TRANSPORT PROBLEMS 2024 Volume 19 Issue 3
PROBLEMY TRANSPORTU DOI: 10.20858/tp.2023.19.3.10

Keywords: electric vehicles; e-mobility; small and medium urban areas; e-sharing; e-chargers; electromobility; SUMPs; e-car charging

Athanasios GIANNOPOULOS[1], Foteini MIKIKI[2]*, Meng YANG[3]

ELECTROMOBILITY IN SMALL TO MEDIUM-SIZED CITIES AND CROSS-BORDER AREAS

Summary. Small and medium-sized cities around the world aspire to become greener, smarter, more liveable for citizens and appealing to tourists. In Europe, they undertake initiatives such as Sustainable Urban Mobility Plans and Electric Vehicle Charging Plans to make their transport infrastructures more sustainable and friendly to electromobility. In Asia, too, Chinese small cities can profit from several policies and incentives to promote electric mobility and it is of interest to see how these compare to the European cases. A major part of this paper refers to the European experience and more particularly that of Greece drawing largely on the experience from Sustainable Urban Mobility Plans and Electric Vehicles Charging Plans studies performed in Northern Greece and its northern border regions. The experience of China and its promotion of e-mobility in small urban areas is also reviewed and useful conclusions are drawn. The results show that there are several measures and policies specifically suited to small and medium-sized urban areas as well as those that are in the periphery of the country near border crossings to other countries. The final evaluation and selection should be made following the formulation, at an early stage, of a comprehensive and all-inclusive strategic plan for the promotion of e-mobility in the area. The novelty of the paper consists of a concise and all-inclusive reference to the factors affecting the promotion of electromobility in the special case of small and medium-sized urban areas as well as border areas and the recommendations for measures and policies that are given in Table 2. A novelty is also the SWOT analysis performed as well as the fact of the parallel presentation of European and Chinese policies.

1. INTRODUCTION

According to the Organization for Economic Cooperation and Development (OECD), an urban area is designated as small when its population is up to 200,000 and as medium when its population is between 200,000 and 500,000 [1]. These limits refer to OECD member countries. In China, the official definition for a small city is up to 500,000, while a medium-sized city is between 500,000 and 1 million. The conditions for the promotion of e-mobility differ between the larger and the smaller urban areas depending on the size and administrative environment of each country. So far, the statistics show that electric vehicle adoption in large urban areas is almost double that in small and medium-sized ones. Moreover, earlier studies in Scandinavia, including some regression analyses, showed that age and education levels have positive impacts on electric vehicles ownership but more so are the individual's personal norms and attitudinal factors towards innovation and climate change [2]. Of particular interest are small and medium-sized urban areas near borders since e-mobility in those areas faces an additional

[1] TREDIT S.A.; 78C Vrioulon & 40 K.Karamanli Str. GR 55132 Kalamaria, Greece; e-mail: tgiannopoulos@tredit.gr; orcid.org/0000-0002-6494-0224
[2] International Hellenic University; 14th km Thessaloniki – N. Moudania, 57001 Thermi, Thessaloniki, Greece; e-mail: fmikiki@yahoo.gr; orcid.org/0000-0003-3401-928X
[3] Country and Area Studies Academy, Beijing Foreign Studies University; No 2 Xisanhuan North Road, Haidian District, Beijing, China; e-mail: yangm@bfsu.edu.cn; orcid.org/0009-0003-1997-6855
* Corresponding author. E-mail: tgiannopoulos@tredit.gr

difficulty because of the need to find favourable conditions and infrastructures on both sides of the border. In this paper, we refer to small and medium-sized as well as small and medium-sized urban areas as SMBs.

Each country, region, and community has unique needs and constraints in promoting e-mobility, but there are general guiding principles that can help SMBs find their paths to promoting electric mobility, as there can be no one-size-fits-all solution. In Europe, the EU has issued guidelines and promotes rigorously the formulation and implementation of the so-called *Sustainable Urban Mobility Plans* (SUMPs) as well as the *Electric Vehicle Charging Plans (EVCPs)* for all urban areas aimed at promoting low- and zero-emission mobility [3]. These plans were well-received by cities and towns across Europe, catalyzing the preparation and update of hundreds of urban mobility plans. This mobility planning approach is successfully implemented on diverse scales and in a variety of cities and regions not only in Europe but currently in other parts of the world. For example, in Asian countries, the Association of Southeast Asian Nations (ASEAN) has developed and published guidelines for the development and implementation of SUMPs in ASEAN metropolitan regions [4]. Regarding the *EVCPs*, studies have aimed to recommend locations for electric vehicle charging points in urban and interurban areas [5].

