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Successful Sustainable Mobility Measures Selection

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Abstract. In recent years, on the EU transport initiatives, the EU member states have been creating sustainable urban mobility plans, which is new practice for the majority of the EU cities. Both municipal experts and plan developers suffer from lack of knowledge, experience and confidence in producing the above introduced documents. The article analyses possible solutions for sustainable urban mobility plans and presents the sets/scenarios of the proposed measures exactly corresponding the specificity of cities different in size and significance.

Keywords: sustainable urban mobility plan, mobility management, mobility measures, environmental impact, transport planning.

Conference topic: Sustainable urban mobility.

Introduction

Until now, an issue of a negative impact of transport on the environment in Lithuania has been considered developing transport infrastructure. This has further promoted the use of cars and increased their congestion thus causing a number of negative consequences, including inefficient economy, time loss, transport pollution and traffic accidents (Burinskienė *et al.* 2011). The main reasons leading to the current situation have occurred due to urban transport systems poorly designed for the needs of the urban area residents of all ages, social and interest groups because of lack of alternatives for travelling by car.

Urban mobility and management plans in European countries have been prepared since 1972. In the last decade, sustainable urban mobility plans (e.g. mandatory for English and French cities having more than 100,000 inhabitants and Italian cities having more than 30,000 inhabitants) have been launched. A sustainable urban mobility plan is defined as a group of interrelated measures and integrated offers for all vehicles to satisfy people and business mobility in the city and its outskirts at present and in the future.

A better quality of life, improved accessibility to objects and facilities, health and environmental benefits make only a part of the plan for implementing an achievable effect, which requires proper methodical preparedness. Up to now, the adaptation of the produced manuals and recommendations in the European Union member states having insufficient experience has been a complex process, because all recommendations are unified and prepared for mid-sized cities characterized by the long-term practice of strategic urban mobility planning and by communication features typical of the cities of a similar size.

Lithuania is not an exception, and sustainable urban mobility plans of 18 cities will be designed for the first time and include Vilnius as the capital city, resorts and the port of Klaipeda. The vast majority of plans comprise the centres of small areas and larger regions. All of them are characterized by their specificity, difference in planning, urban economy management practice and a transportation system for different traffic types, flows and travel habits. The size of cities varies from 2–3 thousand to 0.5 million inhabitants. The development of sustainable urban mobility plans is further impeded by the features of national planning when solutions for mobility management are improperly implemented due to the existing "minimum" standard (i.e. lower number of parking spaces than that specified in technical regulations cannot be installed (Gaučė 2009). Lithuanian sustainable urban mobility plans will be designed in accordance with The National Guidelines on the Preparation of Sustainable Urban Mobility Plans, where 9 thematic areas are recommended to develop – *Promotion of public transport, Non-motor vehicle integration, Modal shift, Traffic safety and transport security, Improvement of traffic organization and mobility management, City logistics, Integration of people with special needs, Promotion of alternative fuels and clean vehicles, Intelligent transport systems demand assessment* (MoTC 2015).

Thus, with reference to the detailed analysis of practical studies and methods applied in foreign countries, the article is aimed at *a reasonable classification of sustainable urban mobility measures and assessment of their efficiency depending on the status (capital city, regional centre, resort area or industrial city) and size* (population of more than 200,000, from 50,000 to 200,000, from 20,000 to 50,000 pop and less than 20,000 inhabitants.) of the city.

Relevance and object of research

Scientists, transport experts, local government representatives and various research agencies have established a few systems for assessing the efficiency and cost-effectiveness of sustainable urban mobility measures used for determining the most effective instruments and their economic benefits (Chakhtoura, Pojani 2016; Nocera *et al.* 2015; Shiau, Liu, 2013; Lima *et al.* 2014; Silva *et al.* 2010; Haghshenas *et al.* 2015).

For example, for developing sustainable urban mobility plans, the major focus in Portugal is shifted on seeking for social and economic benefits. Considering "potential (social) sustainability indexes" established by the National Institute of Statistics (Portugal), the size of the city and transport infrastructure, the following measures for enhancing the mobility of predominant social groups (children, teenagers, pedestrians, seniors, tourists, people with disabilities, public transport users, cyclists, drivers) are imposed (Arsenio *et al.* 2016):

