustainable intermodal mobility and reduce pollution from transport

Objective 10.2: Develop and adapt infrastructure required for internal and international military mobility.

Table 1 National Transport Development Strategy selected objectives, problems, targets, and priorities

Selected objectives	Selected target indicators ¹	Selected problem(s)	1 st policy priority	2 nd policy priority	3 rd policy priority
Objective 5.3	5.3.1 100% of TEN-T core network meeting EU requirements by 2030	Lithuania's transport infrastructure is below EU average in terms of development and quality	Existing road infrastructure has gaps and is of a low technical quality	Existing rail infrastructure is inconvenient and slow	Lithuanian airports have limited connection and low service quality
	5.3.2 100% of European rail track built by 2030	Lithuania's road safety is below EU average	Road accidents are often caused by driver error so additional trainings for drivers are needed	There is a lack of engineered traffic safety solutions so such solutions need to be developed	A significant number of the vehicle fleet are in a state of disrepair
	5.3.3. 35% of railways electrified by 2030				
Objective 5.4	5.4.1 Passenger transport by all modes of transport to reach 420 million passengers by 2030, from 382 million in 2020	The transport sector is not achieving potential value due to lack of efficiency and level of services provided	Inadequate infrastructure in road, rail, sea, and inland waterways	Potential competitiveness in the sector is not exploited	Lack of innovative and digitised solutions
	5.4.3 Innovative transport companies to increase by 60% by 2030				
Objective 6.1	6.1.1 GHG emissions from transport at -	The transport sector is the largest source	Polluting road vehicles, lack of alternative fuel	Public transport is unpopular due to infrastructure	Road transport accounts for

¹ Note: Indicator targets and problems were selected based on relevance to passenger transport, therefore freight and military applications are not included. Only the top three policy priorities were selected for illustrative purpose. For the complete document see [2022–2030 Metų Plėtros Programa \(2022\). Government of Lithuania.](#)

	14% below 2005 levels by 2030	of emissions in Lithuania	infrastructure, and lack of public incentive to use alternative fuel vehicles	not serving individual needs and unequal connection to services between modes and regions	the largest share of freight and passenger transport
	6.1.2 NOx emissions from transport at - 51% below 2005 levels by 2030				
	6.1.3 Share of RE in total energy consumption in transport increase to 15% by 2030				
	6.1.4 10,911 GWh of energy savings in transport by 2030				
	6.1.5 Share of cycling and other non-motorised transport increase to 12.3% by 2030				
	6.1.6 Share of train travel in the total travel mix to increase to 1.9% by 2030				

Lithuanian EU funding programme for 2021-2027

Other short- and medium-term transport legislation includes the “Lithuanian EU funding programme for 2021-2027” (Ministry of Finance of the Republic of Lithuania, 2022). The third priority, titled "Better Connected Lithuania", is dedicated to strengthening the transport sector. Integration to the EU transport network (improvement of TEN-T road and railway infrastructure), railway electrification (mainly relevant to freight

transportation), intermodal linkages, and noise prevention measures are the core objectives of this priority. Other objectives include further development of infrastructure for non-motorised transport means, bypasses, local transport infrastructure, and ITCs.

Recovery and Resilience Plan

Additionally, Lithuania's Recovery and Resilience Plan under the NextGenerationEU recovery fund provides 347 million EUR for sustainable mobility measures which should significantly reduce GHG emissions by phasing out the most polluting road transport vehicles (private, public, and commercial) and by increasing the share of renewable energy sources in the transport sector (European Commission, 2023).

Funds under the reform titled "We move without polluting the environment" will be focused on four investment directions: switching from polluting cars to zero CO₂ emitting cars, improving public transport service quality and attractiveness by upgrading public transport parks, increasing the number of vehicle charging points (including compressed natural biogas and hydrogen), increasing local fuel production from RES including biomethane, second generation fuels, and hydrogen production and usage in the transport sector. Though the focus is only on 'green' hydrogen production, indicated projected hydrogen generation capacities above 500,000 m³/year raises legitimate concern about the possible overcapacity of expensive and energy intensive infrastructure. This could bring inefficient energy use and higher costs and therefore should be reassessed.

Lithuanian modal split and passenger transport emissions in numbers^{2,3}

The total passenger activity in Lithuania has been rising steadily over the past two decades, increasing from 18.4 billion passenger kilometres (pkm) in 2000 to 34.2 billion pkm in 2021. During the same time, total emissions from the passenger transport sector increased from 2.1 MtCO₂ in 2000 to 3.8 MtCO₂ in 2021. When combined with decreasing population, this indicates an even faster increase in emissions per capita from 622 kg CO₂ in 2000 to 1,362 kg CO₂ in 2021 (Climate Analytics, 2023).

**Lithuania passenger transport emissions 2000, 2010, 2021
(kgCO₂/capita)**

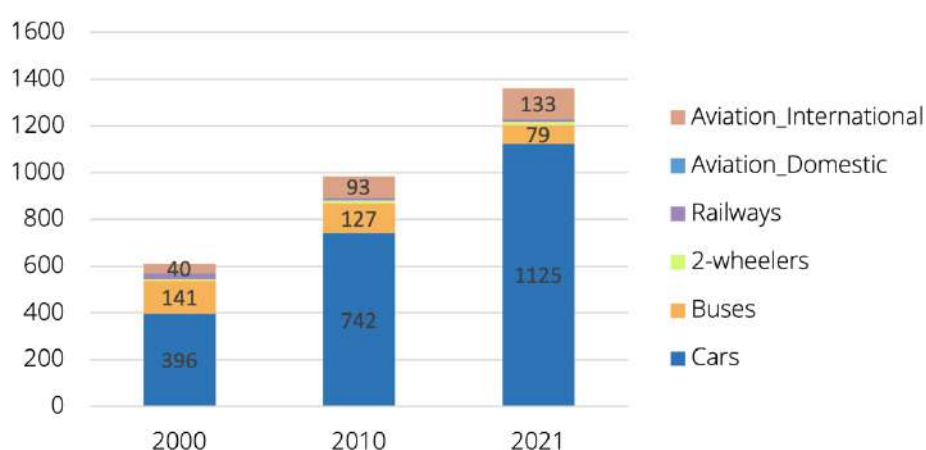


Figure 2 Lithuania passenger transport emissions

This represents a 123% increase in emissions per capita - slightly slower than the increase in mobility levels at 134%.

With 12,230 km travelled per capita in 2021, an increase by 134% in comparison to 2000, mobility by passenger cars registered much faster growth than the average mobility. At the same time, passenger cars saw a significant decrease in occupancy rates: 2.05 persons/vehicle on average in 2000 to 1.5 persons/vehicle in 2021. Their share in total pkm/per capita increased from 65% in 2000 to 83% in 2021, roughly the same as their share of transport emissions. The emissions intensity of passenger cars dropped from 217 gCO₂/vkm in 2000 to 161 gCO₂/vkm in 2021.

²The data provided in this section have been calculated using Transport Emissions Disaggregation Tool (TEDiT). Climate Analytics, (2023). Transport Emissions Disaggregation Tool. Retrieved from <http://tools.climateanalytics.org/tedit/>

³ Due to data availability, this includes urban and intercity bus travels within Lithuania

Lithuania modal split for 2000 (left) and 2021 (right)

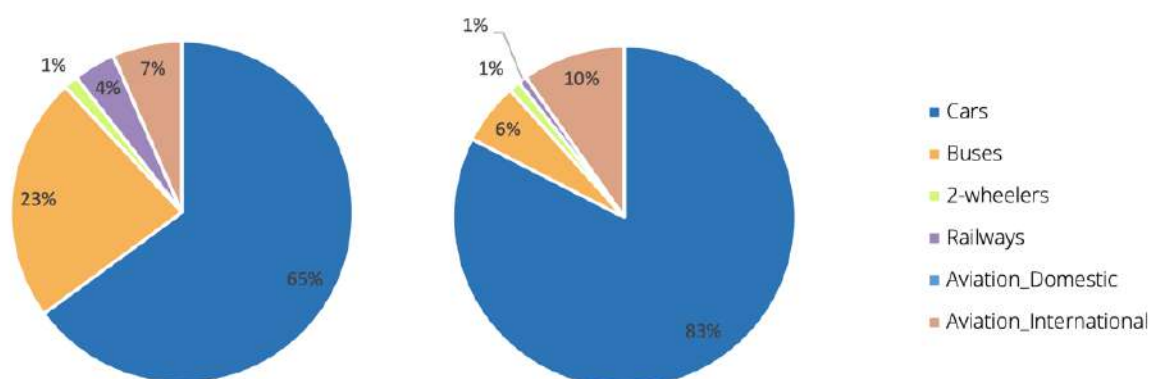


Figure 3 Modal Split and emissions from passenger transport in Lithuania

Passenger cars emissions vs. mobility (as % of total)

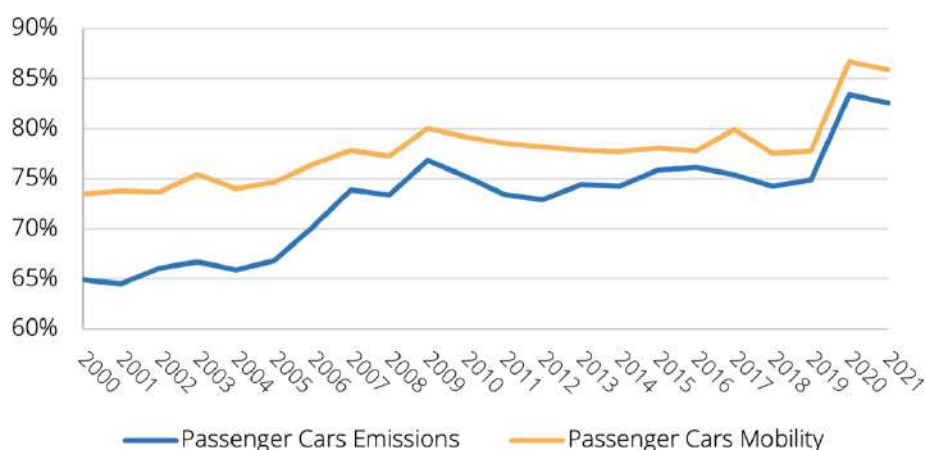


Figure 4 Lithuania passenger car emissions and mobility

The share of emissions from motorcycles decreased slightly from almost 1.4% to 1.1%, in between 2000 and 2021, with more than half of the growth taking place since 2015. However, different sources provide significantly varying data for this mode of transport. Also, the decrease in the share has been driven by more than doubling for the mobility levels.