This paper examines the operational tools and policies with which electric mobility can be promoted in small and medium-sized urban areas as well as in areas near border crossing points (SMBs), offering the experience from a small European country (Greece) and the implementation of SUMP and EVCP studies there, as well as the experience from a country that has promoted electromobility very rigorously over the last 10 years, namely China. The research questions that the paper tries to answer are the following:

a. What are the conditions that differentiate small and medium-sized urban areas lying in the periphery and/or near border crossing areas from the large metropolitan urban areas as regards the use of electric mobility?
b. What are the benefits that electric mobility can bring to such areas?
c. What are the policies and procedures that can facilitate the introduction and wider use of electric mobility in these areas?

2. BACKGROUND

The advent of electromobility has brought about a wide spectrum of advantages, covering environmental, economic, and societal aspects in line with sustainability and climate change pillars. Under the European Green Deal and the European Commission's Fit for 55 legislative packages, the EU is targeting carbon neutrality by 2050, and a 55% reduction in CO_2 emissions by 2030. The regulation for cars and vans sets a 100% CO_2 reduction target for 2035. A series of initiatives and declarations by the European Union have set a target of at least 30% new electric vehicle sales in the EU by 2030. As seen in the statistics collected by the European Alternative Fuels Observatory these policies boosted the growth of sales of electric passenger vehicles from slightly over 21,000 units in 2011 to nearly 2.2 million in 2021, and from only 286 battery electric buses in 2011 to over 7350 in 2021 (see https://alternative-fuels-observatory.ec.europa.eu/). According to the same database, in 2014, the total number of alternative fuelled passenger cars (BEV, PHEV, H2, LPG, CNG, and LNG) and vans in the EU was just over 7.9 million. By 2023, this number had increased to over 17.5 million (i.e. an increase of 122% from 2014-2023). According to the European Automobile Manufacturers' Association (ACEA), a comprehensive public charging network will be essential to support the anticipated surge in EV demand as the European Union phases out the sale of vehicles with internal combustion engines [5]. So far (in 2024), the overall percentage of electric vehicles in the European vehicle fleet (the EU countries plus Iceland, Norway, and Switzerland) amounts to less than 10% of the total.

The path towards sustainable, electrified mobility is a challenging one in general, but it is more challenging for SMBs, where there are fewer potential adopters and the fleets of electric vehicles do not cause economies of scale that would push the advancement of e-mobility further. The charging infrastructures are smaller in numbers and power, and, for the border areas, complex synergies between neighbouring countries must be sought. For SMBs, however, electric mobility can offer advantages that

make such development worth supporting. In addition to improved energy efficiency, reduced greenhouse gas emissions and all the other benefits as regards air quality, climate change and quality of life, electric mobility can improve the business and entrepreneurship conditions both locally and in wider areas (including cross-border areas) through electric vehicle fleet supporting businesses, e-mobility based business like car sharing or public transport schemes, partnerships to support and maintain electric mobility for freight services, and other [6]. A special category of SMBs is that of towns and small cities on an island. There, electromobility may be a more imposing challenge, but it is also particularly beneficial given that these places usually need special environmental protection and have high seasonal variations in touristic flows and thus in demand. Therefore, it is more difficult to develop and maintain electric infrastructures because they are underutilized for most of the year [7]. In Greece, for example, the government is promoting the electrification of transport on small islands and has recently teamed with the Volkswagen Group to introduce electric mobility on several of them; the first was the island of Astypalea in the central Aegean Sea [8]. For the rest of the country, especially large urban areas, the first moves towards electrification of the transport sector date back to the pre-COVID era. Since the COVID pandemic, electric mobility has been promoted by the government steadily. Since 2022, a series of supporting legislation including subsidies for buying electric vehicles, abolition of circulation and other taxes and fees for electric vehicles, and free circulation in otherwise restricted zones for conventional cars in the centre of Athens, have been implemented [9].

Also of interest to this paper are the e-mobility developments in China even though this country is at the other end of the scale than Greece and most other European countries. This is because China is a heavy promoter of e-mobility and is doing this at a very rapid pace. It already has the largest percentage of electric cars (they are called “new energy vehicles” or NEVs), at 33% of the total car sales at the beginning of 2024. This represents 8.25 million electric car sales (i.e. almost half of the electric car sales worldwide). More than 80% of e-cars in China are produced in the country, and by 2025, they are expected to account for half of the volume in the domestic market [10]. At the same time, China’s public charging network accounts for two-thirds of the global public charging infrastructure and is growing rapidly. These public chargers are still unevenly distributed and are mainly concentrated in large urban areas. Cities in eastern and southern China generally have more public chargers than those in western and northern China. In 2022, the top 15 cities in China, by number of public chargers, accounted for 57% of the country’s total public charger stock, while in Europe and the United States, the top 15 cities accounted for 23% and 47% of all public chargers respectively [10]. However, public charger availability on highways is among Chinese EV drivers’ greatest concerns related to long-distance travel. As of 2022, China’s highway public charger density was 105 per thousand kilometres, compared with 654 in Norway. However, in the urban cores of Shanghai, Beijing, and Shenzhen, EV drivers could find a public charger within 20 minutes of drive time, while a large majority could drive to the nearest charger in less than five minutes [10]. By contrast, public charger coverage in SMBs and rural areas in China is still low, which is why the government is now promoting the deployment of charging infrastructures in these areas as a priority [11].

