

## ELECTRIC CAR INTEGRATION IN VILNIUS

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**Abstract.** Rapid increase in the car ownership level in the towns of Lithuania cause environmental problems (noise, pollution, etc.). One of the ways to solve these problems would be a wider use of electric cars instead of usual cars. It is important to analyse and substantiate the optimal deployment of plug-in stations in accordance with the chosen criteria, the related problems and the possibilities. Vilnius was selected as a reference point for the installation and integration of plug-in systems for electric cars in Lithuania. For electric cars to be widely used, a plug-in network should be developed in towns. A pilot electric car battery plug-in and switch infrastructure network is planned to be developed in Vilnius until 2015. Different measures should be taken to motivate Lithuania's citizens to choose green cars, namely: free parking of cars in the downtown area, partial compensation for battery charging, free entrance into the pay zones, free registration of a car, no road charges, etc. Three possible concepts were worked out for the integration of electric cars. In future these three concepts could be implemented and joint into a common electric car plug-in network.

**Keywords:** electric cars, plug-in network, urban transport.

## 1. Introduction

Lithuania, as the EU Member State, contributes to the long-term sustainable development strategy aimed at preservation of clean and healthy environment and higher quality of life for the present and future generations. Implementing this strategy it is important that the economic growth accelerates social progress and improves environment, and that the environmental policy is economically efficient. In the strategy special attention is devoted to the fact that the economic growth should be detached from resource exploitation and environmental impact, i.e. to the aim to achieve that resource exploitation and environmental pollution is much slower than the economic growth or remains at the same level without increasing at all (A. Vasilis Vasiliauskas and I. Kabashkin 2009). Adapting the goals of the strategy for the improvement of the environmental state of Lithuanian towns, a possibility to integrate electric cars into the city of Vilnius is analysed.

Due to the increasing awareness of global warming in many nations, policies to raise the share of renewable energy are being initiated as part of the global response to climate change. A key element in achieving such goals is to use renewable energy in the transportation sector (H. Lund, Woodrow W. Clark II 2008).

Currently electric cars are not popular. However, they start winning popularity in the EU Member States and Japan for the reasons of both environmental protection and saving of fossil energy resources as well as

cutting down fuel expenses. In near future electric cars will become an everyday vehicle, and in the perspective electricity-powered vehicles will dominate in towns. For the citizens to want to drive electricity-powered cars, mere knowing that such cars are environment-friendly and economical of fuel is not enough. Wide prevalence of electric cars is conditional upon a dense plug-in network as drivers must have a possibility to regularly charge batteries of their cars.

It is important to analyse and substantiate the optimal deployment of plug-in stations in accordance with the chosen criteria, the related problems and possibilities. Vilnius was selected as a reference point for the installation and integration of plug-in systems for electric cars in Lithuania. The analysis covered attraction objects, car distribution on the street network, population distribution over residential and business areas and possible locations for plug-in station installation in Vilnius.

## 2. Problem

The main sources of environmental pollution is an increasing number of vehicles in towns. Since 2000, transport sector emissions and their share in the total amount of emissions have been annually increasing. This reveals an increasingly negative environmental impact of the transport sector which could be explained by increasing volumes of haulage and slower development

of low-pollution technologies (J. Barysienė and E. Špeicytė 2009).

In 2010 the number of vehicles in Lithuania amounted to 2.1 million, compared to 1.5 million in 2007). In Vilnius more than 70% of all cars are petrol-powered, 23% are diesel-powered, and about 4% are gas-powered. In 2009, about 80% of all cars in Vilnius were over 10 years old and the average car age was about 16 years.