- Social equality and accessibility are more important for the cities with lower population and density (up to 20 thousand inhabitants) and a lower sustainability index. In most cases, these are the examples of the cities with a lesser supply of public transport. Strategies for developing urban mobility in resort areas are clearly devised (regardless of population size or sustainability index), and cities are focused on improving pedestrian and cycling infrastructure.
- The cities with a population of 20–50 thousand inhabitants place greater emphasis on the development of public and non-motorized transport (bicycles, pedestrians); however, depending on the sustainability index, some cities invest in improving infrastructure for the urban mobility of pedestrians and people with disabilities (lower sustainability index), whereas the others are more focused on infrastructure development, changes in behaviour and habit formation (higher sustainability index).
- Larger cities (population of more than 50 thousand inhabitants) are more concentrated on congestion mitigation, and therefore the options for selecting urban mobility measures are wider and depend on the urban transport system. Improvements in cycling and pedestrian infrastructure, public transport development, the management of car parking places and an increase in the attractiveness of public spaces are the measures for improving the urban mobility of all social groups in bigger cities; nevertheless, the cities counting a higher percentage of young working population prefer the idea of promoting the use of an alternative fuel in vehicles.

Meanwhile, with reference to 3 published studies assessing transport sustainability in certain cities (Lyon, Taipei, Melbourne), scientists Chakhtoura C. and D. Pojani produced a slightly different model for evaluating the transport system in Paris. The model identified the assessment areas, including *the types of public transport, non-motorized transport, personal motorized transport, the mobility of vulnerable groups of people, accessibility, alternative renewable energy, environmental pollution, safety, car storage, the promotion of sustainability, planning, innovation,* and urban mobility indicators having the greatest impact on the above mentioned areas (Chakhtoura, Pojani 2016).

T. Litman (reviewed 54 systems for assessing transport sustainability in 22 countries) revised a number of systems for different sustainable transport indicators in his research work and arrived at a very valid conclusion that the indicators for assessing sustainable urban mobility did not always assist in properly considering urban transport systems. For example, if an area of applying the indicator is very narrow, it does not reflect the true value of sustainable urban mobility (in the case when the assessment of the vehicles using an ecologic fuel only is promoted and the evaluation of accidents is ignored, the index of sustainable urban mobility will not reflect the real situation) or intermediate targets rather than the final result are assessed (length of bicycle routes is an intermediate result that may not necessarily mean the final result that is a greater number of users, because the routes may be planned taking into account the lowest price rather than the real need) (Litman 2016). For assessment purposes, the identification of precise evaluation areas and their relevance to the entire transport system are of crucial importance. Therefore, T. Litman analysed all measures assessing transport sustainability and proposed a personal system for economic, social and environmental indicators, including "most important" (should usually be used), "helpful" (should be used if possible) and "specific" (should be used with particular attention to specific needs and objectives). Besides, the author highlights that these indicators could be also divided considering demographic groups and a geographic location.

In their study, S. Nocera, S. Tonini and F. Cavallaro investigated fluctuations in climate change caused by transport pollution and assessed the economic efficiency of urban mobility measures reducing CO_2 emissions. The scientists conducted research and used the Sustainable Energy Action Plan (EU 2010) that identified 6 major areas of investments in transport. The areas specify the following measures for lowering CO_2 emissions: *reducing demand for transport, increasing the attractiveness of alternative transport, making travel by private car less attractive, information dissemination and marketing, reducing the number of municipal and private business fleet vehicles, smart transport.* The authors also examined in detail the measures employed in urban mobility management, a renovated public transport fleet, sustainable urban mobility universities, a renovated private car park, a renovated commercial vehicle fleet, business mobility management, new infrastructure and limited traffic zones and, in accordance with the expected period of operating equipment, considered their implementation costs and CO2 reduction levels (see Table 1) (Nocera *et al.* 2015). The assessment of reducing CO2 only makes clear that urban mobility measures have no positive economic indicators, except mobility management that does not require large investments and the operation of which is based on employing soft measures.

Table 1. The impact of urban mobility measures on reducing CO2 emissions (Source: Nocera et al. 2015)