3. FACTORS PROMOTING E-MOBILITY IN SMB URBAN AREAS

3.1. Financial incentives

Electric mobility in small and medium-sized (SMB) urban areas is primarily hampered by financial issues relating to the purchase of an EV and the financing of the necessary infrastructures. Because of their small populations, SMB urban areas suffer from low public financing ability and reduced opportunities to attract private capital for charging infrastructures. The generally low GDP per capita, as compared to large cities, makes the price of purchasing an electric vehicle more difficult to pay. Moreover, the resale prices in the second-hand electric vehicle market are relatively low. This challenging economic environment is usually combined with a biased political landscape that tends to concentrate attention on large urban areas and agglomerations. The purchase of an EV is usually incentivized, at the national level, by public co-financing of the purchase value or reducing or abolishing

the taxes that are usually associated with a privately owned vehicle. Financial incentives for SMB urban areas have therefore to be specifically designed to be effective for those areas. For example, a reduction of the VAT for a new EV only for residents in SMBs would be an added incentive. Also, access to affordable overnight at- or near-home charging stations has to be provided and this would necessitate broadening the use of off-peak charging electricity prices for SMB urban areas if grids can adapt to varying demand. The local authorities could also team with power companies to introduce a lower tax rate for at-home charging. If such incentives are put in place local authorities should also look at ways to make overnight street charging closer in cost to charging using residential electricity because many working drivers lack off-street parking or affordable access to, at- or near-home charging.

A particularly demanding financial cost is the cost for (super) fast charging stations, which are particularly helpful for visitors to the area or working drivers who want to have a quick charge or for tourists who do not want to delay their trip. In SMB urban areas with high tourism potential, the installation of fast chargers is an added incentive for both local EV purchase and use as well as unimpeded tourist visits. Facilitating the construction of fast-charging infrastructures can be achieved by local authorities by giving grants for such installations, simplifying tender procedures and speeding up construction in any way possible. Public fast-charging costs can also be reduced by bundling power demand in groups of vehicles across industries that are electrifying, with fleets acting as anchor clients for charging operators.

Governments should also consider adjusting the value-added tax (VAT) on electricity used for public charging in SMB areas as long as consumers (and not power companies) can benefit from it. The investment required for building EV infrastructures in SMB urban areas usually deters private companies from committing to building such infrastructures because the returns are not very quick or even secured due to the low volumes of demand and utilization rates. This problem could be solved by having SMB areas join with neighbouring areas and offering well-coordinated and jointly aligned incentives to investors.

3.2. Creating an e-mobility-friendly business environment

Local governments in SMBs should strive to support the development of their own favourable business environment for e-mobility by taking actions such as:

a. Putting pressure on the central or regional government to redress and upgrade building codes and require the installation of EV charging infrastructures in new developments or redevelopments in residential, commercial, and municipal parking lots.
b. Inviting EV manufacturers who are generally eager to increase the number of charging infrastructures to locate such infrastructures in or near their urban areas. If the size of the SMB urban areas is not attractive enough for these companies, the SMB city administrations could invite them to install such infrastructures in the nearby highway networks at resting areas, supermarket parking lots, or petrol stations, which are associated with the highway but still close to the city.
c. Providing targeted incentives for businesses located in or near the wider area of the SMB city. Such incentives would mainly be using local taxes on businesses (which can be reduced or even waived), as an incentive to buy e-vehicles. In Norway, for example, companies have been offered a 50% reduction in company car tax when purchasing battery electric vehicles (BEVs). Such vehicles have also been exempted from the 25% VAT on leasing vehicles [12].
d. Securing investment from local businesses for EV-related infrastructures. For example, retailers are usually willing to install charging stations because they can earn revenue and attract customers while they charge their cars. In Italy, small- and medium-sized businesses can get a 50% subsidy for constructing public AC charging stations [7].
e. Incentivize landowners to make land available for charging stations. Acquiring land is among the largest costs for private installations of charging stations. SMB city administrations can help to overcome this by providing tax incentives and other revenues to landowners who allow EV charging stations to be installed on their land. This has been an important policy behind China's EV market growth [10, 11].

f. Giving access to EVs in areas or services that are not allowed for other vehicles. For example, allow EV access to bus or carpool lanes (a privilege that can be revoked later when the number of EVs increases to avoid causing undue delays to buses in the lane), access to zero-emission zones, etc.
g. Introducing severe penalties (financial and other) for violations of the e-charging spots by vehicles that use them for parking. This is a common problem in the early days of the adoption of e-mobility when people are not familiar with the sites and functionality of charging stations and use them as parking spots. Access to these charging spots must be always unimpeded and solely dedicated to electric vehicles that need to be charged.