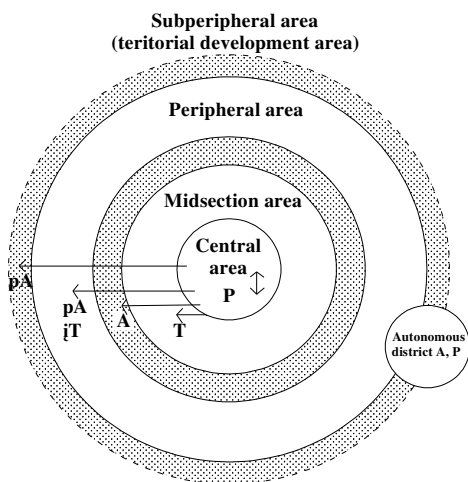
**Table 1.** Population and car ownership level in Vilnius, thous.(Statistikos departamentas prie LRV, 2009)

Year	1980	2004	2005	2007	2008	2009
Population	492.0	552.9	553.6	554.4	555.7	558.2
Car ownership level	71	450	487	545	583	576

In 2010 carbon dioxide (CO<sub>2</sub>) and carbon monoxide (CO) accounted for most atmospheric emissions. Emissions of nitrogen oxide (NO<sub>x</sub>) and volatile organic compounds (VOC) were less than 10 thousand tons. The worst pollution is observed on the main transport corridors of Vilnius, namely on the following streets: Geležinio Vilko, Kareivių, Savanorių, Ukmergės, etc.

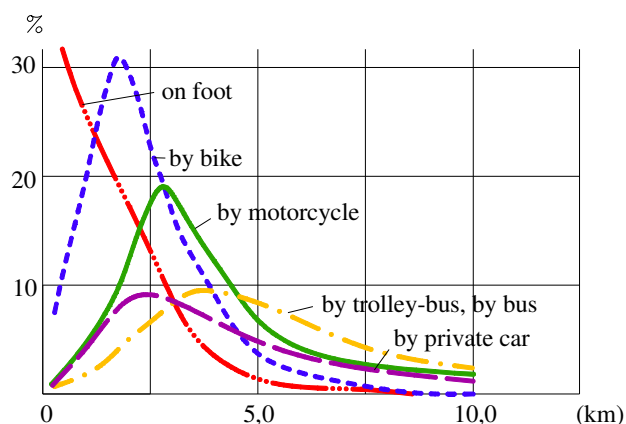
In the Netherlands 26% of trips are chose by bicycles, in Denmark bicycle trips account for 19%, and in Germany – for 10%. In Austria and Switzerland bicycle trips account for 9%. In the mentioned countries people use bicycles to avoid traffic jams, reduce air pollution and noise. The experience of these countries suggests that creating favourable conditions for bio-transport, especially for bicycles, could solve sore problems of transport.

However, trips by a motorless vehicle are limited in larger towns. Bicycles tend to be used for recreation, sport, short trips; they are also used for going shopping, to school and work but not so often. In the downtown area citizens prefer pedestrian traffic. In peripheral areas people travel by the public transport or private cars (Figure 1).



**Fig 1.** The prevailing urban transport model according to Prof. Dr. P. Juškevičius. The prevailing modes of transport: P – on foot, T – by trolley-bus, A – by buss, pA – by private car, iT – by company car

A bicycle as an alternative to other vehicles could be assessed with regard to travel time, travel price, energy input, environmental impact, safety and other criteria. Transport mode depends on distance (Figure 2).



**Fig 2.** Frequency of use of different transport modes depending on distance.( M. Burinskienė, G. M. Paliulis, 2009)

Short distanced up to 1-2 km are usually travelled on foot, while longer distances need vehicles, namely bicycles, motorcycles, public transport or private cars.

In towns 30% of trips by car are up to 3 km long, and 50% of trips by car are up to 5 km long.

The degree of environmental pollution has become one of the main criteria for selection and evaluation of transport modes and vehicles. Physical mobility has a huge positive impact on citizens, however in a modern town it is not popular due to prevailing use of cars. High car ownership level – the consequence of political and economic transformation – has affected distribution of transport modes to the prejudice of walking, cycling and taking the public transport; at the same time, limited opportunities to increase physical mobility of citizens have even shrunk. Choice of transport mode largely depends on long-term community traditions, natural environment of the town, a transport system within the town, also economic and other factors. Rapid growth in the car ownership level is following by changes in the urban environment where more and more spaces go to motor traffic, parking and servicing (G. Stauskis 2009).

With rapid sprawl of towns people will not refuse their cars and will not start cycling. This will result in further environmental pollution and wasteful use of limited oil resources. The present situation would improve if electric cars appear in streets. The electric car plug-in system is not yet available in Lithuania or in other Baltic States. Potential competitors could be car manufacturers and industrial companies aiming at creating a similar product.