	Measure	Costs	Vali-dity	Annual CO_2 reduc-tion	Overall CO_2 reduc-tion	Overall CO_2 benefit	Balance	CO_2 Effi-ciency
		a)	b)	c)	d) b*c	e) d*43,84	f) e-a	g) e/a
n		€	year	t/year	t	€	€	
1	Mobility management	124,500	6	1,758	10,548	462,463	337,963	3.715%
2	Bus renovation	15,700,000	5	89	445	19,510	–15,680,490	0.001%
3	Sustainable mobility at the university	40,000	3	90	270	11,838	–28,162	0.296 %
4	Renovation of the private car park for the period 2006–2010	314,800,000	5	36,497	182,485	8,000,806	–306,799,194	0.025 %
5	Renovation of the private car park for the period 2011–2020	1,386,000,000	10	41,961	419,610	18,397,229	–1,367,602,77	0.013 %
6	Renovation of the commercial fleet for the period 2006–2010	124,000,000	5	3,707	18,535	812,642	–123,187,358	0.007 %
7	Renovation of the commercial fleet for the period 2011–2020	227,000,000	10	6,781	67,810	2,973,037	–224,026,963	0.013 %
8	Improvement in business-like mobility management	10,100,000	10	1,060	10,600	464,743	–9,635,257	0.046 %
9	New infrastructure	696,800,000	10	3,675	36,750	1,611,254	–695,188,746	0.002 %
10	Limited traffic zone (LTZ)	4,280,000	16	2,781	44,496	1,950,867	–2,329,133	0.456 %
	Total	**2,778,844,500**		**98,399**	**791,549**	**34,704,388**	**–2,744,140,11**	**0.012%**

T. Shiau and his colleagues used the extended rough set theory (Greco *et al.* 2001) and developed a system for identifying the most important urban mobility criteria having the greatest impact on the transport system (Shiau *et al.* 2013). Next, T. Shiau and J. Liu applied the created system in their work and selected 21 criteria classifying them according to their economic, environmental, social and energetic aspects. With the help of the Analytic Hierarchy Process, they defined the weights (values) of these criteria (Shiau, Liu 2013). The analysis of the criteria and the application of the Pareto principle helped in selecting 10 main criteria, including *alternative and renewable energy consumption, a modal split in transit, emission intensity of greenhouse gases (GHG), emission intensity of air pollutants, the proximity of transport infrastructure to designated environmentally sensitive areas (ESAs), traffic accidents, mobility and transport for the elderly and people with disabilities, transport infrastructure in remote areas, transit subsidy in remote areas, recycling end-of-life vehicles*, that made 79.1 % of the weight of all criteria. The employment of the above introduced method allows for a clear identification of priority actions and admits to making all investments in the measures having the greatest benefit and the most powerful social, economic and environmental effect.

Researchers J. Lima, R. Lima and A. Silva selected a different method for assessing urban mobility measures. The authors used the method examined by Mancini (Mancini, Silva 2011) and analysed urban mobility measures according to three categories (cost, time required for implementation and political risk). The results of such assessment can be characterized as the combinations of significance starting from “all significant categories” (fully appreciated in terms of time, costs and assuming political risk) to the “hardly implemented” ones (weak results in all three categories) (Lima *et al.* 2014).

For receiving results, surveys were conducted interviewing an expert of municipal administration and an independent specialist of transport and mobility management (answers of two representatives having different competencies and performing different functions in the planning process were compared). The respondents assessed the effectiveness of urban mobility measures in terms of time, cost and political risks (see Table 2). The received findings show that 7 measures playing a crucial role include *information available to the population, the density of the street network, a bicycle fleet, the number of trips, the expertise of technicians and managers, a traffic education* *program* and *on-time performance*. 30 measures are accepted as important, 31 measures are attributed to those recommended for implementation and 19 measures fall into the category of hardly implemented ones. Also, the survey results showed that the expert of municipal administration had a more positive vision of urban transport than the independent specialist of transport and mobility management. This indicates that administration experts sometimes encounter difficulties in assessing and identifying the results and values of different measures. Subsequently, this leads to the inefficient development of the transportation system and low environmental outcomes.

The analysis of research sources concludes that, regardless of the assessment system, urban mobility measures for improving public transport supply and its infrastructure, developing infrastructure for cyclists, pedestrians and people with special needs, employing the renewable sources of energy, information accessibility and education about the benefits of sustainable urban mobility tend to dominate in both theory and practice.

Table 2. The assessment of urban mobility measures according to categories

Assessment	Time	Cost	Political risk	Scores
Good (G)	4 years	High	Big	3
Medium (M)	8 years	Average	Medium	2
Bad (B)	More than 8 years	Low	Small	1

Research methods and results

Taking into consideration different methods for combining urban mobility measures, the authors have developed a common set of instruments and classified them according to the basic principles of sustainable development: economic benefits, environmental improvement and social equality. Most sustainable urban mobility measures are significant not only for some particular sustainable development principle of the above mentioned three ones, but, simultaneously, may be more or less important to some of those; thus, the measures are of *higher* or *lower* significance under the principles of sustainable development (see Table 3).