The activity level of buses decreased from 785 pkm/person in 2000 to 520 pkm/person in 2021, with a steep drop during 2020 and 2021 due to the pandemic. Load factor additionally decreased, dropping from around 11 pkm/vkm to just under 8 pkm/vkm. As a share of overall emissions, buses saw a significant decrease, dropping from around 23% in 2000 to just 5% in 2021, due mostly to a decrease in emissions intensity from buses from over 1.918 gCO₂/vkm in 2000 to 1.203 gCO₂/pkm in 2021.

Average railway activity remains small in Lithuania, decreasing slightly from 106 pkm/capita in 2000 to 102 pkm/capita in 2021. This is lower than the high of 128

pkm/capita in 2019. Due to electrification of the railway tracks, the contribution of railways to overall emissions decreased from 4% of overall passenger transport emissions in 2000 to less than 1%.

The distance travelled by international planes increased significantly from 111 km per capita in 2000 to 593 km per capita in 2021. As a result, international flights are the second largest means of transport in terms of per capita emissions, and passenger kilometres. Even so, 2021 levels are significantly lower than the pre-pandemic era, with international aviation levels peaking at roughly 1570 km per capita. International aviation similarly saw an increase in load factor between 2000 and 2021, shifting from 79 to 132 pkm/vkm during that time. At the same time the share of international aviation in emissions from passenger transport increased from 6.5% in 2000 to 10% in 2021. Due to the sporadic and limited character of domestic flights in Lithuania, we did not include this mode of transport in our assessment.

While there are no data for cycling and walking for Lithuania, we assume an average distance of around 100 km cycled and twice as much walked per person. This is based on the average available for Hungary at around 84 km per capita and between 85 and 491 km for Denmark, the Netherlands, and the UK.

The main drivers of emissions from passenger transport

Economic development and mobility levels are very closely linked. Eurostat reports that Lithuania's GDP grew at an average rate of 2.3% per year between 1995 and 2005, and the volume of freight and passengers transported registered similar growth. Typically, transport volumes grow faster than the economy due to the sector's flexibility and adaptability to consumer needs. Sectoral flexibility, along with its close connection to economic development means that emissions from passenger transport are driven by a mix of interoperable but distinct factors.

Income

Rising income was and still is the main driver of emissions from passenger transport in Lithuania. Higher incomes make cars more affordable, support mobility and allow people to move to suburbs, which makes personal cars irreplaceable in most cases. The Swedbank Lithuanian population opinion survey on citizens' intentions to purchase a car showed that 61% of respondents plan to spend more on vehicle purchases than they did previously (Swedbank, 2021). Roughly one-third of respondents who indicated the desire to purchase a vehicle, intend to use some sort of financing mechanism such as a lease or loan. Almost 40% of respondents plan to change their car over the coming two years.

Improving financial opportunities and changing attitudes also reflect the fact that interest in leasing and new car sales in the country has significantly increased in recent years. About two-thirds (63%) of the country's population would use their savings to purchase a car. For comparison, in neighbouring Baltic countries, this number is 54% (Latvia) and 47% (Estonia) (Swedbank, 2021).

It is likely that inflation, increases in energy and food prices, as well as of interest rates have forced many consumers to rethink their plans for large purchases recently. However, the signs of stabilization are visible in the car market in 2023. Although the turnover of the used car market in the first quarter of 2023 compared to the same period a year ago increased by more than 100 million EUR, the volume of sales remained stable (Autoplius.Lt, 2023).

Personal attitudes

Privately owned vehicles may have advantages compared to public transport and even to car sharing alternatives. It allows one to control the situation, be independent and gives more freedom to choose (Ellaway et al., 2003; Steg, 2003). Also, a car is often perceived as a better option for travel. Even if public transport might offer a better choice in some specific cases (e.g. night train travel for a long distance), a car is mostly considered the primary option due to formed habits around driving.

The survey of public transport passengers done in 2015-2018 by the municipal enterprise Transportation Services (Susisiekimo paslaugos) showed that around 72-83% of Vilnius city public transport users don't have a privately-owned car. As part of a Mobility Week initiative, individuals were asked if they were willing to use public transport during mobility week when it would be free of charge. Out of over 12,000 respondents, 56% answered no and 23% answered yes. Although half of the population is reliant on private-owned cars, a rather significant part of the population might be quite flexible and could be persuaded to change travel habits if targeted efforts would be concentrated to do so (Susisiekimo paslaugos, 2021). Psychological attitudes play an important role in mobility preferences and decision-making and need to be considered when developing mobility policies.

Unsustainable spatial planning practices

Ramping up the capacity of urban roads for many years was considered the principal measure against traffic congestion. This practice tends to be counterproductive, inducing further urban motorisation and making cities even more inhospitable to pedestrians and cyclists. Congestion following expansion was again being “solved” by adding new lanes, creating a “vicious circle of congestion” (Rodrigue, 2017). Traffic, noise, and air pollution led to growing movement from the cities to suburbs, making personal cars indispensable for travels from home to work. Sporadic attempts to change this city development trend often meets with strong individual resistance. Finding the right balance between urban compaction and urban sprawl can help to change negative tendencies in planning. This process is often slow to start, with long timelines and high costs, often meaning that the sustainable spatial planning measures taken today will not bear fruit until many years to come.

Weak and contradictory policies

The transport sector is not exceptional regarding conflicts between different policy goals. Road safety and better transportation goals may come into conflict with environmental protection goals. Investments in improvement of road infrastructure also aim for an increased number of vehicles on the road. Disincentivising car use can be done through measures such as limiting parking spaces, adding pollution taxes, supporting alternative transportation means or EV purchases. Since at least some of these measures have direct implications on users, they are not usually widely supported and therefore are difficult to implement as politicians are keen to avoid unpopular decisions.

Covid-19

Two years of living under COVID-19 pandemic conditions had a significant impact on population mobility habits. On the one hand, the requirements of physical distance have greatly reduced the overall mobility levels. On the other hand, there was an

additional incentive to abandon sustainable mobility habits and use more private cars for commuting. The decline in international air transport was particularly significant. In 2020, the passenger kilometers travelled by air transport in Lithuania had decreased 5 times and reached only 21.7% of 2019 level. Similarly, international passenger kilometers travelled by buses decreased in 2020: it amounted to only 18.7% of 2019 level.

Overall, the COVID-19 pandemic had the greatest impact on travels using public transport. While air transport practically reached the level of 2019 in 2021, both international and domestic passenger public road transport continued to decline respectively by 15% and 56%, compared to 2019.

War in Ukraine

In response to the war in Ukraine, European Union sanctions against Russia and the desire to stop importing energy resources from Russia have raised fuel and especially electricity prices to high levels. Since fuel prices are slowly dropping, almost reaching 2001 levels, such volatility did not affect fuel consumption volumes and intensity of private car usage.

The war in Ukraine caused an unprecedented wave of migration from Ukraine to European countries, and especially to Poland. In order to facilitate the mobility of immigrants, several countries (including Lithuania and Poland) granted the right to people with a Ukrainian passport to use public transport services for free. This had a significant impact on the mobility levels.

Best Practices

Despite efforts to reduce greenhouse gases emissions, emissions from transport sector continue to increase. GHG emissions from road transport as well as the number of passenger cars continues to increase despite the decreasing population.

To change these negative trends and comply with GHG emissions reductions obligations there is a need for complex and efficient measures targeting passenger car usage and fostering transport alternatives. Introduction of low emission zones (LEZs) together with road charging measures and supported by corresponding parking management policies are considered to be highly recommended practices which may support significant emissions reductions in Lithuania if properly organized. Public transport and walking as a form of commuting are the best alternatives to personal car usage, and measures to support these modes of transport are also highly recommended.

Low emission zones

Urban air pollution is a major threat to public health with serious social and economic consequences. Many EU countries have been struggling with high concentrations of particulate matter (PM₁₀ and PM_{2.5}) and nitrogen dioxide (NO₂) in the air. Lithuania's main cities are no exception, and it is a well-known fact that road traffic is an important contributor to these pollutants in these areas. Low Emission Zones (LEZs) can deliver possible reductions of the principal pollutants by reducing vehicle traffic (Müller, 2019). Further, studies show that greenhouse gas emissions have decreased in cities that have implemented strict low-emission zone regulations: CO₂ emissions in London have been reduced by 13% since the introduction of LEZ (CLARS, 2022). Smaller reductions have also been observed in other cities, including Amsterdam, Paris and Berlin (Beedham, 2022). Available data from London indicated that its LEZ led to decreased traffic and reduced car ownership in the zone (Greater London Authority, 2020). Ghent introduced a LEZ and saw a 10% reduction in car ownership over two years (Outters, 2020).

The growth in the number of LEZs could help to shift away from internal combustion engine (ICE) vehicles and make electrified means of personal transportation and other alternatives to personal cars more attractive. A LEZ should be introduced in the areas where traffic, pollution, and population density are the highest, and can consist of one major or multiple smaller areas. Conventionally, city centres are targeted, but also other dense residential or commercial areas may be encompassed. Additionally, depending on the objectives or strengths of the regulation introducing them, different LEZ schemes can be distinguished, and cities can choose the scheme in accordance with local objectives and ambition levels.

A road pricing-based LEZ is the least stringent form of LEZ and might be suggested as an intermediate solution before a more stringent policy can be put in place. Charging a fee disincentivizes vehicle use and discourages from purchasing a polluting vehicle. The fee

tariff might be fixed or dependent on the Euro standard of engines. The choice of taxation model is determined by various factors, including technical ones. Generated revenue should at least cover the costs of the scheme implementation.

Ban-based LEZs require cities to set vehicle emissions standards to define which vehicles are permitted in the zone. The Lithuanian Law on Alternative Fuels defines 50gCO₂/km as a threshold between polluting and non-polluting passenger cars. A ban of internal combustion engines but permitting electric vehicles could encourage the acquisition of the latter. Such zones are referred to as Zero-Emission Zones (ZEZ). Under current regulation implementation of a ZEZ is not possible in Lithuania. Unlike road pricing-based LEZs, ban-based LEZs cannot generate revenue and all the costs are borne by the administrator.

Vehicle-free zones use a complete ban on all cars, leaving the area only for bicycles and pedestrians. Many European cities (Lithuania is not an exception here) have such car-free areas. Introducing car-free Sundays or other monthly or annual car-free days can help cities to promote a car-free way of life and alternative modes of transport. The impact of a single car-free day on emissions may be limited. However, car-free days can demonstrate how the space otherwise occupied by cars can be utilised to benefit citizens and increase support for further mitigation measures. Car-free days can also encourage those who usually do not use public transport to adopt the habit.