3.3. Planning and market organizational factors

In the EU, the SUMPs and the EVCP, which were mentioned in the introduction, have been promoted by the European Commission for almost 10 years. More recently, in 2023, the European Union adopted the *Alternative Fuels Infrastructure Regulation* (AFIR), which further emphasized the need for public power installations to satisfy EV charging needs. In China, the deployment of charging infrastructures (*electric vehicle supply equipment* in Chinese) at an early stage of the electrification drive has been critical to the success of e-mobility. It consists of prioritizing fast charging stations, a drastic cut in bureaucratic delays, and the installation of charging stations in areas with high density, high charging demand, and nearly overburdened public stations.

Stakeholder engagement is another important organizational component of a successful e-mobility promotion in SMB areas. The local authorities should initiate and support the establishment of a coalition of stakeholders to promote electric mobility and build a long-term strategy based on such coalitions to align investment plans. A stakeholder engagement group can take the form of an *EV Task Force* (ETF) consisting of city officials, the car industry or car dealer companies, electricity providers, fleet managers, and other relevant and interested stakeholders. For cross-border areas where there is a need to cater for the common practice of daily crossings of the borders in both directions, charging infrastructures on both sides must be compatible. This is an issue that a cross-border task force could handle. For electric mobility infrastructure planning, the ETF can work with the local electric utility to determine site selection and type of chargers and to provide essential information and other support for e-mobility planning. There are several forms of stakeholder involvement. For example, the *Action Platform on Urban Electric Mobility* (UEMI), which was developed recently in Europe, is an initiative intended to bring together the various stakeholders of electric mobility from the supply and demand sides [14].

The maturity of the market for electric vehicles in SMB urban areas is another important factor. The market maturity index (MMI) is used to express the state of the development of an area's e-mobility market. It expresses all the non-cost factors influencing the consumer's decision to buy and/or use an EV, such as their trust in technology, social influence, and environmental awareness. It is a composite measure that includes two kinds of factors: factors specific to the e-vehicle characteristics and factors specific to the consumers. Vehicle factors include the range of the vehicles (what has been called "range anxiety"), the availability of charging infrastructures, the reliability of the vehicles, etc. Consumer-specific factors represent the likeliness of an individual becoming an early adopter of EVs. This is based on several factors, including knowledge of alternative vehicle options, consumer environmental responsibility, consumer knowledge of maintenance and technology, attitude, and willingness to take a risk [9]. A recent study in Greece calculated the MMI for e-mobility in the country based on two attributes, namely range anxiety/available infrastructure, and consumer attitude independently of cost [9]. According to this study, the market maturity index values that were calculated for Greece (based on 2022 market statistics) show a very low market maturity index for BEVs in Greece, with wide variations between the large urban areas and the smaller ones (the highest maturity in the Athens area). The MMI was found to have a strong positive correlation with the market share of BEVs (+0.88), while the cost had a strong negative correlation (-0.56) and the degree of substitution a moderate negative correlation of -0.22 ([9]; Table 6). The degree of substitution is a quantitative measure showing how the choices in the discrete choice model are alternatives to each other. It signifies the ease with which one can switch between choices in response to a change in cost.

Finally, in designing the path to e-mobility, the administration of an SMB urban area should promote implementation by giving examples. That is, it should demonstrate the value of e-mobility by using it in municipal vehicles, public transport services (e-buses), urban freight delivery vehicles, garbage collection, and so on. It should also monitor and promote e-mobility by establishing a permanent planning and promotion process and do so by setting and evaluating policies for e-mobility in ways that support desired outcomes. This would require the systematic collection of data and information on performance as well as the application of tools to optimize and monitor/measure performance. A recent report by the International Transport Forum gives all the necessary relevant information on how to do this; it also presents relevant indicators for evaluating how e-mobility contributes to policy objectives. Moreover, it proposes standard calculation methodologies, data requirements and reporting frequencies for performance indicators in five policy areas namely sustainability, safety, utilisation, accessibility, and equity [20].

3.4. Existence of e-mobility services

Special mobility services such as EV-sharing play a significant role in promoting e-mobility. The development of innovative electric car-sharing businesses that offer expanded use of EVs to users without owning them is a business idea that, for SMBs, falls into the "chicken and egg" dilemma. In order to be sustainable and economically viable, it should rely on a fair number of users and e-fleet vehicles. Finding the necessary critical mass of demand and supply that would make these services viable could be achieved if two or more SMB areas join forces and cooperate to offer an appealing case to entrepreneurs and with the appropriate public support and information campaign such services could start and become viable over a relatively short time. Many examples of EV-sharing services can be found in large urban areas around the world. In China, the idea was first introduced in 2015 with the *EvCard*, which was launched in Shanghai by the SAIC Group. In London, the *e-Zipcar* fleet was created in partnership with Volkswagen, in Tokyo Nissan has implemented the e-share *mobi* scheme, and in eight European countries, the *ShareNow* system is active with 2,900 EVs in its 11,000-car fleet. ShareNow is a good example of how e-sharing can be organized between several urban areas and, thus, can be used as a blueprint for such services between two or more SMB areas.