To create environment for the use of electric cars in Lithuania, the following main problems should be solved:

- Private cooperation between capital and town municipalities in development of the plug-in infrastructure

- Development of standard technical requirements imposed on plug-in stations and standardisation of electric car plug-in devices
- In future it should be mandatory to make a certain number of parking places available to electric cars and such places should have plug-in devices
- Standards should provide that it is necessary to install plug-in systems when designing buildings (business and trade centres, blocks of flats, etc.)
- A considerable amount of energy will be used for charging electric cars, thus plug-in network capacity should be taken account of when developing the network of speedy plug-in stations
- For electric car charging to become simple and affordable to everybody, a system of payment for electricity is necessary

### 3. Electric car integration in other countries

The European Commission (EC) announced that it intends to support the development of the network of high voltage plug-in stations in Europe. The EC works on the European safety and technical standards for these stations. By this, it is intended to create conditions for the occurrence of green cars in the European markets.

This plan is part of the new strategy aimed at supplying more green cars, which are considered very important in order to relaunch the car industry and reduce oil demand in Europe, to the market. The strategy includes fuel-efficient cars, electric cars and natural gas-, bio-fuel- and hydrogen-powered cars. In Western Europe electric cars have become a reality as car manufacturers already take orders for them and the first electric cars will be presented to buyers in 2011. The following car manufacturers presented the concepts of electric cars: Mitsubishi, Honda, Toyota, Ford, Nissan, Chevrolet, Fiat, Tata, and Tazzari.

The San Francisco Bay Area is going to become one of the first USA areas ready for mass transition to electricity-powered cars. *Better Place*, the company located in Palo Alto (California), has received a permission to install a network of 250,000 plug-in spots and 200 battery switch stations.

A management centre will be opened for the network management. The work is planned to be finished by 2012. Such project is costly, in preliminary estimation it will cost about one billion dollars. According to the representatives of the area authorities, financial measures have already been foreseen: the companies that install plug-in spots will be entitled to exemptions and speedier issue of permissions for installation of such spots.

The authorities of Australia plan to develop the activity field related to services provided to electric cars. In the first stage it is planned to develop networks of electric car plug-in stations in three largest cities: Sidney, Melbourne and Brisbane. 2000,000-250,000 plug-in spots will be installed in the three cities and, in addition, 150

battery switch stations will be built on the way between these cities.

To Australia the project will cost about 667 million USD, and it should be implemented in three years. Currently the authorities of Australia encourage local car manufacturers to start responding to the demand for electric cars as in future this demand will be even higher.

London plans to become a European capital of electric cars by installing 1,300 plug-in stations.

Israel plans to install 400-800 stations (most of them are planned to be installed in Tel Aviv). It is hoped that the number of stations will keep growing after this pilot project is started.

Great Britain provides state support to the buyers of electric cars. A 5 thousand pound compensation is offered to buyers of electric cars, and electric cars are offered free charging, entrance into and parking in the downtown area of London. Similar programmes are carried out in other countries, too. In France an electric car buyer is offered and amount of 4,240 pounds (5,000 EUR), in China – 4,721 EUR, and in USA – 4,708 pounds (7,300 USD).

### 4. Electric car integration in the towns of Lithuania

Vision of the Ministry of Transport and Communications of Lithuania until 2015 provides that a pilot electric car battery plug-in and switch infrastructure network will be developed. It is planned that in 2020 an electric car plant will be built in Lithuania and that in about 2030 the public transport of the largest towns of Lithuania will be electricity-powered, and that green cars will account for up to 40% of all cars.

In Lithuania electric cars have good prospects. Lithuania has good conditions for testing electric cars due to favourable climate and suitable distances (the largest inter-town distance in Lithuania is 400 km).

Another advantage of Lithuania is relatively cheap and skilled labour. Recently businessmen have been interested in installation of electric car plug-in stations and in being representatives of electric car manufacturers.

