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Research methodology on the development of a strategy on e-mobility in Greek cities. The case of Athens.

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Abstract

This paper aims to present a concrete methodology for developing a strategy for the promotion of E-Mobility within the framework of sustainable mobility planning. However conventional parameters of e-mobility such as vehicles' capacity, charging systems, station allocation, are not directly linked to Sustainable Urban Mobility Plans (SUMPs), the promotion of electric vehicles can contribute to the achievement of a number of SUMP objectives, such as improving air quality, energy saving, noise reduction etc. In this context, this paper analyses the basic parameters of E-Mobility advancement (regulatory policies, incentives, urban planning and transportation incentives) and explores the main strategic objectives that incorporate sustainable mobility pillars. The developed methodology is tested in the pilot case of Athens, where integrated measures are proposed.

Keywords: *e-mobility, Athens, urban mobility, electric vehicles, sustainability*

1. Introduction

Transport accounts for about one quarter (25%) of EU greenhouse gas emissions, while road transport accounts for one-fifth (20%) of total CO2 emissions in the EU (EU, 2016). According to recent data (EU, 2016), urban transport is the only area where greenhouse gas emissions are rising, hence the gradual phasing out of conventionally-fuelled vehicles and shift to low emission mobility is regarded as the main alternative. The EU sets specific targets to reduce GHG emissions up to 40% until 2030.

Numerous cities worldwide are promoting policies to eliminate conventional fuel vehicles and shift from car-centric urban and transportation planning to sustainable urban mobility principles. This transition shall bring several environmental, social and economic benefits as reported in Beria and Grimaldi (2014), however requires the development of appropriate measures, specialized policies and implementation of relevant infrastructure.

E-Mobility can be integrated in cities through two strategic tools, namely the Strategic Energy Action Plans (SEAPs) and Sustainable Urban Mobility Plans (SUMPs). These act as enablers to cities in order to actively promote and introduce frameworks, policies and relevant measures. It is important that some of the operational goals of E- Mobility are related to SUMP targets, such as the improvement of air quality, energy efficiency and GHG emissions reduction. CIVITAS report (2016) states that integrating E-Mobility should result in a sub-

plan or a sub-strategy that strengthens its role as part of a multimodal system. The four main elements in the planning cycle of a SUMP that cities should consider this integration are a) involving stakeholders (step 2, activity 2.3 in the SUMP Cycle), b) defining visions and objectives (step 4, activity 4.1), c) developing an effective package of measures (step 6, activities 6.1-6.4) and d) evaluation (step 8).

Moreover, promoting E-Mobility requires a holistic approach in terms of providing incentives for buying and using electric vehicles, as well as delivering an evolving legal framework for authorization and operation of charging stations. Among the key reasons for adoption and promotion are: a) the improvement of quality of life in large urban centers; b) development of new forms of entrepreneurial activities in areas such as energy, industry and alternative mobility services and c) the utilization of new energy resources. Lower use costs and preservation costs, both for individuals and the state, are also recognized as crucially important.

According to ChargeMap (2016) Greece has 24 charging stations which have 42 charging sockets in total, 71,4% of them are rapid charging points, 9,5% are accelerated charging points and 19% of them are standard charging points. Indeed according to MOVIVA (2014) there were only 60 registered electric cars circulating in Greece by 2014, while Mandravelis (2016) argues they reached 150 cars by the end of 2016.

2. Methodology for E- Mobility enhancement. Research on case studies.

European cities and regions have a key role in promoting electric mobility (E-Mobility). Due to the available range of EVs and the potential of urban fleets in organizations, the introduction of EVs will primarily take place in urban areas (CIVITAS, 2016). Introducing electric mobility in – unfamiliar with the context- countries and regions requires a number of procedures to be undertaken in order to explore the current situation and plan for further integration. Research on the leader EU states promoting EV such as Norway, Netherlands and Sweden, has shown that apart from the private sector generators, governmental policies at the national and regional level determine the thriving of green economy and all its sectors.

The logic towards enhancing E-Mobility include a number of steps to be integrated in an overall strategic framework, starting from a thorough exploration of the national regulatory and institutional framework. Following the current framework, benefits and impacts are analyzed along with the market trends and the potential government grants and European funding.