3.5. Other pros and cons – SWOT analysis

The pros and cons of e-mobility for SMBs in urban areas are summarized in the SWOT analysis in Table 1, where the strengths, weaknesses, opportunities, and threats for e-mobility promotion in SMBs are presented. Special mention is warranted for the following weaknesses of EV technologies that, although they are rapidly being addressed by new advances, may be given undue weight and importance in promoting e-mobility in SMBs:

a. Deep discharge or overcharging cycles in electric vehicles can lead to internal electrical imbalance, causing damage to the separator and resulting in an explosion.
b. EVs accelerate much more quickly than conventional ICE vehicles. This might present a safety risk on public roads. Cost issues may also arise from excessive tyre and brake wear.
c. Increased risk of spontaneous fire from either a damaged battery pack (e.g. due to a crash) or battery overheating. Next-generation EVs using sodium-ion batteries are less likely to ignite spontaneously. Even less likely to ignite are solid-state power packs, which are expected to be developed in the near future.

4. FOCUS ON CHINA

China is rapidly becoming the world's champion for the electrification of the transport sector and is the largest exporter of e-mobility globally. According to the latest *Global Electric Mobility Readiness Index* figures, published by A D Little ([16]; Table 1), in 2023, China was only second to Norway and is expected to soon become ranked first in the world. China has initially given generous incentives for

the supply side of e-mobility (i.e. for manufacturing EVs and relevant equipment). It also provides incentives for raising the demand (subsidies for purchasing an EV as well as negative incentives for buying conventional cars). Policies on the demand side have focused on consumers and include purchase subsidies, purchase tax exemptions, exemptions from purchase restrictions (in many Chinese cities, there are strict restrictions on buying internal combustion cars, especially in large urban areas), and exemptions from the vehicle and vessel (V&V) tax, parking fees, bridge and road tolls, compulsory insurance fees, and public charging fees. EVs have also benefitted from preferential access to bus lanes. These policies started in 2015–2016 and have gradually been lifted as the number of EVs in the country has increased rapidly.

Since the beginning of this decade, the Chinese government's priority, especially for small urban areas, seems to be the further expansion and universal coverage of the electric charger network. This is due to the fact that insufficient access to chargers is seen in China today as the major barrier to more widespread EV uptake for SMBs according to the *National Development and Reform Committee* of the country. Therefore, the *General Office of the State Council of China* recently issued specific guidelines (opinions) for building a high-quality charging infrastructure system [18]. Based on these guidelines, China is now actively promoting the construction of rural-level charging networks and the corresponding development of power transmission and distribution networks. This includes the construction of public DC fast charging stations in county-level cities. These charging stations are located near rail stations or ports, as well as other public transport stations, public parking lots, and logistics bases. Private enterprises are given full control over the development of EV charging innovation and creating "smart integration innovation platforms for vehicles, charging piles and transport networks". Research and innovation for e-mobility are encouraged and financially supported by technologies such as fast charging and battery swapping, high-power charging, intelligent orderly charging, wireless charging, and the cooperative control of optical storage and charging. As for financing, local governments are encouraged to establish operating subsidy standards linked to service quality and increase subsidies for demonstration projects such as high-power charging and vehicle-network interaction. The central government can also finance the construction of qualified charging infrastructure projects through local government special bonds [18].

A quick review of the measures to promote e-mobility, as implemented in two Chinese SMBs, will serve as a further example of the policies followed in China:

Example 1: *Shenmu City*, Shaanxi Province, population of 579,800. Recently, the Shenmu municipal government has issued the "Interim Measures for the Construction and Operation Management of Electric Vehicle Charging and Swapping Infrastructure in Shenmu City". The measures were implemented on April 24, 2024, and are valid for two years. They include [19]:

- Building an electric vehicle charging and swapping service network and incorporating it into national spatial planning to connect with transportation, electricity, and other network planning.
- Promoting the coordinated construction of car charging and swapping facilities in public parking lots, transportation and road management stations, bus stations, and highway service areas.
- Reserving electric vehicle charging and swapping stations in mining areas, power plants, logistics parks, consolidation stations, and other suitable scenarios.
- Accelerating the construction of public charging infrastructure in tourist attractions.
- Connecting the charging and swapping facilities to the Shenmu New Energy Digital Intelligent Computing Platform and the Shaanxi Smart Vehicle Networking Platform to obtain real-time data (automatic collection of information and analysis of various abnormal data to ensure the safety of new energy vehicle charging and swapping and operation).