Researchers think that in 2020 Lithuania could have 200,000 electric cars and that would account for 10% of the country's car fleet. The electric cars will need special infrastructure that would make it possible for them to get integrated in the towns of Lithuania. To achieve such a level of electric car ownership in Lithuania, conditions should be created for those who want to acquire an electricity-powered car, subsidies should be offered, experience of other countries regarding integration of electric cars should be learnt of, and Lithuania's citizens should be motivated to care about ecology.

Different measures should be taken to motivate Lithuania's citizens to choose green cars, namely: free parking of cars in the downtown area of the town, partial compensation for battery charging, free entrance into the pay zones, free registration of a car, no road charges, etc. For greater stimulation of electric car market in Lithuania close cooperation among the Ministry of Transport and Communications, the Ministry of Economy, the Ministry

of Environment, municipalities, businessmen and scientists is necessary.

## 5. Ways for electric car charging

Electric cars need electricity for charging their batteries. Special infrastructure is necessary for charging these cars, usual filling stations are not suitable. It takes longer to charge an electric car battery than to fill the tank of a usual car (it takes about 5 minutes to fill a tank and on the average 2-8 hours to charge a battery). Storage of new and used batteries needs premises rather bigger than usual filling stations.

Different ways for battery charging are offered, namely: remote battery charging, switching a flat battery with a new one, using Li-on battery charger plugged into a mains socket.

In case of remote battery charging no wires are necessary, they are replaced by high resonance inductive current. The technological principle is the following: electric power source is assembled in the garage floor on in the parking lot pavement (near business and trade centres) and a receiver is installed on the bottom of a car. When a car is parked on the panel the system automatically starts charging the electric car battery.

Li-on battery charging using a charger plugged into a mains socket: this plug-in system is of the size of a fuel dispenser and it uses specially adapted lithium-ion batteries that accumulate energy at night when electricity is cheaper. Batteries generate five times larger amount of current compared to other systems. That could be compared to filling a car with gas.

The quickest way is to switch flat batteries with the new ones but that needs special premises for storing new and used batteries.

Parameters of the electric cars available on the market differ only slightly. An average distance that could be covered by an electric car is about 150 km, a full charging of a battery takes about 4 hours, the maximum speed is about 100 km/h. On the average an electric car consumes about 16 kWh energy per 100 km. Efficiency of an electric car is almost 5 times higher than that of internal-combustion powered cars. Efficiency of an electric car reaches 90%, while that of a simple car reaches about 16%-22%.

In Lithuania, in the temperature of  $-25^{\circ}\text{C}$  the battery capacity decreases by 10%, so the covered distance will be shorter, too (in the temperature of  $-25^{\circ}\text{C}$  the distance would be 135 km rather than 150 km under normal conditions).

The electric car charging time depends on the following:

- 1) battery capacity
- 2) energy still remaining in a battery
- 3) power of a charger

Full charging of various electric cars takes from 30 minutes (using a special charger and an inlet) to 8 hours (using a simple 120V-220V household energy).

An increasing number of car manufacturers issue electric car models with different parameters and

charging types. Charging system parameters of some electric cars are given in Table 2.

**Table 2.** Charging system parameters of cars produced by different manufacturers

Manufacturer, model	Distance covered after a single charge of the battery, km	Battery charging time, h	Maximum speed, km/h
Ford Focus <i>Electric</i>	160	6-8	-
JFE Engineering Corporation <i>Mitsubishi i-MieV</i>	90	0.25-0.5	-
Tazzari <i>Zero</i> Lithium-ion batteries	142	6.5	90
<i>Elinta E-force</i>	150	2	170
<i>ZX40S</i>	64-80	-	40
<i>Tesla Roadster</i>	392	3.5	200
<i>Dynasty electric vehicles</i>	50	6-8	40
VW Golf <i>Variant</i>	90	8	120
Kia <i>Soul</i>	110	8	120
VW <i>Caddy</i>	180	12	140
Smart <i>ForTwo</i>	120	8	120
Renaut <i>Ze</i>	160	6-8	135
Renaut <i>Dezire</i>	160	8	180

## 6. Demand for electric car plug-in stations in Vilnius

The present level of car ownership (576 vehicles/1000 inhabitants) in Vilnius is very high and it is similar to that in many EU towns. In 1999-2009 the increase in the level of car ownership in Vilnius was highest in Lithuania, it reached on the average 7.8% annually. The car fleet of Vilnius accounts for 18.5% of the total car fleet of Lithuania. Despite complicated traffic situation in Vilnius, people use their private cars as the existing public transport system fails to satisfy their needs. Characteristics of residential areas of Vilnius presented in Table 3 reveal that it is important to replace some cars with electric ones.