To further develop the urban planning model analysed in the paper by R. Hickman, the authors identified 4 major scenarios for urban mobility management (Hickman *et al.* 2013). These development scenarios were simulated referring to the urban planning model proposed by R. Hickman. The model suggests that technology development and environmental friendliness have the greatest impact.

Scenario No. 1 represents *Business as Usual (BAU)* which is the steadiness of the current development trends bearing in mind low investments in public transport infrastructure, minor changes in vehicle fleet management (age, parking fees, etc.) and the use of an alternative fuel under lack of a rational development strategy. Such a scenario is mostly used in the cities having small population (up to 20 thousand inhabitants), not encountering significant transport or pollution problems and owing a well-developed street network and excellent accessibility to services.

Scenario No 2 represents the *Low Carbon Driving* system focused on an increase in traffic flows to achieve a fair reduction in emissions from vehicles (approximately 25–30%). In this case, success largely depends on the ambitions and scopes of implementing technological measures (engines of the vehicles with low emissions or the use of an alternative fuel in vehicles). Such a scenario is mostly used in medium-sized cities (from 20 to 50 thousand inhabitants) that are known for more intensive transport flows, a higher number of attraction objects and job offers as well as acting as the centres of smaller regions.

Scenario No 3 represents *More Local Travel* that concentrates on the development of public transport, cycling and pedestrian infrastructure and smart management (travel plans, flexible work schedules, etc.) and a fully integrated transport system. Such a scenario is mainly used in larger cities (from 50 to 200 thousand inhabitants) having a clear communication system with public transport and integrated transport systems. These cities retain the main features such as heavier traffic flows, higher expectations for congestion, a large supply of services and attraction objects. This scenario may involve resort areas that pay considerable attention to enhancing environmental quality and to increasing urban attractiveness with the help of technological instruments.

Scenario No 4 represents *Sustainable Mobility* that combines the most efficient use of technologies and instruments for changing human habits thus aiming to reduce environmental pollution from vehicles up to 60–80%. Serious attention is paid to the integration of different social groups and to the development of new technologies. Such scenario is most frequently used in large cities (population of more than 200 thousand inhabitants) and mostly includes capital or other famous cities where the transport system is formed following the latest tendencies, employing the latest technologies and seeking to improve the image of the place in the context of other European cities. These urban areas face big transport problems (congestion, poor car storage management, inadequate development or quality of the public transport network, etc.). In addition, this type of cities experiences the increased activity of social groups striving for better living conditions.

The Hickman's model is supplemented with sustainable urban mobility measures assessed by the authors in Table 3 thus proposing the following city development model, including sustainable urban mobility (see Fig. 1).

Table 3. Sustainable urban mobility measures and their significance

	Economic		**Environmental**		**Social**		**Scenario**
Title	**High EC**	**Low EC**	**High EN**	**Low EN**	**High SC**	**Low SC**	
Traffic accident prevention	x			x	x		2, 4
Car-sharing penetration		x	x		x		3
Managing delivery services		x		x		x	1
Density of the street network		x		x		x	1
Population education about sustainable development		x	x		x		3
Electric vehicle infrastructure	x		x			x	2, 4
Facilities for bicycle parking		x		x	x		1, 3
New cycling infrastructure		x	x		x		3
Security cameras for public safety		x		x	x		1, 3
Improvement in public space (street pavements, lighting, removing barriers)		x		x	x		1, 3
Improvement in public transport quality (air conditioning, cleanliness, overcrowding)	x		x		x		4
Renewable energy consumption in public transport	x		x			x	2, 4
New public transport routes		x	x		x		3
Special lines for public transport	x		x			x	2, 4
Quality of public transport stations		x		x			1, 3
Public transport time and frequency		x	x		x		3
Improvement in public transport for users with special needs		x		x	x		1, 3
Improvement in signage and information systems for drivers (electronic/conventional)		x		x	x		1, 3
Information available to the population		x		x	x		1, 3
Mobility promotion campaigns	x		x		x		4
Park & Ride	x		x			x	2, 4
Parking fees	x		x			x	2, 4
Parking spaces to users with special needs		x		x	x		1, 3
Pedestrian-only zones	x		x		x		4
Priority to cyclist and public transport		x	x			x	1, 3
Reduced black spots	x			x	x		2, 4
Reduced freight transport traffic in the city centre	x		x			x	2, 4
Reduced noise level		x		x	x		1, 3
Reduced parking places		x	x		x		3
Reduced traffic speed in the city centre		x		x	x		1, 3
Traffic speed cameras		x		x	x		1, 3
Plans for the tourists seasons	x		x		x		4
Tourist shuttle	x			x	x		2, 4
Road safety education program	x			x	x		2, 4
Congestion charges	x		x			x	2, 4
Transport fleet age (companies, public authorities, etc.)		x	x			x	1, 3
Transport plans for companies/schools	x		x		x		4