Example 2: *Anning City*, Yunnan Province, population of 507,000. The relevant policies and measures include electrification of the public transportation fleet (the city uses electric buses in public transportation as of 2021). There are currently 455 electric buses in Anning City, of which 373 are pure (battery) electric buses and the rest are hybrid. Also, regarding the development of the charging infrastructure, from January to October 2022, the city built 1477 charging stations, of which 337 are in public spaces and 1140 are in private self-use sites.

Table 1

SWOT analysis for e-mobility in SMB urban areas

	STRENGTHS	WEAKNESSES
"Internal" environment	• Higher driving performance • Zero circulation fees • Reduced charging fees • Free municipal parking • High energy efficiency • Lower overall energy consumption per km travelled. • Zero levels of noise pollution • Contribution to an improved and healthier urban environment • Alignment with the overall environmental and climate change mitigation aims and objectives. • Facilitation of access to SMB areas by e-vehicles of visitors from other regions	• Higher prices for purchase of the e-vehicles • Few public chargers • Reduced autonomy – range anxiety • Reduced capacity of the electric power grid • Small market penetration of EVs yet • Weak public information • Lack of coordination and alignment of e-mobility promotion among authorities • Recycling of batteries • Deep discharge or overcharging cycles in electric vehicles can lead to internal electrical imbalance (charging explosion) • Need for greater coordination between sustainable urban mobility and electric charger location planning.
	OPPORTUNITIES	THREATS
"External" environment	• Fleet renewal for municipality fleets and private companies • Attraction of new investment in the area mainly for privately owned charging infrastructures • Creation of new job opportunities • Reduction of overall noise and air pollution • Incentives for greater use of green technologies • Together with other sustainable mobility options, the creation of future smart and green cities • Contribution to the net-zero fossil fuel situation by 2050	• Lack of cooperation between relevant public authorities and organizations • High age of the vehicle fleet (e.g. 16 years on average in Greece) • Lack of adequate incentives for EV purchase (as of 2024) • Slow and cumbersome public administration procedures for the financing and installation of charging infrastructures • Cumbersome and expensive recycling of batteries • Delays in the implementation of the EVCPs • Lack of e-mobility data • Danger of accidents due to overseeding • Danger of fires either by damaged battery packs or spontaneous combustion of batteries (though not very likely)

5. CONCLUSIONS AND SUMMARY OF RECOMMENDED POLICIES AND MEASURES

The experience from current practice in Europe and China indicates that small and medium-sized cities and border areas (SMBs) have been slower to adopt electric mobility than large urban areas. As a result, the market maturity index for electric mobility will reach its self-sustainable value much later in SMBs. Thus, there is a need to take special steps customized to their own market and socio-economic environment to promote market maturity in their areas. In the previous sections, several measures and factors promoting e-mobility in SMBs were presented. It is now of interest to classify all these measures.

In Table 2, we have summarized the most widely used measures and policies for promoting electric mobility in SMB urban areas.

Table 2

Recommended measures and policies for electric mobility promotion in small and medium-sized areas, as well as cross-border areas

A/A	*Name of Policy / Action*	*Time scale for implementation*	*Recommendations*
1	Prepare a short- to medium-term plan for sustainable mobility in the area that includes specific measures and policies for e-mobility (e.g. SUMPs)	Short-term	+ Integration of electric mobility in the context of the overall urban transport planning for the area. + Promote and accommodate a mix of electric mobility service options (e.g. for shared mobility, e-micromobility, e-deliveries, etc.). + Integrate it into active and high-capacity modes of transport. + Adopt an integrated mobility approach, seeking synergies and cooperation between local transport modes as well as with other localities in the region. + In border areas, pursue cross-border cooperation and stakeholder involvement for common measures and policies regarding the promotion of e-mobility. + In all plans and decisions, consider residents' needs as well as those of the visitors.
2	Support the purchase of e-vehicles and reduce the costs of transitioning to BEVs relative to ICE vehicles taking also into account the heterogeneity of different vehicles (e.g. bus, e-bike, e-car, e-taxi, e-truck)	Short- to medium-term	+ Introduce "local" incentives for EVs such as free parking in municipal parking areas, use of priority lanes, reduction of local taxes where applicable, reduction in charging rates and other incentives. + Keep and increase "local" incentives as other upfront national purchase incentives are phased down. + Introduce differentiated promotion plans and strategies for different types of e-vehicles at different stages
3	Prepare and implement a comprehensive plan for charging infrastructures	Short- to medium-term	E.g. the Electric Vehicle Charging Plans in Europe.
4	Expand the charging network with the deployment of fast chargers that are particularly attractive for long-distance travellers and tourists	Medium-term	+ Provide an adequate number of and unimpeded access to charging stations for all users. + Provide finance through central government or other funding + Mobilize and enhance private or public-private financing. + Consider issuance of bonds or any other forms of financing.
5	Steadily promote the creation of "market maturity" for electric mobility by taking measures to incentivize BEV uptake factored into urban policymaking	Short- to medium-term	+ Redress and upgrade current building codes to "EV-ready" level by requiring the installation of EV charging infrastructures in new developments. + Invite EV manufacturers to increase the number of charging infrastructures.