The town of Vilnius has been chosen for integration of electric cars in Lithuania. The town was analysed with the following regard:

- population density in residential areas;
- the number of jobs in the districts of the town;
- distribution of the large daily transport flows on the street network of the town.

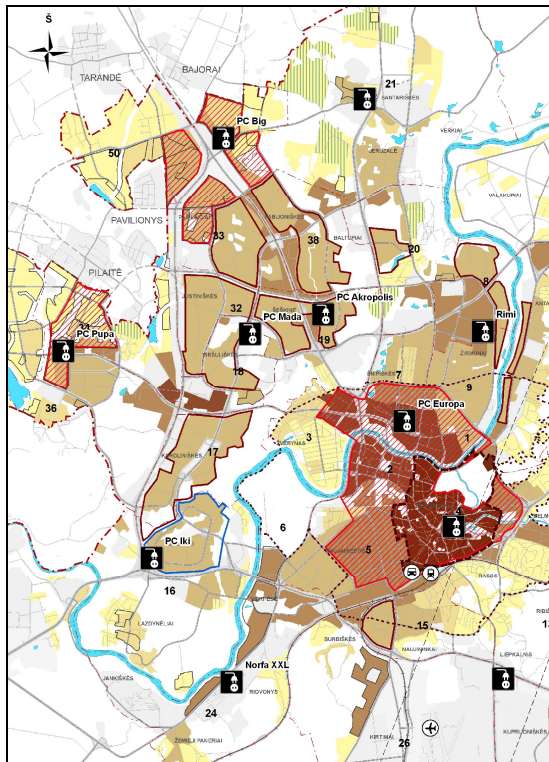
**Table 3.** Urban and transport characteristics of several largest residential areas of Vilnius. (General plan of Vilnius till 2015)

Residential areas	Population	Built up areas, -ha	Number of parked cars	Street length (km)	Car flows during peak hours	Run, thousand vehicles/km
Lazdynai	32.4	133.24	4909	16.4	3200	23.02
Karoliniškės	31.4	172.71	6080	11.2	3920	21.78
Viršuliškės	16.4	80.93	3570	8.6	2135	13.14
Pilaitė	14.4	58.36	3501	7.7	1825	15.80
Šeškinė	36.9	143.26	7990	10.6	4093	26.21
Justiniškės	31.2	137.47	6774	19.5	1700	1.77
Fabijoniškės	36.6	212.4	8663	11.8	1885	15.83
Pašilaičiai	25.1	143.48	6908	7.6	1990	7.74
Vidurkis	224.4	1081.85	48395			

With regard to the deployment of electric car plug-in stations in Vilnius, three concepts have been developed.

*Concept 1. Population density in residential areas.* Residential areas are the key factor in formation of the urban structure development policy and of a corresponding spatial model until 2025 by optimising infrastructure systems.

The plug-in station deployment depending on population is illustrated in Figure 3.



- electric cars plug-in station

**Fig 3.** Planning Electric car plug-in stations near supermarkets located in residential areas of Vilnius

Electric car plug-in stations deployed near the largest supermarkets in accordance with residential area spread would fully serve population of Vilnius.