Current challenges

The primary challenge and motivation for Lithuania to introduce LEZs is pollution and urban air quality. Urban air quality in Lithuania approximately corresponds to the European average and concentrations of PM₁₀, PM_{2.5}, O₃, and NO₂ usually do not exceed limit values. Occasionally, values above the limit are registered at air quality monitoring stations, particularly when unfavourable conditions for the spread of pollution are present (Lithuania Environmental Protection Agency, 2022). The concentrations of pollutants are often substantially greater in streets with heavy traffic volumes. Major Lithuanian cities like Vilnius, Klaipeda, and Kaunas have seen increases in passenger cars and pollution levels. Therefore, in the case of Lithuania, the primary objective of establishing the LEZs is greenhouse gas emissions reduction from the transport sector. Considering impacts and traffic intensities there is a reasonable basis to designate and LEZ in the five to seven largest Lithuanian cities.

Implementation

The decision to implement LEZs may be part of a national scheme, especially considering the fact that the EU New Urban Mobility Framework defines general principles of urban vehicle access regulation schemes (European Commission, 2021). The size of the zone and strictness of regulation depends on the policy preferences of the city administration. In Lithuania, the Law on Alternative Fuels only sets the responsibility of municipal administrations for establishing such zones and defines 'non-polluting vehicles' that emit below 50g of CO₂ per kilometre (OECD, 2023). Guidelines

aiming to ensure the application of common principles will be prepared and released soon.

LEZ design decisions about the size, scope, and framing should be based on concrete evidence of the local problem, which might be localised within recognizable urban boundaries such as a particular street or district. Generally, the LEZ addresses air pollution or even some particular pollutants, while considering the priorities of those exposed to and affected by LEZ (residents, commuters, workers, students, etc.). Additionally, it is crucial to take into account local demographics and car ownership.

The aims of LEZ implementation should be clearly indicated from the beginning. Though the primary goal is often to curb air pollution, in the case of Lithuania, LEZ was first promoted as a measure to reduce greenhouse gas emissions from passenger cars. Achieving this goal requires working on a large scale and therefore some proper planning might be necessary as it will take a long time to scale up the zones.

Starting from the beginning of 2023, the low pollution zones had to be established in the big cities. Nevertheless, it is not clear yet when and based on what principles this will happen. The template for such an arrangement has not been provided to the representatives of the city municipalities by the Ministry of Communication. It must be noted that during the preparation of Sustainable Urban Mobility Plans, until 2018, certain cities, like Vilnius, had already planned the establishment of such zones. The LEZ in Vilnius had to be implemented in at least three stages and cover the central part of the city. During the first stage an additional fee (100-200% of the parking price in the zone with the highest parking fee) had to be applied for diesel cars with engines below EURO 5 standard and for gasoline cars with engines below EURO 4 standard. During the second stage only vehicles with engines of EURO 6 and EURO 5 respectively and above could enter the zone free of charge. The boundaries of the zone also had to be expanded. Moreover, a so-called CO₂-free zone had to be established within the boundaries of the Old Town by 2030.

It seems that the Vilnius city administration would like to follow these initial plans. It is claimed that the most likely area to fall into the low pollution zone is the Old Town. Currently, exact limits and good and bad global practices are being examined.

Kaunas would like to cover at least the central part of the city. The restrictions on polluting car traffic will be planned. Smart cameras will be employed to control, scan the licence plates, and determine whether vehicles meet set requirements. In case of non-compliance, a fine will be applied. In the future, as the number of environmentally friendly means of transportation increases, vehicle entrance to the central city area might be banned.

Klaipėda would like to base their decisions on noise and air pollution maps and keep further consultations with the Ministry of Communication. Analysis of the existing situation shows that too many uncertainties are yet involved. It is expected that guidelines will give all answers to available questions. But it might not be the case, if the

municipalities and the Ministry of Environment were not sufficiently consulted during its preparation.⁴

Localization and scale

As the primary aim of designing LEZ is to reduce air pollution, it is appropriate to start from a small, compact part of the city, e.g., the city centre. City centres are often more walkable and car access tends to be more regulated. Due to higher property prices, local residents also tend to have higher incomes and own newer cars, therefore they could be less affected by the new restrictions.

If LEZ expansion is planned from the beginning, it is essential to communicate the plan, timeline, and following steps. Learning from the first step enables better adoption of further measures, increasing acceptance. A timeline is essential for several reasons. Firstly, it gives local residents visibility into the process and a better understanding of the foreseen measures. Secondly, they could know how much time they have to prepare for a change and to find the most suitable way to adapt. Also, the objectives are easier to achieve when the entire process is divided into smaller steps.

Depending on the ambition and timeline, a gradual approach could be reasonable. Lithuania already fixed a threshold for low emission vehicles of 50 g/km CO₂, which is rather low and will definitely cause problems in implementation.

Stakeholders

The main stakeholders are:

- the Ministry of Transport and Communication, the Ministry of Environment,
- municipal administrations and city council members,
- citizens, local communities, and businesses, and
- environmental groups and NGOs.

The Ministry of Transport and Communication as responsible for sustainable mobility should take the lead in the process of designing the LEZs. The ministry must provide guidelines for municipalities, as common principles have to be applied in all municipalities. Moreover, the Ministry of Environment should take part in the discussion about goals as LEZs are intended to solve environmental problems. The low involvement of the Ministry of Environment in the process is not advantageous. As municipal administrations do not fully comprehend the main goals and tasks, they should get more involved in developing the guidelines. Only close cooperation between municipalities and two ministries could help to achieve the expected results that the designation of LEZs' could bring.

⁴ The above analysis was completed before the 2023 municipal election. Changes in political leadership in Vilnius and Klaipėda have led to a shift in the policy environment, and new administrations may be less favourable towards LEZ implementation.

Furthermore, any effort to regulate polluting cars is seen as an encroachment on the individual's freedom of choice. In order to reach an agreement, the voice of citizens must be heard, and possible intermediate solutions must be sought. Granting temporary permits to local residents, setting somewhat longer deadlines for the implementation of measures, or approving gradually increasing tax rates are some of the possible solutions.

Proposed changes to the existing legislation

There are currently no required amendments. On the contrary, there is a need for an explanation of how the provisions of the Law should be implemented. LEZs designation, timing, toll tariff, use of income, fines (if road pricing-based option will be chosen) and other essential elements must be determined by decisions of involved municipalities.

Co-benefits

The main benefits of established LEZs were found in:

- reduction in emissions of carbon dioxide, nitrogen oxides, and particulates,
- reduction in energy consumption,
- change in the fleet towards more fuel efficient and cleaner vehicles, and
- more attractive city centres or areas in which LEZs are established.

LEZs may contribute to making public spaces more usable for different societal needs, as well as increasing urban life quality. If a road pricing-based option will be chosen, collected fees could be used to improve and develop sustainable mobility infrastructure. Fewer cars in the streets will lead to increased safety and security. Shifting to alternatives should help to get more revenue from passengers of public transport and to make it better able to cover its expenses.

Conclusions

Low emission zones can be an effective and comparatively inexpensive measure to curb CO₂ and pollutants while also reducing traffic in designated areas, if properly planned and effectively communicated. Although it is easy to implement this measure as all necessary technologies and know-how are available on the market it might take years to implement it in a full scope.

Parking fees and management

Management of parking spaces affects car use and traffic congestion. Charging for public parking spaces, especially in urban areas, is widely implemented as an efficient measure to address several concerns raised by congestion, including tackling the lack of parking spaces, reducing traffic in surrounding areas and minimising the number of passenger cars in the area. This policy can lead to emissions reductions in the transport sector as a result of decreased traffic and lower total vehicle density.

Parking pricing policy can be a powerful tool especially if it is used in conjunction with other travel demand management strategies – improvement and development of alternatives to personal car usage, and multimodality. The primary reason for considering this measure is the drop in the number of cars in the associated area induced by charging for parking space, leading to a modality shift. Modality shift is regarded as an alteration that results in more sustainable transportation with less overall CO₂ emissions per capita. The Vilnius Urban Mobility Plan (2018) and numerous other Lithuanian strategic documents are dedicated to enhancing transport sustainability, emphasising parking pricing.

Pricing, in general, is a typical market-oriented instrument that distributes resources to users with high willingness to pay (users with high demand to a certain extent) through price adjustment (Mei et al., 2020). Several pricing strategies are employed to address various target groups and fulfil different objectives. Parking prices may vary depending on time, location, and user. If the price is too low, its rationing effect will erode and it will work only as a budget income measure. If it is too high and introduced too quickly, it may result in a backlash and high political costs for politicians introducing it.

Two distinct charges are applied for both temporary and permanent parking. Permanent parking charges are designed for local residents and companies utilising public parking spaces for their employees. It should be noted that permanent parking charges for residents, in a certain area, are used only in combination with temporary parking charges as a means of saving parking costs. If properly priced, it also might serve as a tool to influence car owners' decisions about whether or not to own a car is worthwhile. It can especially influence the decision to own the second car, which may turn out to be less utilized, thus not worth the additional charges for parking.

Legal entities can also apply for and receive permits for permanent parking in certain areas in the vicinity of their premises. The expansion of reserved parking spaces contradicts the objectives of the introduction of parking fees, therefore not all requests must be fulfilled and the price of licence issues kept at a high enough level. For example, a reserved car parking slot in the central part of Vilnius costs between 36 – 525 EUR/month (Susisiekimo paslaugos, 2022b). Costs are accordingly lower in Kaunas and Klaipėda.

Expansion of free reserved parking spaces should also be strictly controlled. In Lithuania, the state organisations and institutions can apply for free reserved parking

spaces based on an exemption provided in the Law on Tolls of the Republic of Lithuania. Only five to 15 metres long parking spaces could be provided in this case (Susisiekimo paslaugos, 2022a).

Temporary parking charges are usually applied for all passenger cars. Naturally, some exceptions may apply. In order to support the transition towards an electrified car fleet, the parking fee is not applicable for electric cars in Lithuania as a rule. Municipalities issue permits in response to requests. In addition, car-sharing cars are entitled for free parking in most locations. Charges are not applied for disabled people.

Temporary parking rates should vary according to demand, while keeping in mind that demand might be different depending on time and localization. In Lithuania, parking fees are different in various designated zones and cities. The highest fee is in Vilnius, where 12 minutes of parking in the central part of the city costs 0.5 EUR, while 20 minutes of parking in the cheapest zone costs 0.1 EUR (Susisiekimo paslaugos, 2022b). Moreover, cities have various zone markings. In addition to cities, different zones have quite diverse toll collection schedules. Differences indicate the intentions of city councils to use this measure as locally targeted as possible.