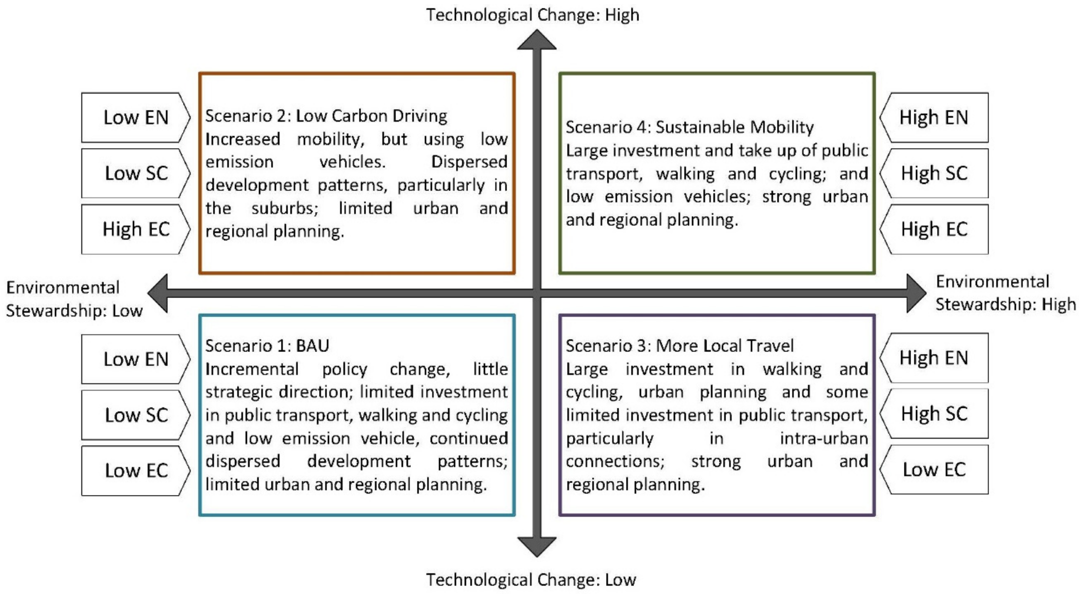

Fig. 1. A model for urban development scenarios and sustainable urban mobility measures inherent in them

The applied benefit of the model includes result-oriented planning of the most effective urban mobility measures taking into account urban specificity and development opportunities. The model should be particularly useful to cities "beginners" designing plans for the first time and to the institutions producing methodological recommendations.

Conclusions

1. Up to now, a negative impact of transport on the environment in Lithuania and other European countries has been considered by the development of transport infrastructure. This has further encouraged the use of cars, increased their congestion, and simultaneously, a negative impact on the environment.

2. A sustainable urban mobility plan is defined as a group of interrelated measures and integrated offers for all vehicles to meet people and business mobility in the city and its outskirts at present and in the future. According to the European Commission White Paper (EC 2011) and having regard to Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions "Together towards competitive and resource-efficient urban mobility" (COM 2013), the European Union member states must prepare sustainable urban mobility plans in accordance with national planning specificities.

3. The analysis of research sources has shown that, regardless of the assessment system, urban mobility measures for improving public transport supply and its infrastructure, developing infrastructure for cyclists, pedestrians and people with special needs, employing the renewable sources of energy, information accessibility and education about the benefits of sustainable urban mobility are agreed to be the most efficient and tend to dominate in both theory and practice.

4. A comprehensive analysis of foreign methods and practical studies has reasonably classified sustainable urban mobility measures recurring in 37 investigated sources and assessed their effectiveness in the context of sustainability.

5. Taking into account foreign experience, four main future scenarios supplemented with sustainable urban mobility measures, including *Scenario 1 – Business as Usual* (cities counting up to 20 thousand inhabitants), *Scenario 2 – Low Carbon Driving* (district / regional centres counting from 20 to 50 thousand inhabitants), *Scenario 3 – More Local Travel* (larger cities counting from 50 to 200 thousand inhabitants and resort areas) and *Scenario 4 – Sustainable Urban Mobility* (capital, port and large cities up to 200 thousand inhabitants), applied primarily to Lithuanian cities but also transferable to other EU countries have been created.

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