			+ Secure investment from local businesses for EV-related infrastructures. + Incentivize landowners to make land available for charging stations + Give access or preferred pricing to EVs in areas or services that are not allowed for other vehicles. + Introduce severe penalties and monitor regularly for violations of the e-charging spots by vehicles that use them for parking. + Consider designating restricted vehicle access zones, that allow for preferred pricing and access for BEVs over ICE vehicles.
6	"Lead by example" strategies	Medium-term	Force municipal and other local government-dependent public bodies to own or use EVs in their fleets.
7	Lower the cost of charging for BEVs, particularly for drivers without access to domestic charging	Short-term	+ Make public overnight charging more affordable and readily available with adjustments to the value-added tax code and "right to plug" initiatives. + Arrange streamlined tender and build processes that suit both public and private partners, to speed public EV charging deployments. + Provide special charging rates for on-street parking near the residence (details in section 2.2.1).
8	For very low-density areas, introduce an on-demand service	Short- to medium-term	Introduce transport on-demand services using BEVs.
9	Mobilize and involve all stakeholders and strengthen public-private partnerships	Short-term	+ Build stakeholder and institutional cooperation across the board and engage all relevant stakeholders, especially in near cross-border areas.
10	Promote equity and inclusion in the deployment of electric mobility	Short-term	Take equity and inclusion in consideration for all cases of plan preparation and implementation
11	Encourage the participation of the private sector in the development and uptake of e-mobility functions.	Short-term	+ Create co-ownership of the transition at all cases and levels. + Make use of web platforms and other means of virtual cooperation.
12	Prepare and implement dissemination and information campaigns	Short-term	+ Provide adequate and reliable information on e-mobility facts, figures, and expected benefits. + Arrange for test drives or public awareness campaigns. + Provide information, advice, and guidance for drivers.
13	Promote e-multimodality by interlinking e-personal transport (e-bikes and e-vehicles) with public transport (e-buses)	Short- to medium-term	+ Provide opportunities for multimodal transit hubs through the strategic location of charging infrastructures + Plan and implement last-mile services using electric vehicles.
14	Promote EV-sharing schemes	Medium-term	+Promote shared e-mobility.

6. CONCLUSIONS

Electric mobility in Europe and China is currently advancing. China and several European countries are among the top in the world for EV adoption. Norway is currently ranked first globally, followed by China and other Scandinavian countries, as well as Holland, Germany, and France. Electric mobility in SMBs, however, is still at its beginning in all these areas. A well-coordinated effort on behalf of the governments is still needed to support and incentivize the introduction of e-mobility infrastructures and services in SMBs. To this end, several potential measures and policies for SMB urban areas are recommended in Table 2.

The most usually employed incentives, especially at the beginning when the penetration of EVs is small, are financial incentives in the form of subsidies, exemption from vehicle-related taxes, etc. These actions are normally taken by central governments and have a universal (national) application. However, local financial incentives are also possible, especially in countries where the legislative environment permits it. The second most important and concurrent measure is the installation of an adequate number of charging infrastructures. This is a priority and a common initial activity in all successful e-mobility cases examined. In the beginning, these infrastructures may be underutilized due to the small number of EVs in the area, but their existence in place, from the beginning, serves as a reassurance to reduce and eventually erase range anxiety for EV owners. Other notable measures and policies are those that promote non-financial incentives for e-mobility, such as allowing the use of otherwise restricted (to conventional vehicles) infrastructures to EVs, adopting an integrated mobility approach, seeking synergies and cooperation between local transport modes and EVs or e-mobility services, creating a cooperative environment between all relevant stakeholders in the area, and leading by example (i.e. having local administrative bodies be the first to buy and use EVs). Finally, there are several strengths, weaknesses, opportunities, and threats related to e-mobility promotion in SMBs, as presented in Table 1.

It is hoped that the proposals and recommendations made in this paper can serve as guiding ideas and examples of measures that can be taken by interested local authorities and decision-makers in SMB urban areas to promote EV uptake and the development of e-mobility services and use. The final selection and implementation of measures should always be the result of a proper planning study that will analyse and consider the local socio-economic conditions and characteristics, as well as those of the neighbouring areas and the current legislative and policy environment in the country concerned.