Escalating rates are used to discourage long-term parking. These rates increase the longer a vehicle is parked at a location. None of the cities in Lithuania applies escalating prices strategy. As an alternative to escalated rates strategy, a limited parking measure might be adopted. In Lithuania, it is used in private parking spaces owned by retailers, near vital tourist and social infrastructures. In line with the limited parking concept, "Kiss & ride" parking spaces are located near schools and kindergartens.

Current challenges

Increasing car ownership levels leads to increasing air pollution in the central parts of the cities, traffic jams and occupation of sidewalks and green areas by parked cars. To meet the need of an increasing number of personal cars require a growing amount of financial resources and the absorption of new public spaces areas. Examples from other cities, e.g., Krakow (Poland) demonstrate that a permanent increase of parking spaces might reach a dead end when every space is filled. This situation is well-presented in the "Feasibility Study of the Development of Parking Spaces in Residential Areas", prepared for the Vilnius City Municipality in 2013. According to it, the expected increase of parking area had to occupy an additional 110.5 ha of Vilnius city territory at the expense of green areas. The cost of installations according to that year's pricing would amount to between 77 - 261 million EUR, depending on the type of parking installation (above-ground, above-ground multi-storey parking lots, or underground parking lots, respectively) (Vilnius City Municipality, 2013).

Such proposals are incompatible with the concept of sustainable mobility in cities, as only one mode of transport is considered - the personal car, which has the highest impact on CO₂ emissions, air quality in the cities, and therefore on human health. Additionally, these proposals are detrimental to urban space utilisation, visual pollution,

and increasing insecurity. The necessary costs deprive other modes of transportation of proper funding.

The long-term experience of Vilnius and other cities has shown that ramping up the capacity of urban roads, and expansion of parking spaces just induced further city motorization and made cities even more uncomfortable for walking or cycling. Newly arising congestion again was being solved by adding new street lines and widening them. This is how a “vicious circle of congestion” is formed (Buis, 2009). In order to reduce society's dependence on the private cars and to reduce their negative impacts, it is necessary to continue further parking management in combination with other measures focusing on sustainable mobility.

Implementation

Car parking management is a crucial measure to achieve sustainable urban mobility. Charging for public parking spaces is the main element of car parking management. However, as mentioned above, applied charging schemes should be justified and coordinated with other measures, especially development of attractive alternatives to private cars. Only an integrated approach can lead to sustainable mobility goals. The following is a discussion of several key components to pay attention to when introducing charging for parking spaces.

Better parking spaces planning and further reduction of reserved parking lots

It is widely known fact that a guaranteed parking space at the workplace is the main driver of using cars for commuting. Available data show that if companies guarantee parking spaces for their employees, the number of employees travelling to work by car is much higher in comparison to a situation in which parking space is not guaranteed.

Therefore, city administrations try to regulate private and public parking spaces by setting certain limits on the number of parking spaces in different city areas. There is a tendency now in Lithuania, that real estate developers are very keen to reduce dependent private parking lots, as it saves resources, and seeks to shift induced need for car parking to public parking spaces. At the first glance, this supports sustainable mobility goals, as reduction of overall number of parking spaces in the area significantly reduces congestion. However, if it is not supported by better public transport service and other comparable alternatives to private cars, it will lead to an increase in the utilisation of public spaces for parking and this increase public dissatisfaction with urban transport planning and discredit the goals of sustainable mobility.

The lack of private parking spaces puts pressure on public parking spaces and leads to requests for parking space reservations. There was a widespread tradition in Lithuanian cities to reserve part of public parking spaces for different institutions, organisations, and companies. For state institutions reservations of public parking spaces were made available for free, and the private companies were charged. The situation has changed significantly now, especially in Vilnius. If a request is approved, the private company has

to pay a significant fee to get reserved parking in most cases: in the most expensive zone prices vary from 525 EUR/month in Vilnius and 205 EUR/month in Kaunas to 90 EUR/month in Klaipėda (Parkavimas Kaune, 2022; Susisiekimo paslaugos, 2022a). Even considering the fact that parking lot rental prices are around twice as high in Vilnius than in Klaipėda, where it is about 40-50 EUR/month, there is a reason to say that Klaipėda City Council still does not use all available tools to achieve more sustainable mobility management in the city. Parking fees can help to cover the costs of parking provisions and to raise revenues. Klaipėda City Urban Mobility Plan in fact was used also to improve conditions for the use of cars in the city. Mixed targets compete with each other and make the situation even more complicated.

For state institutions, the Law on Tolls regulates the provision of reserved parking lots. In some instances, the ministries that have large parking lots also reserve places in public parking. Although the cancellation of reserved parking lots, especially in the zones with high parking demand, does not necessarily reduce traffic, it does support commuters' modal shift to alternatives to private cars.

Performance-based pricing

Performance-based pricing refers to parking pricing that is determined based on intended results for transportation intensity or parking space occupancy levels. It allows cities to better manage the available parking space. Vilnius introduced the "85% rule" to regulate parking charges. When the share of free parking spaces remains less than 15%, the parking fee is increased. The fee is calculated according to several formulas approved by the City Council. Higher vacancy rates may indicate that the pricing is excessively high.

A vacancy rate of 15% might be a desirable performance goal, although it is crucial to consider other objectives. Pricing can be raised to achieve a transition from private cars to alternative travel modes. However, this measure is not widely implemented. To succeed, it needs to be preceded by a targeted assessment of the local parking context and establishing a balance between parking availability and demand. Analysis of demand is crucial as these data support analysis of drivers of demand and lets us evaluate the availability of alternatives to meet this demand.

Each parking space consumes from 15 m² to 30 m², and the average motorist uses two to five different parking spaces daily. When public space in densely built-up areas is used for purposes other than parking cars, it has a higher value from a social, economic, and environmental perspective. Like many other rare collective goods, this space should be managed by price. Moreover, according to research, providing green space could have a bigger positive impact on the value of a city house than providing parking space. Therefore, no public space in city centres should be made available for free parked cars (Rye et al., 2015).

A survey in Graz, Austria, on the use of public space by stationary traffic showed that 92% of spaces used for transport infrastructure, are used for parking cars, with private

parking and garages not included; (Rye et al., 2015). Only 2% is for bicycle parking, 3% are areas that could be summarised as being for pedestrian use (including benches, street cafes, etc.) and 3% is dedicated to public transport. This survey shows the incredible privilege of the use of public space for parking cars. There are no similar evaluations done in Lithuania, but there is no reason to believe that the situation in Vilnius, Kaunas, and Klaipėda might be significantly different.

The parking fee level indicates willingness to pay for the opportunity to have public spaces not occupied by cars. Despite the high value, readiness to pay usually is not high. It is difficult to expect that city council members, being drivers, could impose a high fee on themselves. Therefore, current permanent parking charging schemes for residents do not support transport modality change. The fee for the first car parked at a public parking space in a central part of Vilnius is 43 EUR/year (Susisiekimo paslaugos, 2023b). A similar price per month is paid for the parking lot in the underground garage in the territory adjacent to the central part of the city. Kaunas has introduced the same fee for all Kaunas territory – 35 EUR/year. In Klaipėda, the fee has been changed from 2 EUR to 10 EUR per year only in 2022.

About 34-35% of the population in Vilnius and other big cities have more than one car (Delfi Auto, 2022). There is no data on the share of the people that own two or more cars that park them on the streets and other public parking spaces and on the share of the people using one of their cars to commute daily. These data would help to evaluate whether current fees for a second car might be more stringent and to what extent. Currently, fees for a second car only in Vilnius are rather high and vary from 7.20 EUR/month to 43 EUR/month depending on the parking zone. Meanwhile, Kaunas and Klaipėda introduced corresponding 70 and 72 EUR/year fees.

It has to be noted that only parking on the streets and other common spaces is charged. Inner courtyards of apartment buildings usually are not charged even if they do not belong to the building. A fee can be introduced upon request by the owners. Parking of the second car in the charged courtyard's parking area in Vilnius city costs twice less. Other cities do not apply such criteria. An expensive parking fee for a street can push vehicle owners towards the further occupation of green spaces, and playgrounds, that are located in the courtyards. Therefore, only if it is ensured that this does not happen, the parking fee can be increased. And on the contrary, promises to gain some extra space in courtyards by arranging additional parking lots in the streets should also be carefully monitored and possible attempts to cheat on this prohibited. Cities might increase the area where parking spaces should be extended without contradiction to the principles of sustainable mobility if a total parking space in the district is far below the city average. The mobility challenges of the residents of those territories must be addressed in order of priority, offering all possible alternative means of travel and the necessary infrastructure.

Additionally, it would be essential that the planned increase of the parking fee could be extended over time. This could help citizens to see perspective and plan their transport needs accordingly. The fee also could be linked to inflation, fuel price, and long-term

sustainable mobility goals. The fee calculation formula also should consider above mentioned local circumstances and should be adjusted in case of any changes. In this way, it would be more difficult to make ad-hoc decisions that contradict the principles of sustainable mobility for the sake of political dividends.

Better enforcement

Establishing toll zones and ensuring toll collection must be accompanied by their strict enforcement. Since it is difficult to secure relevant control levels in every area, it is important to develop a parking enforcement plan where priorities and enforcement strategies can be developed. To draw a consistent plan, timing, intended results, key performance indicators, and responsibilities should be taken into account. Personnel should develop conflict-avoidance skills and be prepared to explain parking rules and regulations smoothly. Moreover, consistent enforcement implies that the violator should be held accountable for illegal parking. Parking illegally will not be deterred by excessively low fines and penalties. Fine rates also should be dependent on the severity and frequency of violations. In this essence, smart technologies including security cameras with automated licence plate readers could be employed.

Timely reaction is an important factor acting as a preventive measure for the future. In areas with a high level of violations, proper signage should be ensured. It is important to note, that a fine for the violation that is committed due to the absence of a reasonable alternative for parking, does not support achieving progress. On the opposite, it might merely lead to dissatisfaction with the enforcement actions and encourage doing the opposite.

Park & Ride is not an option for cheap car parking.

Park & Ride parking is an important element within the transport multimodality scheme if properly localised. Attempts to introduce Park & Ride in Vilnius were not successful due to unmet main requirements. Therefore, it operated as a cheap car parking option for locals and visitors with a bonus to use public transport free of charge.

The fact that the implementation of Park & Ride in Vilnius was not successful does not mean that this system has no perspective there. It just means that many criteria must be carefully considered before starting to implement this system, such as the volume and direction of traffic flows, convenience and speed of public transport. It is also important that such places could function as multifunctional hubs that can provide all the necessary daily services. This could help to reduce extra travels around the city by car down to minimum.

Kiss & Ride: a mostly temporary option.