An important principle that shall be prioritized in decision making is the promotion of all electric vehicles, starting from public transport fleets, municipal special vehicles, ambulances, garbage and fire trucks, bikes and private cars. Defining all forms of incentives, such as regulatory measures, economic incentives and facilitation policies can be extracted after a comprehensive research on case studies - best practices for E-Mobility enhancement. The determination of the strategic pillars on E-Mobility and development of action plan are regarded as the final steps along with the research on all forms of needed preparatory actions. Pilot testing in small regional units or cities allow for quicker feedback and implementation of activities.

In order to fill the gaps in the Greek legal framework, research has focused on case studies in order to receive a crucial input in incentive policy development. According to numerous researchers in the field of E-Mobility, **financial incentives are the most effective** and

successful measures for efficient promotion in all countries of application. Particular examples of incentives in countries worldwide, include the following:

- In China, the EV buyers are exempt from the purchase tax and excise tax in terms of vehicle capacity and price, according to information from Mock and Yang (2014).
- In Japan – and several other countries- there is a direct subsidy available upon purchase of an electric vehicle (both full electric and plug-in hybrid vehicles). This one-time subsidy takes into account the price difference between an electric vehicle and a comparable conventional vehicle, and is capped at a maximum of about 6,500 EUR (Mock and Yang, 2014).
- In France, the subsidy amount can reach 6,300 EUR for the purchase of an electric vehicle (BEV vehicle emitting less than 20 gr CO2 /km) and 1,000 EUR for the purchase of the electric vehicle type PHEV (a vehicle emitting from 20 to 60 gr CO2 /km). According to MEEM (2016a and 2016b) the implementation of the Bonus/ Malus fee vehicle taxation system, promotes the withdrawal of diesel vehicles for an additional financial support of 10,000 EUR for the purchase of a BEV, and 3,500 EUR for a PHEV.
- In Norway, according to the International Energy Agency OECD (2016), the direct incentive of purchase tax exemption can reach a 10,000 EUR reduction in the total cost of an EV. In addition, for the purchase of a BEV vehicle, there is an extra VAT exception (25% benefit) (Mock and Yang, 2014).
- In Sweden, passenger cars with emission levels below 50 g CO2 / km are subsidized with up to 4,000 EUR from 2011 (OECD / IEA, 2016).
- In the Netherlands, cars with zero CO2 emissions are exempt from circulation taxes, while a differentiated taxation system with five levels of CO2 emissions is applied for progressively increasing taxation per g CO2 / km.
- In Portugal, BEV vehicles are exempted from the initial registration fee with a benefit of approximately 1,250 EUR and the circulation tax (Saldopositivo, 2014).
- In Great Britain, the BEV passenger car market is subsidized with up to 6,000 EUR, while the freight vehicle market subsidies reach 10,000 EUR per vehicle.
- In the USA tax relief may be as high as $7,500 nationally. Individual incentives are provided in each state. Jin, Searle and Lutsey (2014) estimated that on average the incentives range from 950 EUR to 5800 EUR.

Other incentives include **operational compensation measures** or **facilitation policies**, related to the potential access of EVs in car-restricted zones (e.g. access to the city center), parking privileges etc. Examples of such incentives include: a) the access of EVs to bus lanes in Norway (Lutsey, 2015) and France (EVI, 2016c), b) special access of EV owners to residents' privileges (reduction fee in city buses, parking etc.) applied in various UK cities such as London, Nottingham and Bristol (GOV.UK, 2016b) as well as German cities (Mock and Yang, 2014), c) use of high-capacity lanes on motorways in Spain and the USA (EVI, 2016d).

Other incentives related to e-bikes and other special vehicles are applied in France, Belgium, Luxemburg and Italy.

The aforementioned incentive schemes were studied among others, in order to influence and contribute to the development of similar schemes and formulation of key principles in the case of Greece and Athens in particular. Research has proposed specific incentives and measures including financial incentives, operational compensation measures and facilitation

policies aiming at the state's level. The scheme is being reviewed and will be published shortly.