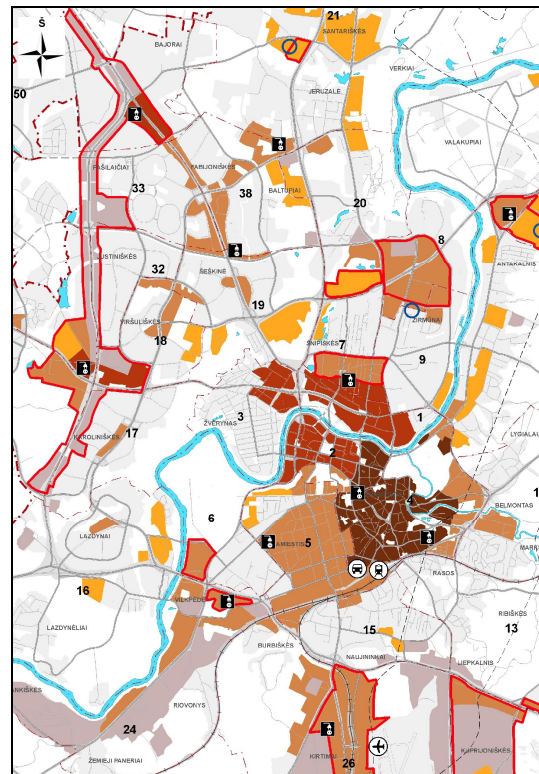
In 2010 the total population of Vilnius was 548,816. According to the general plan of Vilnius and the carried out research, the highest population density is observed in the residential districts of Justiniškės, Fabijoniškės and Šeškinė, and, according to the prognosis, population density will be high in these districts in 2015, too.

To find out the attraction objects that should have plug-in stations, the attraction objects of Vilnius were analysed taking account of the population distribution. As electric car charging takes on the average 2 hours, plug-in stations are planned near large supermarkets and recreation centres of Vilnius. Citizens coming to supermarkets or recreation centres with some specific purpose would also be able to charge their cars and then continue their trips.

The downtown area of Vilnius is densely populated; about 250,000 citizens live in that area permanently. Two electric car charging stations are planned in that area.

New development areas of priority are foreseen in the west, north-west and south-west of the town, namely: northern and southern parts of Pilaitė district, northern part of the street of Ukmergės, and northern part of the highway of Minsk. Plug-in stations will be installed taking account of the development tendencies and of the most popular supermarkets in these areas.

*Concept 2. The number of jobs in the districts of the town.*



- elektric cars plug-in station

**Fig 4.** Planning Distribution of jobs in Vilnius and foreseen electric care plug-in stations deployed taking account of the number of jobs

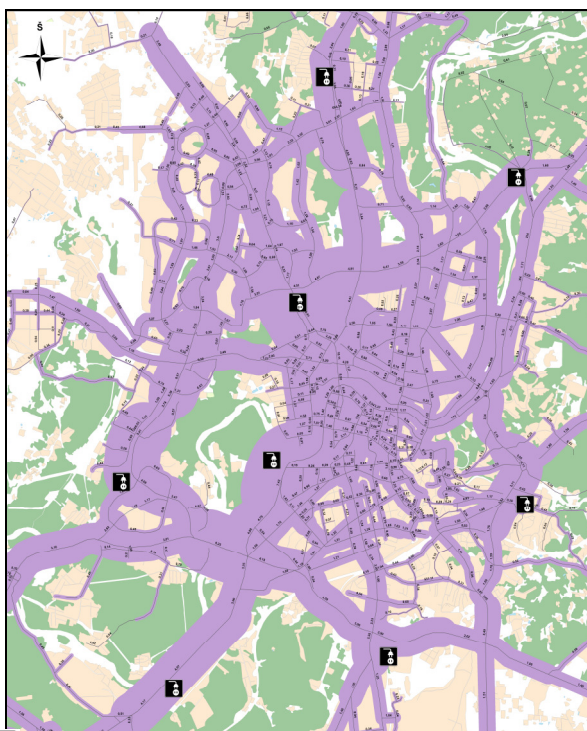
Citizens spent most of their time at work, at that time their cars are parked in parking facilities of their companies or on public parking lots. To stimulate a more

intensive use of electric cars, some area of parking facilities and lots should be given to electric cars, such areas should have plug-in devices.

In Vilnius expansion of jobs is foreseen in the districts of Fabijoniškės, Pašilaičiai, Šeškinė, Justiniškės, Karoliniškės, Lazdynai and Pilaitė. Commercial centres to undergo further development are those close to the streets of Ukmergės (in the northern direction) and T. Narbuto (in the western direction). Therefore, plug-in stations are planned in those areas, too (Figure 4).