Since 2017, a number of quick boarding and disembarking areas for passengers have been introduced mainly near schools and kindergartens in Vilnius. In accordance with global trends, quick boarding and disembarking areas are set up in separate areas at

entrances, forming traffic circles near educational institutions. Although these pitches are not equipped according to standard requirements, they provide benefits, such as allowing parents to drive and drop their children off safely at school and not offend other road users.

It is a well-known fact that parents driving their kids to school causes a significant amount of traffic. In order to improve this, optimisation of school network and elimination of educational disparities is needed. This would ensure that children could attend the nearest schools and reach them on foot or by bicycle. Fast passenger boarding and disembarking areas does not help to reduce traffic. Therefore, Kiss & Ride can be only a temporary measure allowing adapting to the problem, but not solving it.

Stakeholders

The main stakeholders that need to be involved in parking charging are:

- municipal administrations and city council members,
- the Ministry of Communication and the Ministry of Environment,
- citizens, local communities, and
- environmental groups and NGOs.

Responsibility for car parking schemes rests with municipal administrations. Knowing the city's needs and circumstances, municipal administrations can prepare the most appropriate charging schemes. The final decision belongs to city councils, therefore the adopted charging scheme also contains a political dimension and shows the extent to which politicians are ready to push for change towards sustainable mobility in particular by strengthening the transition from private cars to other mobility alternatives.

Role of the state institutions is to provide clear guidance and define the scope of action in line with international commitments on climate change. In the case of sluggish cooperation in achieving climate change mitigation goals, it is useful to define the role and responsibilities of municipal administrations more precisely, linking them to emission reduction targets.

Reduction in private car trips is not very popular among drivers. There are plenty of examples when local residents insist on reducing green areas in favour of car parking spaces. An increase of parking prices is often perceived as an attack on personal freedom of movement and quality of life. By improving pedestrian paths and building roads for cyclists, more and more people are beginning to understand the direct benefits of such solutions for themselves. Discussion on parking charges cannot be understood without seeing a bigger picture. Therefore, it is crucial to have people involved in urban revitalization projects, to make them more familiar with urban sustainability principles and their benefits.

For this purpose, environmental groups and NGOs are important sustainability ambassadors. Municipalities administrate the so-called Environmental Support Programs, which are used to support environmental activities and to finance different

environmental projects. These resources could also be used to co-finance NGO activities dedicated to achieve better social acceptance of sustainable urban mobility goals.

Parking management is a continuous process where charging is only one of the elements. In order to have a system which helps to achieve a modal shift from personal cars to other modes of transport, restructuring and careful design of the parking system is essential.

Proposed changes to the existing legislation

Parking charges and enforcement occurs at the municipality level. In order to have a long-term charging policy, these charges have to be revised once at least every two years considering inflation and performance results. The decision itself should contain described methodology, and transparently communicated indicators on how the charging fee should be calculated with regard to key performance indicators. Now only one indicator – share of occupied parking spaces – is usually used for the assessment of temporary parking fee eligibility. There are no criteria established to evaluate the eligibility of permanent parking fees.

To improve enforcement, it could be recommended for municipalities to prepare an internal procedural document, including a parking enforcement plan, where enforcement goals and tactics could be described. This results in looking at enforcement activities more strategically and distributing limited resources more efficiently.

The Standard Technical Regulations should also be revised to allow municipalities more freedom to decide about the number of parking spaces and to reduce it where alternatives to private cars exists. At the same time, other standards currently preventing the expansion of greenery in certain city areas could also be revised. It would also contribute to creating a more comfortable urban environment and encouraging walking.

Co-benefits

The ultimate goal of the parking charge is to reduce CO₂ emission from personal cars, overall air pollution resulting from this mode of transport, such as particulate matter, carbon monoxide, nitrogen dioxide, and decrease noise pollution. Also, it should free up public spaces, which might be used for many other societal needs, and increase activity (bigger share in modal split for walking, cycling). Less congestion allows for better public transport services. Shifting to alternatives should help to get more revenue from passengers of public transport and to make it better able to cover its expenses. Collected fees are important income to mobility funds which can be used to improve and develop sustainable mobility services and infrastructure. Fewer cars in the streets will lead to increased safety and security.

Conclusions

Within the parking management scheme, parking charges might be efficient and rather well-accepted by citizens' measures to regulate passenger car traffic. To ensure its efficiency, permanent performance assessments should be carried out and charging fee rate corrections made as appropriate.

Lithuanian cities' administrations use parking management schemes widely, however more stringent approach regarding second household car and public space management is lacking. Additionally, the number of new parking spaces should be better controlled, and conditions to minimise parking spaces should be created.

Road charging

A road charging framework contributes to the internalisation of external costs related to road transport, such as those generated through the use of infrastructure or its environmental and social impacts. Road charging can also be used to generate new sources of revenue to support cleaner, more energy-efficient modes of transport (European Commission, 2022).

Up to now road charging was used for financing development and maintenance of road infrastructure and has not been used as an environmental measure. Lack of political support for proposed car ownership tax requires searching for new forms of measures which could be more acceptable to society and politicians as well. Road charge could be a very effective substitute for car ownership tax, which is perceived as a property tax as you have to pay it even if a car is not used. The "Pay as you are on the road" principle could be more acceptable, but it requires a lot of investments into infrastructure and bears maintenance costs. Lithuania is already working on the establishment of a toll system for heavy vehicles, which could be expanded to include all vehicles in the near future.

The "Pay as you are on the road" principle applies to drivers for using a specific section of the road or for a specific period of time on a road network. This tax should discourage drivers from using private passenger cars for trips when alternatives exist or using the road when traffic is high. It should be noted that if charging of heavy vehicles is regulated at the European level, as the transport of goods is linked with the functioning of the single market, road charging of private vehicles is under regulation of the EU member states.

The vast majority of Western and Mediterranean EU Member States deploy road charging for all types of vehicles, based on either time, distance or area. Time-based charges (vignettes) allow the use of a particular road, usually motorway or highway for a specific period of time (e.g. in Austria, Slovenia, and Slovakia). Lithuania has a vignette system, which is time-based and applied only for heavy duty vehicles that carry goods

or more than 8 persons. Vignettes are sold with validity of one day, seven days, one month and a year. The vignette is tied to the registration number of the vehicle and, in addition to the usual points of sale, it can also be purchased over the Internet. A vignette is required only for using motorways and highways. Vignette systems can be introduced relatively quickly and at low cost, however time-based charges do not correlate with use of roads in terms of driven kilometres. Therefore, such charges are not suited for internalisation of external costs and do not help much to change behaviour towards sustainability if a charge is applied for personal cars.

In Lithuania, different charges are applied depending on the vehicle's weight. As collected revenues are used for road maintenance and development it is presumed that heavier vehicles have a greater impact on the road surface. Weight in general correlates with emission levels, but individual engine characteristics are not taken into account and therefore the weight-based approach is not very suitable from environmental goals point of view. Furthermore, some countries differentiate the price of vignettes reflecting certain vehicle environmental performance criteria. This scheme would work if the difference in price could be significant enough.

Toll systems based on distance- or area-based charges are much more widely used in Europe. Tolls can be charged on motorways (e.g. in France, Hungary, Croatia, Italy) and also at some local point like bridges, tunnels or viaducts (e.g. in Croatia, Greece, Ireland). Charges might depend on vehicle type (e.g. in France, and Portugal). A toll system is very suitable to reflect environmental needs as charges can be distance-based and reflect the environmental performance of the vehicle or its contribution to climate change and air pollution. On the other hand, toll systems entail additional high costs for the construction, maintenance, and operation of toll collection facilities. Also, charging may lead to a shift of traffic towards non-toll roads, causing congestion at toll stations. Contemporary ITCs systems could significantly simplify the passage of checkpoints and create conditions for use of toll systems more widely.

Responding to current challenges

Since the main vision for the transport sector until 2050 is an environmentally and socially friendly transportation system, measures to reverse negative trends must be implemented. The polluter pays principle has not been fully implemented for passenger transport, and this challenge still needs to be dealt with by the Lithuanian government.

The car ownership tax that was proposed in 2022 and was met with public hostility, did not receive political support and was immediately rejected after the first reading. The public opinion situation requires searching for new forms of measures, which could be more acceptable by society and politicians. A "Pay as you are on the road" charge could be a very effective substitute to car ownership tax, however, implementation of this principle requires a lot of up-front investments into infrastructure and bears the maintenance cost.

Implementation

Technology plays a key role in implementation of road charging. Toll systems using physical barriers are now outdated, with modern technologies allowing the use of smartphone apps or in-vehicle technologies to charge passenger cars. Smartphone-based e-ticketing offers a solution for flexible and cost-effective passenger car tolling systems. Lithuania has chosen smartphone-based technology for implementation, which proved to be more efficient than Global Navigation Satellite System (GNSS) using technology.

A final consideration for implementation is the level of the charge. When the road pricing was introduced in Stockholm, vehicle usage dropped by 25%. Stockholm already had a well-developed public transit system before the congestion charge was introduced, so an alternative was available. This was essential for its success.

If tariffs are too high and no acceptable alternatives are developed, the use of alternative routes may increase. Then the expected result will not be achieved, and the situation may even worsen if the costs of travelling on an alternative route will be significantly lower than on a toll road, resulting in longer routes and thus higher emissions.

Time-based vignettes will be phased out for heavy-duty vehicles on the core TEN-T network within eight years of the entry into force of revised road charging rules (Eurovignette directive) (Ala-Honkola, 2021). Lithuania is already implementing an e-tolling system. Around 200 devices will be installed on highways in 2023. According to initial calculations, costs of such a system are about 40 million EUR. It is less than collected annually using the current vignette system (50 million EUR/year). It is expected that revenue after installation of the e-tolling system will be around 110 EUR yearly if suggested tariffs will be approved.

The new system will comply with the principles of "user pays" and "polluter pays" of the European Union and will be fairer to road users. After its implementation, the fee tariff will depend not on time, but on the distance travelled. The fee will be calculated depending on the car type and emission standards. The e-tolling system is going to be used only for heavy-duty vehicles. There is no ongoing discussion to which extent this system might be expanded to passenger cars. Considering the fact that private cars' contribution to air pollution is the highest, applying a road fee to them would be a logical and understandable next step.

Due to the rising number of electric cars, revenue from fuel excise duty will be decreasing and new ways to raise revenues from motoring will be needed. After the failed proposal to introduce a car tax, the Ministry of Environment should start exploring this option and open discussions within governing parties, opposition, experts, and society.

Proposed changes to the existing legislation

If principal agreement on personal car charging on the road will be reached, a corresponding legal act should be adopted. Additionally, a decision would have to be made on the taxing of light commercial vehicles. The levels of penalties for non-compliance should be determined. Furthermore, the procedure of toll collection and distribution of responsibilities for using the revenues should be established.