References

1. OECD Regions and Cities at a Glance 2022. *OECD publications.* 15 Nov 2022. 135 p. DOI: 10.1787/14108660-en
2. Westin, K. & Jansson, J. & Nordlund, A. The importance of socio-demographic characteristics, geographic setting, and attitudes for adoption of electric vehicles in Sweden. *Travel Behav. Soc*. 2018. Vol. 13. P. 118-127.
3. *Sustainable Urban Mobility Planning*. European Commission (EC). Recommendation no. 2023/550 of 8 March 2023. Available at: https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32023H0550.
4. *Guidelines for the Development of Sustainable Urban Mobility Plans (SUMP) in ASEAN Metropolitan Regions*. ASEAN Secretariat, Jakarta. 2022. ISBN: 978-623-6945-70-4. Available at: https://asean.org/wp-content/uploads/2022/01/asean-sump-guidelines-english.pdf.
5. *Charging ahead: accelerating the roll-out of EU electric vehicle charging infrastructure*. ACEA (European automobiles' manufacturing association) report. April 2024. Available at: https://www.acea.auto.
6. Grzesiak, S.S. & Sulich, A. Electromobility: Logistics and Business Ecosystem Perspectives Review. *Energies* 2023. Vol. 16. No. 7249. DOI: 10.3390/en16217249.
7. Qadir, S.A. & Ahmad, F. & Al-Wahedi, A.M.A.B. & Iqbal, A. & Ali, A. Navigating the complex realities of electric vehicle adoption: A comprehensive study of government strategies, policies, and incentives. *Energy Strategy Reviews.* 2024. Vol. 53. No. 101379.

8. *Electric island Astypalea: Transformation of mobility fully underway*. Volkswagen Group Technology, Andreas Gross. Press Release 13/6/2023. Available at: https://www.volkswagen-group.com/en/press-releases/electric-island-astypalea-transformation-of-mobility-fully-underway-17312.
9. Shaban, F. & Siskos P. & Tjortjis, Ch. Electromobility prospects in Greece by 2030: a regional perspective on strategic policy analysis. *Energies*. 2023. No. 16. DOI: 10.3390/en16166083.
10. Cui, H. & Ma, R. & Liu, Y. & Yu, R. & Peng, X. & Zhang, J. & Yang Li, Y. *Charging up China's transition to electric vehicles: A dive into China's public charging infrastructure deployment and comparison with Europe and the United States*. The International Council on Clean Transportation (ICCT). January 2024. Available at: https://theicct.org/wp-content/uploads/2024/01/ID-93-%E2%80%93-China-charging-Report-A4-70131-v6.pdf.
11. GOCSC. 2023. *Guidance on further developing a high-quality charging infrastructure system.* General Office of China State Council. Available at: https://www.gov.cn/zhengce/content/202306/content_6887167.htm.
12. Motowidlak, U. & Bukowska-Piestrzyńska, A. Determinants of electromobility development from the perspective of a zero emission, innovative and resilient economy. *Economics and Environment* 2024. Vol. 1(88). P. 1-15.
13. D'Alonzo, V. & Zambelli, P. & Zilio, S. & Zubaryeva, A. & Grotto, A. & Sparber, W. Regional infrastructure planning support methodology for public and private electrified transport: a mountain case study. *Applied Sciences.* 2023. Vol. 13. No. 7181. DOI: 10.3390/app13127181.
14. SOLUTIONSplus transformative Living Labs. *SOLUTIONSplus research project (Integrating Urban Electric Mobility Solutions in the Context of the Paris Agreement, the Sustainable Development Goals and the New Urban Agenda).* EU Grant Agreement No. 875041. Project brochure, published February 2023. Available at: https://www.solutionsplus.eu/_files/ugd/de12cd_12522b09607944e2a1f4c2f0673cd1fc.pdf.
15. Mpoi, G. & Milioti, C. & Mitropoulos, L. Factors and incentives that affect electric vehicle adoption in Greece. *International Journal of Transportation Science and Technology*. 2023. Vol. 12. No. 4. P. 1064-1079.
16. Arthur D. Little. *Global electric mobility readiness index – GEMRIX 2023*. October 2023. Available at: https://www.adlittle.com/en/insights/report/global-electric-mobility-readiness-index-gemrix-2023.
17. Zhang, T. & Burke, P.J. & Wang, Q. Effectiveness of electric vehicle subsidies in China: A three-dimensional panel study. *Resource and Energy Economics*. 2024. Vol 76. DOI: 10.1016/j.reseneeco.2023.101424.
18. GOCSC. *Guiding Opinions of the General Office of the State Council on Further Building a High-Quality Charging Infrastructure System*. General Office of China State Council. 8 June 2023. Available at: https://www.gov.cn/zhengce/content/202306/content_6887167.htm.
19. GOGSC. *Interim Measures for the Construction and Operation Management of Electric Vehicle Charging and Swapping Infrastructure in Shenmu City*. General Office of China State Council General Office of the Government of Shenmu City. Document No. 27. April 24, 2024.
20. ITF. Measuring New Mobility Definitions, Indicators, Data Collection. *International Transport Forum – Mobility Innovation Hub.* OECD bookshop. May, 2023.

Received 07.05.2023 accepted in revised form 04.09.2024