**Concept 3. Distribution of the large daily transport flows on the street network of the town.** The transport flow cartograms reveal the distribution of trips made by private cars in Vilnius. According to the research carried out in 2009-2010, the largest flow of cars is observed on the streets of Ukmergės (6910 vehicles/day), Savanorių (4170-7420 vehicles/day), Laisvės (5410 vehicles/day), Geležinio Vilko (3850 vehicles/day), S. Batoro (3710 vehicles/day), Žirnių (3390 vehicles/day), O. Milašiaus (2880 vehicles/day).

Use of electric cars in Vilnius should be started by installing plug-in stations on the streets with the largest transport flows. Deployment of stations is illustrated in Figure 5.



**e** - elektric cars plug-in station

**Fig 5.** Transport flow cartogram of Vilnius and foreseen electric car plug-in stations

Further research should integrate all the three concepts, and a common electric car plug-in station network should be developed after evaluation each of the concept.

In 2020 electric cars will account for 10% of the EU fleet, this is an optimistic tendency of Lithuania and it

would be a really if 21.000 electric cars are register every year (Figure 6).



**Fig 6.** Tendency of the number of electric cars in Lithuania in 2020 [

### 7. SWOT analysis

The SWOT analysis of a possible use of electric cars in the towns of Lithuania revealed vast strengths and opportunities in the near future.

**Table 4.** SWOT analysis

<b>Strengths</b>	<b>Weaknesses</b>
<ul style="list-style-type: none"> <li>+ Electric cars are noiseless</li> <li>+ They are environment friendly, generate no emissions</li> <li>+ Run of an electric car is sufficient for trips within the town as trips of 80% of European citizens do not exceed 60 km per day</li> <li>+ A car could be charged while driving</li> <li>+ Small electric cars raise less problems related to street capacity and parking</li> <li>+ Electric car maintenance costs are 20% lower, while service costs are 50% lower compared to internal-combustion cars</li> </ul>	<ul style="list-style-type: none"> <li>+ Large investment into plug-in network installation</li> <li>+ New batteries are expensive (10,000-12,000 USD)</li> <li>+ Dependence on the development of plug-in network in the town</li> <li>+ Run after a single charge is up to 150 km, a car is not good for long inter-town trips</li> <li>+ In the temperature of -20°C the battery capacity becomes 50% lower</li> <li>+ Price of an electric car is 30-40% higher that that of an internal-combustion car</li> <li>+ A car itself and its luggage compartment are small</li> <li>+ Batteries serve 10 years or 200,000 km</li> </ul>
<b>Opportunities</b>	<b>Threats</b>
<ul style="list-style-type: none"> <li>- Strict ES environmental requirements encourage use of electric cars</li> <li>- No impact is caused by fuel price rise as electric cars use electricity that could be generated from renewable sources and nuclear fuel</li> <li>- New technologies allow manufacturing and use of new generation cars</li> <li>- Priority for those who drive and park in the downtown and old town area of the town</li> </ul>	<ul style="list-style-type: none"> <li>- New technologies are necessary for manufacture and use of electric cars</li> <li>- Electric cars are very silent so this may result in incidents that involve pedestrians</li> <li>- Run after single charging reduces with a car getting older</li> <li>- Charging voltage above 24V is dangerous for those who are around</li> <li>- Dependence on foreign energy source suppliers (in Lithuania power-stations use gas or fuel oil)</li> <li>- Amendment of legislation</li> </ul>

## 8. Conclusions

1. Electric car plug in stations and their number in Vilnius would depend on population density in residential areas, on jobs in downtown and surrounding areas as well as close to busy high-speed streets.
2. According to research, 80% of trips made by citizens of the town amount to 60 km, so single charge run of 150 km would be fully sufficient to satisfy the needs of citizens of the towns of Lithuania.
3. There actions should be performed in the towns of Lithuania in order to stimulate use of electric cars, namely: political environment should encourage acquisition of electric cars, plug-in infrastructure should be installed, standards imposed on electric cars and infrastructure should be developed and such standards should encourage sticking to the EU requirements.
4. In the EU market electric cars should account for 3-10% of total cars by 2020. According to the data of motor-businessmen association, after 2015 citizens of Lithuania could annually acquire 6000-21,000 electric cars.

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