Stakeholders

Key stakeholders are:

- the Ministry of Environment, the Ministry of Communication, Lithuanian Road Administration,
- public transport operators, including Lithuanian Railways,
- specialists from different sectors: economists, environmentalists, transport engineers, etc.,
- environmental groups, NGOs, and civil society.

Discussion on road taxes for passenger cars should be initiated by the Ministry of Environment which is responsible for pollution and climate change issues and endorsed by the Ministry of Transport. Moreover, the Lithuanian Road Administration implements the e-tolling system and will be responsible for maintenance in addition to technical details and costs. Participants in the discussion should involve specialists from different sectors.

Further, there is a requirement that the proposal is presented and consulted with the public. Therefore, environmental groups and NGOs are expected to play an important role in promoting the road tax for passenger cars and communicating main messages to the public.

Co-benefits

Road charge revenues would be a very important source of income to the mobility fund. Financial resources could be used to improve and develop sustainable mobility infrastructure. Cyclists and public transport users could benefit from improvements made. The revenue might also be used to subsidize rail passenger transport. Shift to public transport might bring additional income to service providers. It can also have a positive effect on the number of car accidents.

Conclusions

The “polluters pay principle” is not applied for passenger car usage yet. The development of an e-tolling system for heavy vehicles could be extended to passenger cars without huge additional upfront investments. It might be an acceptable alternative to rejected proposal on annual car ownership tax. The revenues could be used to support public transport and development of alternatives to private car usage. It is time to start a discussion about it.

City of short distances

Poorly regulated urban sprawl and increasing population density in the central part of the cities require finding appropriate solutions to ensure proper transportation service, which could be convenient and have a low environmental impact. That is a dilemma, which every bigger Lithuanian city faces. After many years of various trials, errors, and searches for solutions urban planners over the world came to the conclusion that it is impossible to have a healthy, energy efficient, and lively city if walkability is eliminated from the core of the urban design. A walkable city is an answer to many of the problems plaguing our cities today.

It is estimated that a person may tend to walk about 15-20 minutes (1-1.4 km), cycle about 25-30 min (5-6 km), and use public transport to travel between 0.5-15 km (Juškevičius, 2003). Only enabling people to reach their destination within these limits would facilitate shifts to these sustainable modes of transport. If distances are bigger, measures to reduce the use of private cars are unlikely to be successful. Considering the fact that each kilometre travelled by car in Lithuania generates on average around 190 gCO₂, should the approximately 50,000 people living in the central part of Vilnius choose short-distance walking instead of driving at least twice a week could save approximately 1000 tCO₂ per year.

The “walkable city”, or “city of short distances” concept is built around the idea of delivering a complex space of mixed functions, with the goal of reducing demand for transport by passenger car. A city modelled like this has less dependence on personal cars, lower emissions, reduced energy consumption, more economical use of infrastructure and a more accessible urban area. These factors contribute to the regeneration of urban vitality, an overall higher quality of life, and the creation of favourable conditions for increased economic and commercial activity. In other words, conditions are created for sustainable development, based on combined economic, social and environmental elements.

The short-distance city is not about restricting mobility, but rather about providing local infrastructure opportunities to inhabitants in such a way that the number of unnecessary daily car trips is minimised. In a compact city, connections to other places are important because people need and want to travel to other places. A combination of fast, efficient, and reliable transport systems is essential and must enable people to switch easily between different modes of transport. Pedestrian transport contributes to activating people in the immediate vicinity and counteracts the atomisation of urban society.

The compact city does not mean that it lacks green zones and social infrastructure. To the contrary: sparsely populated areas will not necessarily be green. However, not every compact city is walkable. It might be just densely populated and dependent on private car usage. The method of organisation matters, not the form.

Responding to current challenges

As cities develop, freeways have been expanded and the inability to control urban development has led to inconsistencies in the street network. For example, in Vilnius, bypasses planned during the Soviet era became a part of the city, which expanded beyond its boundaries even before they were built. At the same time, areas near the highway are attractive for commercial activities due to good transport links. Since bypasses cannot be used for public transport, without connecting roads only passenger cars remain as an option to reach these areas and ongoing development outside the central ring locks in car dependency. Therefore, the development of such urban areas should be especially cautious, and alternative transportation options should be planned in advance.

This situation implies that without a spatial plan, which provides all the necessary safeguards that can ensure the sustainable development of the transport system, and its consistent implementation, it is very challenging to control permanent tension between the individualistic interests manifested in the desire to own and use private cars and the need to reduce transport-based impacts. Situation is much worse when we have neglected problems, which have not been addressed at all for many years and ramping up the capacity of urban roads was considered as the principal measure against traffic congestion.

The walkable city is primarily an urban planning strategy. If walkability is not defined in the general spatial plan, it is rather difficult to secure distribution of different functions like social and recreational ones within walking distance. Additionally, once the habit of using a private car is formed, it becomes very difficult to change. The concept of a walkable city consists of a set of comprehensive measures, the diversity of which determines its versatility and the possibility of implementation in any town. Therefore, it is recommended for cities of various sizes and varying challenges.

Stakeholders

Since the implementation of walkability requires a broad range of different measures, all levels of authority and different interest groups should be involved in the process.

The main stakeholders are:

- the Ministry of Environment, the Ministry of Communication, Lithuanian Road Administration,
- municipal administrations,
- specialists from different sectors: economists, environmentalists, transport engineers, etc.,
- environmental groups, NGOs,
- the active part of society, and
- businesses including property developers.

The role of the Ministry of the Environment is related to the establishment of standards for roads and green infrastructure, as well as the regulation of urban development, the

distribution of climate change mitigation tasks, and the preparation of recommendations for architecture. The Ministry of Communication is responsible for the transport sector strategies in particular for sustainable mobility, regulation of low pollution zones, and road traffic rules. Moreover, the Lithuanian Road Administration ensures road maintenance and implements an e-tolling system.

Municipalities deal with urban spatial planning, issue permits for construction activities, maintain and develop transport and green infrastructure, establish pedestrian and limited traffic zones, transport charging rules, regulate parking and carry out enforcement. They are the main institutions having to balance different interests and to comply with national standards.

Environmental groups and NGOs play an important role in promoting walkability, use of non-motorized transport, support behaviour changes and adaptation to new conditions, provide comments and recommendations to municipal administrations for better walkability implementation. Active parts of society should have a possibility and a forum to share their thoughts and visions, even if these visions contradict the goals of sustainable mobility. They have to be considered in one or another way and establish adequate transitional periods. Additionally, businesses and especially developers have dedicated resources for the protection of their interests and often their influence is much higher than other groups. Therefore, the municipality has an important role of balancing all needs and interests and at the same time be able to achieve the goals of sustainable mobility.

Level of implementation

Implementation of the walkable city is an interactive process typically occurring at the municipal or neighbourhood level in which alternative travel options are developed through a variety of means to induce the decision to walk or cycle as opposed to using a private vehicle. The process of developing induced demand is complex, and a significant part of the population considers efforts to regulate car usage and parking space as an attack on their right to choose. This is a major obstacle that needs to be addressed and considered before any regulatory plans are started to be implemented.

Management of vehicles and their parking spaces is a key challenge for implementation of compact cities. Traffic restrictions remain limited. Vilnius recently introduced loop traffic in the Old Town, in addition to seasonal street closures to car traffic, both of which gave a significant reduction of cars in this area. Results from an online survey shows that people generally are satisfied with the measure (26%) and would be positive regarding the traffic ban in the whole Old Town territory (17%) (Made in Vilnius, 2021). Only 17% were against this measure. The traffic ban was inspired by the success of Savičiaus street closure in previous years and the popularity of outdoor cafes and other activities resulting from the pandemic (Ó Conghaile, 2020). Preparation for the implementation of low-emission zones is currently underway.

Other traffic management concerns include speed limits for pedestrian safety. Pedestrian safety has typically been ensured by maximising separation between people and vehicles, however this may have an inverse effect and lead to unsafe driving as drivers are not as concerned about hitting pedestrians. This dynamic plays out in public opinion, with a survey from the end of 2021 showing that almost 64% of respondents are against car speed reduction in cities. Driver's general disregard for pedestrian traffic may be countered by heightening drivers' awareness of pedestrians so they naturally slow down or choose an alternate route. Streets in living zones and central parts of the cities should be narrowed and speed-limiting infrastructures implemented.

The safety of pedestrian traffic is a key concern for the implementation of a walkable city. Walkable transit corridors are not perceived as a part of the transport system and therefore still are not mapped in cities' general plans often. In the process of buildings' reconstruction, land privatisation transit corridors disappear, because residents perceive them as incompatible with security needs. However, recent public spaces plans treat walking seriously and try to identify and integrate walking corridors into planning schemes.

At the same time, sidewalk maintenance and quality are improving but are still far from perfection. Maintenance and quality of infrastructure require permanent investments which are not always available. The possibility of using EU funds for urban revitalization projects may help improve entire districts, but some territories in peripheral areas remained untouched. Therefore, the situation in the same city can be very different and worsen away from the centre. However, in Vilnius it is understood that good sidewalk maintenance over a year is an important factor in supporting walking and reducing social exclusion.

Non-motorized transport is gaining ground, but not without controversy. Despite significant investments in bicycle routes in Lithuania, the bicycle network is still very segmented. Bigger cities are struggling to increase total bicycle routes length and it is sometimes accomplished at the price of reduced walking routes and even destroyed tree lines. Although cycling has increased significantly over the last ten years, it is still used more for leisure or sports activities than as a mode of mobility. In recent years, the food delivery service using bicycles has grown. However, in general, the number of people commuting by bike is not growing as fast as needed. Furthermore, increase of cycling infrastructure should be accompanied by developing parking spaces for bicycles.

The spread of the use of electric scooters in cities constitutes a new challenge for the cities and caused a lot of dissatisfaction among both pedestrians and drivers due to the occupation of sidewalks and reckless use. Irresponsible behaviour from both users and service providers and lack of clearer regulation of their use need to be dealt with in a comprehensive manner.

Looking beyond transport concerns, land use is critical to walkable cities. The benefits of mixed-used environments are understood because there are many examples where this is not the case: empty commercial districts after business hours, or residential

neighbourhoods without any commerce. This is recognised in Vilnius, where one of the Ten Rules of Urban Planning and Architecture requires the multi-functionality of streets and spaces. Practice shows that businesses already fully recognize what benefits could provide development of various types of mixed-use environment and this principle is applied in all possible cases. The attractiveness of a mixed-use district needs to be considered as well. In order to achieve this, all larger objects should go through an architectural competition procedure. However, we must admit that the architecture of smaller objects is not always attractive, as often when following the developers' instructions in order to save money, insufficient attention is paid to the architectural expression and its appeal.