3. Main design principles and action plan development

Observations in relevant schemes and developed strategies have assisted the formulation of key design principles, through the exploration of three cases, namely the UK scheme 'Go Ultra Low City Scheme', Vienna E-Mobility Strategy (Vienna City Administration, 2016), and 'Electric Mobility Pilot Regions' implementation in Aachen (ELMOS, 2013).
E-Mobility Strategy is typically a formal document covering e-mobility in all aspects ranging from vehicles and charging stations to the needed measures and infrastructures. The developed principles should focus on the electrification of the existing vehicle fleet (both private and public), the implementation of measures and installation of infrastructures. A useful element in such a strategy is the setting of specific measurable targets, which can be monitored through a set of indicators. The strategy can involve citizens in its initial development or engage stakeholders in the implementation phase. In cases where citizen engagement is not well established through a SUMP or common sustainable mobility policies, it is suggested that stakeholders and citizens are involved in latter phases.
The key principles to be followed are depicted in the diagram (Figure 1) and analyzed below:

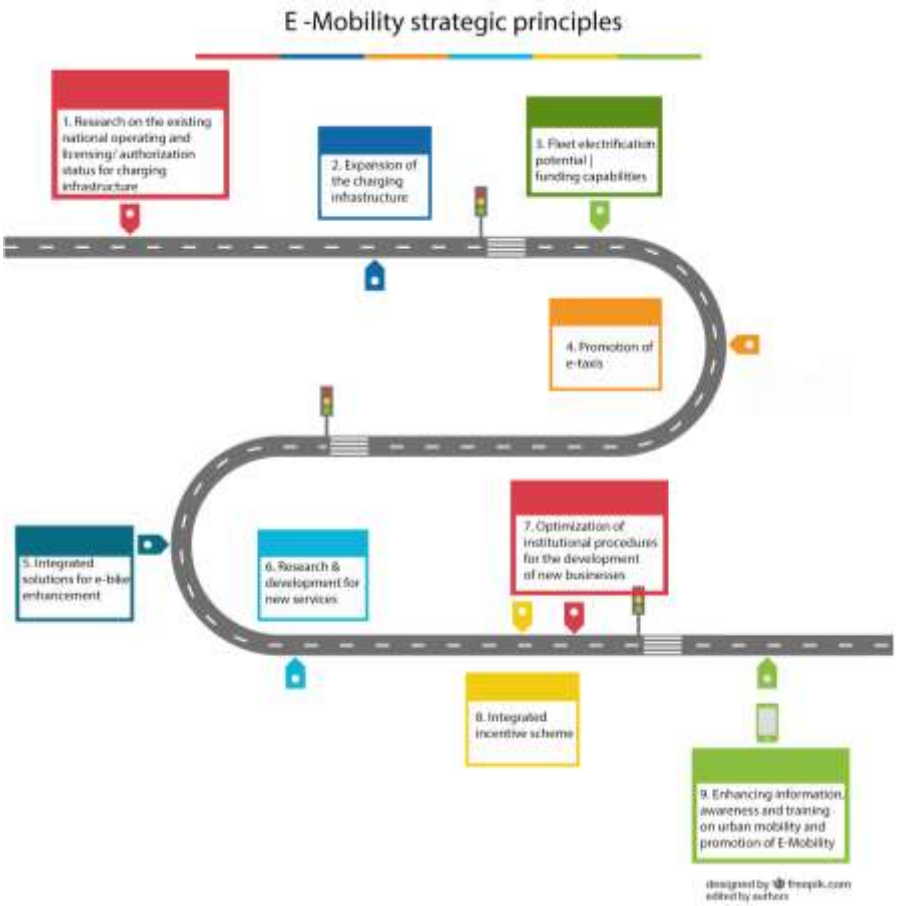

Figure 1: *E-Mobility strategic principles outline (Source: designed by freepik/ edited by authors)*

a) Research on the existing national operating and licensing/ authorization status for charging infrastructure; the foundation of all steps is the exploration and clarification

of the current national policy framework, technical specifications for authorization, acceptable charging methods, certification standards, allowed placement locations etc. Strategic proposals can include the framework for locating a network of public and semi-public charging stations etc.