At the same time, the protection of trees and green spaces has gained tremendous momentum. Various community groups actively participate in the evaluation of city development projects and raise valid questions about each tree that is planned to be cut down. However, city and national authorities do not always respond to high public expectations. Often urban development is undertaken at the expense of green areas and green spaces are not ensured during the development process in some districts. At the national level, attempts were made to reduce the expectations for green areas in cities. There have been cases where lines of old trees were cut down or all greenery was extirpated in urban squares and later covered with cobblestones in the name of urban revitalisation. Most of these cases were met with huge public outrage.

Proposed changes to the existing legislation

Many improvements could be implemented without changing the legislation if these actions would be wider supported by different groups of society. Existing habits prevent the achievement of a significant breakthrough. As a result, more attention needs to be paid to promoting behavioural change.

Further, in order to achieve better conditions for pedestrians, improvements in spatial planning regulation must be made. Missing requirements for district planning do not allow planning alternatives to car use in advance. Additionally, there is a need to change standard technical regulations for road and green infrastructure and establish appropriate norms for green zones in urban areas. Changes in road traffic rules could create preconditions for establishing low-emission or other types of zones. By decisions of municipal councils, parking regulations can be strengthened, establishing limited traffic or pedestrian zones.

Co-benefits

The benefits of the walking city concept are huge and go beyond climate change mitigation. Transport planning practice underestimates non-motorized travel, considering walking usually as a mode of transport with little significance and recognising only the marginal benefits of walking. From a wider perspective, walking can be counted as an essential part of the transportation system, from which society can benefit greatly.

Walking promotes active living for longer and better lives, improves mental health, and brings happiness for many people. It also strengthens community identity and encourages inclusiveness. Reduced dependence on cars saves financial resources and allows using them for other purposes. Additionally, improved air quality, and fewer road deaths due to better traffic safety could be achieved. In general, it helps to strengthen both individuals and communities in many ways. Walkable city benefits contribute to the regeneration of urban vitality and the creation of favourable conditions for increased economic and commercial activity.

Conclusions

To benefit from a sustainable transportation system, an active but wise public education is needed to address the problems arising from conventional transport planning practices. In essence, a walkable city serves as a winning solution in different aspects. However, the full benefits of walking are not properly appreciated yet. A greater appreciation could support less car-dependent urban planning. This justifies more funding for walking facilities and money transfers from street lanes to sidewalks and paths. Greater emphasis on the importance of behavioural change is needed to achieve broader acceptance of walkability and support for corresponding measures.

Improving public transportation

The role of public transport in combating congestion and pollution is well known. Apart from facilitating emissions reduction, public transport provides people access to employment, education, health care institutions, community resources and recreational facilities. Improvement of public transport within this report is understood as the improvement of the following public transport characteristics regardless of whether it is intercity or city transport: time of a travel, reliability, frequency, convenience, user friendliness, and facilitating intermodality.

Travel time is one of the most important criteria determining the choice of transport mode. Generally, about a quarter of responders cite travel time as a main obstacle for choosing public transport (Vilnius City Municipality & Susisiekimo paslaugos, 2018). Urban transport travel time depends on traffic: the higher traffic, the longer time is needed for a trip. If public transport has a priority against private cars on the road, it can compete with them in terms of travel time. This also explains the advantage of rail transport, as the railway usually has the dedicated space for it and has the right of way at the junctions. An alternative to light rail is the bus-based transport system (bus rapid transit system – BRT), which includes dedicated roadways and provides priority to buses at intersections. Additionally, the possibility of rapid boarding and leaving buses and ticket purchasing could reduce travel time.

The public's choice to travel by public transport is highly influenced also by the reliability of public transport. Departure and arrival delays, lack of information about timing are

important reasons why people choose cars. Urban public transport is especially sensitive to it, as even short delays might be unacceptable. Misleading or inaccurate travel schedule announcements in the public areas reduce trust in public transport as it increases uncertainty and prevents reliable route and time planning. This is especially unacceptable for passengers who must transfer to other modes of transport.

The success of public transport is also determined by its frequency and reliability, which allows public transport users more opportunities to avoid stressful situations. Delays can be avoided through an efficient public transport system network, relevant vehicle capacity, adequate vehicle quality and proper maintenance, security, easy ticketing and friendly pricing.

Efficient urban public transport networks should be easily accessible (public transport stops should be no more than roughly 300 m apart) and provide transportation in all the most important directions. Connections with the central station for intercity travels should be well developed. This is very important as travel time to and from the stations is always included in the total travel time. Even a trip with a very fast intercity connection by public transport may not be chosen simply because it takes a long time just to get to and from the station by bus.

Crowding must also be considered. Overcrowded public transport does not provide a pleasant public travel experience for passengers. Commuters often prefer travelling by car if they can, trying to avoid crowding and jostling with other public transport passengers. In urban areas, the number of passengers increases significantly during peak hours. In Vilnius, according to the data for 2022, the number of passengers is increasing by 50 percent at that time. This is less than 5-6 years ago, when the number of passengers was increasing from 79 percent during evening peak to 86 percent during morning peak hours (Susisiekimo paslaugos, 2023a). This requires having more vehicles of different capacities, as well as having enough drivers to work in flexible working conditions. "Susisiekimo paslaugos" data shows that BRT and main routes vehicles are usually occupied above limits. Simply adding more vehicles can solve the situation only partly since the capacity of transport stops to accommodate vehicles is limited in many places and therefore it should be considered at first.

Travelling by public transport is significantly more pleasant when the vehicle is in good order, clean, noiseless and in general well maintained. Dirty, badly smelled and poorly maintained vehicles give a bad experience and make potential passengers avoid public transport if possible.

Transport companies do understand the importance of transport fleet and carriages renewal, but some vehicles still do not meet the requirements of today's consumers. One of the worst situations is with the trolleybus fleet in Vilnius. The average age of the vehicles is even 22 years (BNS, 2022b). Vilnius municipality already announced the call for purchasing 91 new vehicles with autonomous off-wire run. It is planned that Vilnius will renew the entire fleet of trolleybuses by 2026, and the average age of trolleybuses will reach just over two years (BNS, 2022a).

Trains passengers complain that the wagons on non-main routes sometimes are of poor quality, lacking basic hygienic conditions, and are not suitable for transporting disabled people and bicycles. Cleanliness and proper vehicle maintenance are essential elements for newcomers. Most transport companies have introduced new efficient cleaning facilities. Therefore, there is room for maintenance improvement.

A sense of safety and security ensures public trust in the services. The main known factors that make public transport passengers feel unsafe are the presence of disorderly, intoxicated persons, persons violating public order, the presence of unpleasant odours, damaged or dirty public transport inventory, and the presence of signs indicating that public transport vehicle is poorly maintained or even technically out of order.

Ensuring a sense of security is also important when travelling to and from a public transport stop and while waiting for the vehicle to arrive. Pavilions at transport stops should also be maintained. During the winter it is important to secure access to transport stops by shovelling snow from the sidewalks. They should also be well lit during dark hours of the day.

A critical element of increasing public transport attractiveness is simplicity, particularly in ticketing and navigation. The ticket sales and distribution network should be as convenient as possible for the user. When choosing a transport means, the user also evaluates the price of the provided services. If the price of services is not an economic incentive, the user tries to avoid it and chooses private car option. The simplicity of the public transport system makes it user-friendly for all members of society to use public transport services and helps to attract new users who often do not choose public transport, because they don't know how to use it. Also, the unified ticketing system could help to simplify the system and to make easier use of different modes of transport. Finally, the public transport system must be adapted for people with special needs.

The combination of different modes of transport offers the possibility to optimise the transportation network, to adapt it towards existing urban and logistic structure and to match personal preferences in terms of costs, time or activities. Combining different transport modes can help to cut transportation maintenance costs and to provide user needs oriented transportation services. Intermodality can be applied for long distance travels and in case of everyday mobility as well.

It is important to note, that none of the transport modes is advantageous just because of its form. The most advantageous mode is one that scores highest on the four basic principles: affordability, accessibility, connectivity, and ecological footprint based on life cycle assessment.

Responding to current challenges

Despite decreasing total population in Lithuania both in cities and in rural areas from 1990, the urbanisation process during the last two decades progressed significantly. The number of people living in urban areas more than twice exceeds the number of people living in rural areas. Therefore, cities face major mobility challenges followed by increasing environmental impacts as urban transport expands. Thus, attention is primarily paid to urban transport systems, but the issue of organising passenger transportation between cities remains no less important.

The towns in Lithuania are connected by a fairly well-developed road network. Therefore, most trips are made by road transport: private cars and buses. The low population density in Lithuania decreases the efficiency of public transport outside of the major cities. Although the railway network is not very convenient for travelling around the country, connection between the main cities (Vilnius, Kaunas, Klaipėda and Šiauliai) are reasonable and competitive with road transport. Therefore, these routes have to be improved and developed further to maximise utilisation. At the same time, international connections should be improved, particularly with Warsaw.

Looking to the municipal level, the urban public transport service is unable to respond to the current users' needs in biggest cities and always ensure fast and reliable transportation options. The public transport network must be modernised, including a network of dedicated roadways and corresponding infrastructure. Public transport must provide high-quality services corresponding to international standards. Advanced urban passenger transport management and traffic control systems should be introduced. Additionally, railway integration into urban transport schemes is still missing. Therefore, further improvement of intermodality, like introduction of common service terminals for different modes of transport, is needed. Unification of the ticketing system is still missing.

Implementation

Improvement of public transport requires a broad scope of measures. These include optimization of public transport network, investments into corresponding transport management and public infrastructures, proper maintenance, and better coordination between different players providing passenger transportation services.

Time of travel

Time needed to get from Vilnius to Kaunas, Klaipėda or Šiauliai is almost the same if the trip is made by personal car or by train. As of 2023, the highest speed of passenger trains in Lithuania was 120 km/h. Without exceeding this speed, the train already travels from Kaunas to Vilnius in 59 minutes, which is faster than travelling by car. The railway company "Lietuvos geležinkeliai" is implementing a program aimed at increasing the speed of train travel and shortening the travel time. Currently, there are several sections where the speed can be increased to 160 km/h without major investments.

Ongoing reconstructions of some sections of Vilnius-Klaipėda route also will increase the speed up to 160 km/h (Lietuvos Geležinkeliai, 2020). Thus, travel from Vilnius to Klaipėda also will become faster. Now the train can compete only with buses: it takes the same 4 hours to reach the city of Klaipėda, which is on the opposite side of the country.

The recently opened link between Vilnius, Warsaw and Krakow is currently very popular among the tourists only because of reasonable prices, but not because of travel time. The journey from Vilnius to Warsaw takes nine hours, a third longer than if such a trip is done by car (LTG Link, 2022). Ongoing development of "Rail Baltica" project will help to reduce travel time needed.

Railway electrification helps to increase the speed, but it should be followed by corresponding railway reconstruction works. Considering resources needed it is unlikely that such progress is feasible any time soon.

Time for travel to and from the train station is a part of the total travel time and good railway network interlinkages with other modes of transport, allowing passengers to reach their final destinations, are essential for competitive train travel in terms of time needed for a journey. There is no single solution for all cities and places on how to improve intermodality. It should be considered case by case taking into account local circumstances and responding to users' needs.

At the city level, infrastructural interventions to reduce travel time include exclusive public transport lanes and preventing their unauthorised use, as well as giving public transit priority at intersections. Overhead contact line systems for trolleybuses need technical improvements that allow them to pass junctions without reducing vehicle speed.

In addition to going to and from the start/end station, travel time is very dependent on transfers needed. Surveys showed that one third of passengers have to transfer once during their trip and around half of passengers travel without transfer in Vilnius (Vilnius City Municipality & Susisiekimo paslaugos, 2018). The time spent at transfer points is perceived as twice as long compared to the travel time by vehicle (Ibid.). Thus, required transfer from one vehicle to another and waiting at a bus stop discourages users from using public transport services. Although generally well regarded, transfers are cited by passengers as some of the least satisfying moments as a customer satisfaction report of Vilnius city shows (Susisiekimo paslaugos, 2021). Cities with a high number of public transport users lack such local transfer points, which could allow passengers to quickly change buses.

Combined bike-bus trips should be promoted in sparsely populated areas adjacent to bigger towns where broader coverage by public transport is not efficient. Infrastructure to leave bicycles safely near bus stops and bicycle roads for safe cycling from home to bus stop and back could be very welcome especially for school children. The possibility of maintaining such systems as a part of city transport infrastructure should be

assessed and evaluated further. Until now, there is no known example of such intermodality application in Lithuania. Only by introducing the measures in a complex way, it would be possible to reduce travel time and increase passengers' satisfaction accordingly.

Reliability and user trust

The customer satisfaction analysis shows that passengers highly valued railway services. Punctuality gave 9.1 points out of 10 in 2020 (Made in Vilnius, 2021). In social networks and below corresponding mass media reports, a significant spontaneous increase in dissatisfaction with the quality of the services and a decrease in trust in the service provider could be observed (Kauno Diena, 2021). Passengers' information in extraordinary situations is essential in order to maintain reliability of the service on a high level, therefore lessons should be learned.

Customer satisfaction analysis showed that urban transport passengers' responses were very positive and satisfaction with the service grew over the last 6 years. Punctuality was not indicated as the strongest side of the service, however highly rated (Susisiekimo paslaugos, 2021).

It is obvious that 100 percent reliability is not achievable. Vehicles break down, road accidents happen. It is important to provide further information about events which delay or hinder vehicle arrival and to implement more broad usage of information boards at transit stops. Of course, near real time information about vehicle current location can be accessed using mobile phones. Additionally, better maintenance and permanent fleet renewal are important factors ensuring reliability of the service. A case in point is the purchase of new trolleybuses in Vilnius. Due to their possibility of travelling certain distance without overhead charging, they will be able to go around road obstructions in case of accidents. This should increase their reliability.

Distrust in public transport is also catalysed by public transport drivers' strikes. Due to strikes, the long-lasting paralysis of public transport reduces the willingness of the population to rely on public transportation services. The recent driver's strike in Vilnius at the end of 2022 showed that the situation leads to damaging of public transport service reputation, especially when the city authority meets the demands of the strikers only after the certain time of strike.

Coverage in rural areas

The COVID-19 pandemic has had a severe impact on intercity and regional transportation services. Service providing companies together with municipal administrations had to review both their routes and frequency of transfers. The situation remained almost unchanged even after the pandemic. In reaction to reduce utilisation rate, some rural municipalities and service providers cut remote and weekend routes and reduced frequency of trips (Lankininkaitė & Mizgirdė, 2022). In

recent years, state compensation for passenger transport losses has approached 40 million EUR per year (Jankuviene, 2022).

Trains run more frequently between larger towns. However, some routes have been cancelled and others are going to be cancelled later (Mizgirdė & Valiauskaitė, 2021). Thus, residents of remote areas are left without transportation service, and where it was already poor, it is made even worse. The situation in larger cities is better, but the number of passengers did not reach the numbers of pre-pandemic period (Statistics Lithuania State Data Agency, 2022).

As has already been mentioned before, the Covid-19 pandemic largely determined public transport service coverage. Remote and sparsely populated areas have been left on their own. This also touched bigger centres, where shuttles from adjacent areas with low occupancy have been cancelled. The joint work of municipal administrations and service providers is needed to maintain a core of the passenger transport network and secure its integrity and connectivity.

Urban areas have to be planned considering requirements for public transport network development and demands of users. Convenient access to transport stops is an important element of transport network planning which largely determines the acceptance of the service in the future since the long and inconvenient path to them reduces the attractiveness of public transport. Most of the new large attraction sites are planned with minimal adjacent parking spaces. This means that the passenger transport service should be adaptive and capable of transporting more passengers before the event and after it.

Digitalisation and pricing

Looking towards digital infrastructure, the ticketing system is quite well developed in general. Simple mobile applications allow the purchase of a ticket for urban transport when it is needed. On-line ticket services available for all modes of transportation. Introduction of single ticket for train and bus is needed. Public transport ticket prices are competitive enough for single travellers.

A one-time ticket for urban public transport is quite cheap. In many rural areas, it is provided free of charge due to the low number of passengers using public transport. Despite some suggestions to make all Vilnius city public transport free of charge it would not be recommended. The main arguments against it is existing chronic deficiency of financial resources for transport system maintenance.

Train ticket prices from Vilnius to Warsaw and Krakow are very competitive. However, the service on both sides should be improved. From the Polish side: lack of catering services during a significant part of the trip, lack of Wi-Fi, problems with lightning and electric sockets, no digital ticketing, and from Lithuanian side: absence of places for luggage, no shelters in Mocava to hide from rain, snow or wind where passengers had

to change the trains. When "Rail Baltica" starts operating, the situation should change fundamentally.

Among more general recommendations dedicated to improving user-friendliness of urban public transport, especially considering the elderly and those who don't speak the language, wider use of graphic visual information, which in a simple way explains how to buy a ticket and where to find more information about routes and schedules, is recommended. For the younger part of the population Wi-Fi and USB ports in the vehicles – buses or trains - are of increasing importance.

Greater integration leading to better modal choices

The most complex interaction between modes of transport occurs at junction points. International practice shows that these junction points work most effectively when they are integrated into intermodal passenger terminals, which can serve local, regional or national transportation needs depending on the purpose. Such terminals both make public transport more attractive and reduce transit time.

Transport terminals serving local transportation needs can be just a simple platform where several transport modes are located in the same area or are at least close to each other. The design of such a platform should encourage modal transfer. As it was mentioned previously, such platforms could be useful in sparsely populated areas where combined bike-bus trips might be an option.

The most practical upgrade for transport terminals, at least in the case of Vilnius, would be integration of car parking facilities with public transport. Such terminals should have BRT connections and be integrated with supermarkets and other commercial facilities forming a hub on the outskirts of the city or at least in remote city districts. With the Park & Ride option, they will form points of attraction and could stimulate further development of a polycentric city.

Stakeholders

The main stakeholders are:

- municipal administrations and city council members;
- transportation service providers;
- the Ministry of Transport and Communication, the Ministry of Environment;
- residents, local communities; and
- environmental groups and NGOs.

Responsibility for local public transportation schemes and strategies belongs mainly to municipal administrations. Together with the transportation service, municipalities should elaborate cost efficient public transportation schemes which could adequately serve residents' needs. The overall responsibility for transport and in particular sustainable mobility strategy, compensations for transport losses and development of the national railway system belongs to the Ministry of Transport and Communication.

Since direct users of the transport systems are different members of society with their needs and expectations, it is crucially important to reflect it. Possible options are shaped by political orientations and priorities and there is a need for a strong voice from different environmental groups, NGOs and the Ministry of Environment to secure environmental concern and sustainability principles strengthening transition from private cars to other mobility alternatives.

Proposed changes to the existing legislation

The actions needed which have been described in this chapter on improving public transport do not require any specific changes in existing legislation since it is about implementation of existing legal requirements. Only a revision of Sustainable Urban Mobility Plans might be suggested, as they are not directly targeted at the reduction of CO₂ emission in most cases now.

Co-benefits

Public transport can significantly reduce the high dependence on cars and thereby contribute to climate change mitigation. It also plays an important role in facilitating interactions, especially for those who cannot afford a car, or are not able or eligible to drive, thus promoting social equality. It provides cheap access to employment, education and mostly everything needed for daily life. Public transport also creates employment opportunities as many people earn their livelihood either directly or indirectly from it.

It helps to exercise and improve physical fitness while walking to the public transport stop. Travel using public transport in general is safer than using private cars. Public road transport helps to reduce congestion and opens roads for ambulances, fire and food trucks, taxis and many other services that need to use roads to access points of destination. Decreased need for parking spaces and extra lines on the road increases land value and lets people use it for more valuable uses.

Conclusions

The use of domestic passenger transport has halved due to the COVID-19 pandemic. Financial challenges have forced reviewing of passenger transport routes and frequencies. In order to reach and exceed the pre-pandemic passenger volumes, it is necessary to maintain the quality of transportation service and to focus on the means that allow the recovery of transport usage. Measures enabling public transport to compete with cars should be continued to be introduced further, giving priority to those measures which the public find most attractive and encourage them to plan their trips with greater reliance on public transport.

Conclusions

Despite the overall downward trend of greenhouse gases emissions in Lithuania during the last 20 years, emissions from transport sector grew around 50 percent during the last 15 years. But it is only a matter of time before this growth ends and we see the opposite trend. Electrification of the transport sector is inevitable and should be strongly supported.

However, the inevitability of change does not mean that efforts are not needed to reduce greenhouse gas emissions from the transport sector and to strive towards sustainable mobility in general. Inevitability is more about common sense which is based on knowledge of global natural processes induced by human activities.

Now we are facing global changes that humanity has never faced before, at least not on such scale. Thus, any efforts to make our lives more sustainable make sense. Increasing the energy efficiency of passenger transport is part of this efforts.

Our efforts also have to be cost effective and lead to set goals. This report contained a list of proposed comprehensive and effective measures aimed at the use of passenger cars and promoting alternatives, which, if properly organized, could lead to more sustainable passenger transport in Lithuania.

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