b) Expansion of the charging infrastructure; charging stations should be installed in strategic locations, public or semi- public spaces such as on- street zones (parking lots), shopping malls, parking facilities, sports arenas, and places with high human traffic.
c) Fleet electrification potential and funding capabilities; public transportation, city logistics, police- fire- emergency and municipal fleets should be prioritized in the supply of electric vehicles and cooperation schemes. High capacity public transport (i.e. metro, subway, rail) are sustainable transport modes contributing an important share on urban mobility, presenting clear economic, environmental and social benefits. Fixed electric bus routes are at the forefront of future public transport schemes, while the standardization of charging interfaces is expected to ensure the interoperability of the various e-bus brands fleets.
d) Promotion of e-taxis; taxis cover 10% of daily trips in cities like Athens, adding an important share to congestion and delays. Electrification of the taxi fleet can be accompanied with specific privileges regarding their movement (i.e. in bus lanes, areas with car-restrictions), while innovative schemes to integrate them in the SUMPs could enhance their circulation patterns and relieve congestion.
e) Integrated solutions for e-bike enhancement; charging stations and parking infrastructures contribute to the expansion bike use, while the progress of the SUMP and development of protected and standard bike lanes will enhance cycling mobility.
f) Support to research and development of new services and products; Strengthening the research and development of systems, services and products will directly promote electric mobility by both private innovative entrepreneurs and research centers, universities, etc. Interconnection and cooperation between research and the business sector can significantly promote the use of EVs and increase human resources trained and staffed in the sector. E-Mobility research programs will also promote institutional and policy shifts in the sector, resulting in further enrichment of objectives and applications.
g) Optimization of institutional procedures for the development of new businesses and networks/ schemes promoting electric mobility; promotion and extension of existing companies associated with e- mobility (companies providing/ maintaining/ replacing charging stations, electricity companies, EV market businesses, innovative alternative mobility services, A.). Business reform for registration and licensing, technology assisted services to support such businesses, can further contribute to the needed direction.
h) Integrated incentive scheme; policy support mechanisms can be crucial for the promotion of E-Mobility hence the development of an integrated incentive scheme – adapted to the study area- is critical. It shall include a set of EV purchase incentives,

EV use and circulation incentives, waivers on access restrictions as well as specialized policies to encourage EV use. Funding potential shall be studied and cost- benefit analysis could assist on proper allocation of resources.

i) Enhancing information, awareness and training on urban mobility and promotion of E-Mobility; E-mobility is a pioneered transport sector hence demands proper information and awareness raising in order to attract users, investors, researchers etc.

The action plan must determine specific actions for each of the aforementioned principles and set specific targets to be met in a specific timetable. The key output should include a concrete catalogue of measures. The implementation of measures shall be examined in a yearly basis through a specified monitoring process. Revisions and amendments should be added in a predefined manner.

4. Pilot Action Plan for the City of Athens

Developing the pilot for Athens has integrated the aforementioned principles, included suggestions by CIVITAS report 2016, especially in terms of the three elements (b. defining visions and objectives, c. developing an effective package of measures, d. evaluation), and provided specific actions to improve the existing network of electric cars and public transport, as well as create a bike sharing system enforced with e-bikes and charging stations. The study area includes the historic city center of Athens (see Figure 2).
At first, the determination of the relevant procedures for placing a public or semi- public charging station network is explored, in the context of the Greek environment.

- Initial selection of charging station locations* (network planning according to the existed EVs, population density, future predictions),

* locations shall be studied according to the overall SUMP development, however an official SUMP has not been established yet. The Strategy for Sustainable Urban Mobility in Athens, which is currently being developed and reviewed, has included the indicative locations in an integrated manner.

- Raising public awareness for EVs' benefits | Promotion of E- Mobility,
- Selection of the typology for charging equipment, quantitative elements, communication with potential providers,
- Exploration of funding options,
- Contact with relevant stakeholders in the electricity sector (individuals, municipal companies, transport companies, electricity provider etc.),
- Development of cooperation model among the different stakeholders,
- Feasibility study and final selection of locations,
- Initiation of licensing procedures (competent ministries, municipal / regional council, technical service, general secretary of Decentralized Administration, national electricity provider)
- Placement of stations (in phases)
- Evaluation & monitoring (new stations in phases etc.)

The actions to improve the existing network of electric cars have included measures to increase information and awareness for the public, engagement of stakeholders, participatory workshops, promotion of car-sharing and many more. Following the European guidelines, specific measurable targets were set for: a) replacing 10% of conventional fuel vehicles with EVs until 2027, b) replacement 25% of conventional freight vehicles with electric ones, and c) predetermined density of charging network with one station (with 2 to 6 charging sockets) for each coverage area of 250-400 meter radius.
Adopting the European practice of other capital cities, the planned network of charging stations, for all implementation phases, was developed to include one station for areas of 250-400 meter radius, or one station every 6 to 15 urban blocks. Figure 2 below depicts the location of existing charging stations (in green and blue) and draft location of future stations (in red).

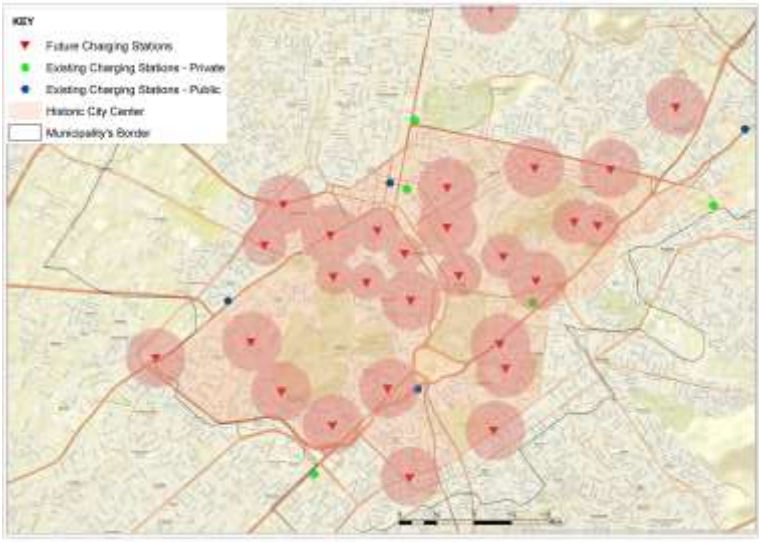

Figure 2: *draft map of existing and proposed charging stations with 250-400 meter radius coverage areas (Source: own elaboration)*

The proposed locations of future stations are indicative areas meeting the basic criteria of similar infrastructure location (i.e. attraction nodes, distance from public transport stations, vicinity to parking places, population density, cbd location etc.). This network can be developed by both public and private legal entities, while it is easier to be applied in phases and have the economic support of local entrepreneurs, such as shopping centers, private parking infrastructure, companies with many employees etc. Several metropolises have followed a similar development pattern with private funding, however with the support of the state's funding and other institutional incentives.

Similarly, actions to create a bike sharing system equipped with e-bikes and charging stations, have included measures to increase information and awareness for the public, engagement of stakeholders, participatory workshops, promotion of traffic calming measures, speed reduction policies, enhancement of horizontal and vertical signaling etc. Following the European guidelines, specific measurable targets were set for: a) replacing 20% of daily trips conducted with private cars by bike or e-bike commuting (part of the SUMP strategy), b) promotion of bike logistics by replacing 25% of short distance light deliveries with bike logistics, and c) a network of bike sharing stations every 250 meter, while e-bike charging stations should be located every 500 meters within the network. These targets are related to

the phasing of the bike sharing system development and monitoring will be further defined in the context of the SUMP.

Athens is already equipped with a strong electric network of public transport means including metro, subway, suburban railway and some trolleybuses, however there are 2,300 buses and no e-buses. Actions to introduce electric buses have included measures to increase information and awareness for the public, engagement of stakeholders etc. The measurable targets cope with the increase of modal share in public transportation and a 30% replacement of conventional buses with electric ones until 2027, along with a pilot e-bus scheme in the dense area of Kypseli.

As seen below (figure 3), the selection of the e-bus serving area followed several criteria (such as inclination, population density, congestion characteristics, station density, existing bus connections, number of passengers, presence of older bus fleet etc.) while the geometry of its urban grid determined the size and specificities of the potential e-bus service.

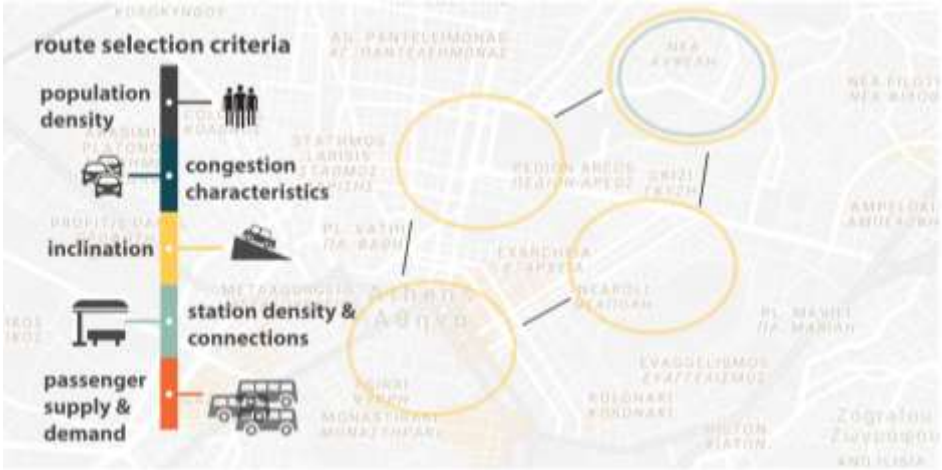

Figure 3: *route selection criteria for e- bus service*

Route selection has assessed 3 scenarios (figure 4); the first two deal with connectivity between Kypseli and two metro stations, while the third is a circular route. Initial route selection has also assessed existing routes running through main urban arteries, however was rejected due to several reasons.

Figure 4: *bus route connection | development of alternative scenarios for route planning*

In particular, investigating the effects of replacing an existing route (i.e. popular connections running through Panepistimiou or Alexandras Avenue) with an electric vehicle would demand the existence of current data regarding its emissions, passenger numbers, demand characteristics etc. Due to the lack of such data, the proposed route serves an area previously underserved with severe congestion issues and increased demand. Following the determination of the e-bus route, a complete questionnaire survey took place in the study area to assess the public opinion for promoting such an e-bus survey. Results have shown that 35,6% of the respondents use public transport daily (morning use), 32,8% use public transport

twice a day and 31,3% use public transport once or twice a week. 46,8% use mostly the bus for daily commutes, 28% trolleybus, 14,2% metro. 35,4% of the respondents mentioned lack of service for the given routes, as the key reason for not using the bus or trolleybus and 26% do not prefer it due to timetables. It is important that 25,1% of the respondents consider that bus stations are far from their residences. Asked about the potential introduction of a new electric bus service, 60,3% replied that they 'definitely agree' and 39,5% 'agree'.

5. Conclusions and discussion

The future of urban mobility embraces evidently new types of environmentally friendly, economically and socially equitable forms of mobility, with E-Mobility performing a leading role in the urban discourse. Understanding that E-Mobility is not limited to the electrification of the existing fleet, but rather encompasses several sustainable urban mobility objectives, is important in order to achieve better quality of life, upgrade of urban places and environmental enhancement. Developing a concrete strategy and laying out measures integrating urban mobility, contribute to complete urban solutions. The developed principles and more importantly the pilot implementation case of Athens, show that inefficiencies in policy and administration lead to fragmented solutions with limited results. The drafted strategy is currently under revision and integration within the Strategy for Sustainable Urban Mobility in Athens.

Research is extended to the development of a strategy for a feasible incentive scheme specifying the potential support within the various administrative levels. The pilot strategy for Athens has assessed so far the overall designated principles, however put an emphasis to the first five. Research and development, support of new businesses, incentive schemes and awareness raising are following, towards better integration of E-Mobility in the city. Research on the existing national operating and licensing/ authorization status for charging infrastructure is completed and all technical specifications (charging methods, authorization status, and certification standards) have been clarified within the existing legal framework. However, the insufficient and complex Greek institutional framework may have a high impact on the proceeding of processes, especially in terms of authorizations. Research on the charging network has concluded in indicative locations, but places are not restrictive and shall be finalized according to the interest of investors, the progress of the SUMP and the overall results from the promotion of E- Mobility. The fleet electrification potential is tested through the assessment of the presented electric bus route in Kypseli. Experience from the study on electric bus promotion shows the need for further promotion of inter-modality as well as the development of current data in terms of environmental nuisance from fixed bus routes and traffic data in congested road sections. These data can be obtained through traditional methods, new digital technologies, IoT sensors, crowdsourcing methods etc., and the output is critical to future E-Mobility planning as well as urban mobility planning.

Electrification of taxis has not been yet forwarded, however promotion of e-taxis has started and discussions with the union show positive results.

E-bike enhancement will follow both the overall sustainable urban mobility strategy integration and the Cycling Integration Study in Athens. The developed cycling network with cycle streets and protected bike lanes within the commercial city center, which is currently under authorization, shall promote cycling use and SUM strategy will follow with enhancing the mobility culture of people.

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