Situation Analysis of Electric Vehicles, Renewable Energy and Smart Grids for Sustainable Urban Mobility in Five European Regions

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***Abstract*—Urban electric mobility and renewable energies are innovative and smart technologies that can significantly contribute to reducing greenhouse gas emissions and increase energy efficiency. In order to increase their integration, the INTERREG EUROPE "EV ENERGY" project was initiated by five European countries (Italy, Lithuania, Spain, Sweden and the Netherlands). The project partners shared their mobility policies in order to learn how to overcome obstacles for the implementation of sustainable urban mobility. This research project comprises a situational SWOT analysis of electric vehicles, renewable energy and information and communication technologies. The greatest weakness that most countries encounter is the high price of electric vehicles and the lack of a developed charging infrastructure, however, a high number of private initiatives and an increasing people's awareness are promising.**

Keywords-electric vehicles; renewable energy; smart grids; mobility; situation analysis.

I. INTRODUCTION

Transport systems have a significant impact on the environment, accounting for 33.1 percent of the total energy consumption in 2015 [1]. Furthermore, the transport sector has the biggest oil demand at the European level, as two-thirds of the final demand for oil comes from transport. Road transport accounted for 54 percent of the final demand for petroleum products in 2014 [2].

According to Eurostat, all the sectors, except fuel combustion in transport and international aviation, contributed to the overall greenhouse gas emission reductions from 1990 to 2015. In 2015, transport emission rose for the second consecutive year. Besides, the average share of energy from renewable sources in transport increased from 1.4 percent in 2004 to 6.7 percent in 2015 [3].

Electrification of road transport has become a major trend and two of the most important technologies in European countries are Electric Vehicles (EVs) and Renewable Energies (REs). There is a spectrum of EVs technology, such as hybrid electric vehicles, battery electric vehicles and plug-in hybrid electric vehicles [4]. EVs can significantly reduce global and local emissions and are part of the future vision for global mobility.

Additionally, EVs are not only used for mobility, but also for energy services, including: energy back-up services, EVs participating in energy market, vehicle delivering energy to home/street/grid/city applications, variation in EV charging connected to local energy sources, accelerated storage of electricity in EV and/or electric public transport, implementing renewable energy sources for EV and/or electric public transport [5].

In the framework of the INTERREG EUROPE "EV ENERGY" project, an innovative approach was used to develop a framework of policies and experiences where energy, mobility and smart grids will work together. The project consists of partners from five European countries: Italy, Lithuania, Spain, Sweden and the Netherlands. The partners recognized a need to share technical and practical experience to learn how other institutions overcome the difficulties for the implementation of sustainable mobility. Interregional exchange and cooperation is necessary in order to achieve a better framework of policies, making it possible to develop more sustainable cities [5].

The main objective of this paper is to conduct the situation analysis of EVs, RE and Information and Communication Technologies (ICT) for sustainable urban mobility in five European regions.

II. METHODOLOGY

The study area of the current research comprises five European regions: Italy (Lazio region), Lithuania, Spain (Barcelona), Sweden (Stockholm) and the Netherlands (Amsterdam and Flevoland). The situation analysis was performed in each project partners' region by using Strengths, Weaknesses, Opportunities and Threats (SWOT) matrix, based on the inventory of good practices and mobility policies in each region. All the partners were actively involved in the data collection process. To ensure harmonisation of information and data collection, templates for the inventory of good practices and mobility policies were prepared and spread among the partners. The good practices and mobility policies were analysed on the city/regional, national and the EU scale. Additionally, the inventory was based on the three pillars approach 1) EVs; 2) REs; 3) ICT. Information and data were obtained by analysing secondary resources: bibliography, laws/regulations, relevant sites, public reports, national and international standards. In addition, focus groups meetings gathering policy makers, researchers and business representatives were held in each project partner's countries. What was collected within the inventory of good practices and policies contributed to the SWOT analysis.

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III. RESULTS AND DISCUSSION

This part of the paper presents features of EVs, renewable energy and smart grid-ICT sectors integration as SWOT analysis in 5 European regions. The most important features are presented in Table I.

TABLE I. MAIN FEATURES OF SWOT ANALYSIS IN FIVE REGIONS [5]

	STRENGTHS	WEAKNESSES	OPPORTUNITIES	THREATS
Italy	- Kyoto rotation fund grants 50 million euro to support sustainable mobility. - Exclusion of EVs users from motor vehicle tax for 5 years. - Increasing production of renewable energy.	- High purchase price of EVs and their batteries. - Government lacks a clear legislative basis and national/ regional financial instruments. - High motorization rate in Rome (9 vehicles per 10 inhabitants) causes high pollution, noise and congestion.	- According to new construction regulations, new housing must have e-charging infrastructure. - Government initiated the National Infrastructure Plan to develop a recharging system in Italy.	- Most of e-charging network is not developed. - Strong dependence on traditional energy sources (oil products)
Lithuania	- Vilnius city allowed EVs to use bus and taxi lanes. - Parking EVs is free of charge.	- High purchase price of EVs and their batteries. - Lack of vehicle taxation mechanisms encourages people to use second-hand vehicles.	- Rejuvenation of a national car pool and reduction of dependence on oil products. - Opportunities for business and science in developing a new market and increasing car sharing competitiveness, additional subsidies and support mechanisms.	- Political decisions are lagging and are a way behind other EU states. - No single body responsible for e-charging infrastructure development. - High risk that second-hand EVs will be more expensive than fuel powered cars.
Spain	- Financial support for the development of e-charging infrastructure. - Lots of sunny days in Spain - a great potential of photovoltaic solar electricity.	- E-charging infrastructure lacks developed electrical networks and corridors, adequate power supply and maintenance that is more consistent. - EVs and hybrids take only 0.4 percent of the market.	- Growing investments and decrease of the photovoltaic energy price increase the number of EVs owners. - Promising initiatives of e-charging infrastructure, lowering Barcelona's energy dependence on imported energy.	- Lack of facilitating regulations, standards, training and framework for implementation, various barriers for public access to e-charging stations. - Limited control mechanisms to store surplus energy and generate additional during high demand.
Sweden	- Subsidies and tax reduction for EVs. - The power grid used for e-charging network is more or less already developed and is powered by mostly renewable energy.	- High purchase price of EVs and their batteries. - Companies expect high return, and the value of used EVs is low.	- Good potential of light EV. - The costs of EVs can be shared between partners. - People are eager to produce their own energy and use it on their own mobility.	- Additional tax if charging at the workplace and no parking benefits. - Budgets of municipalities too small to finance high costs of EVs and their infrastructure.
The Netherlands	- Part of MRA Elektrisch programme (20 000 EVs by 2020). - Culture of close public-private cooperation.	- Complexity of integrated energy projects. - Need of multi-stakeholder cooperation.	- Modern energy network. Spacious cities. - Awareness of need for integrated energy systems.	-Unstable national EV policies. - Large part of PV in rural areas. - Lack of awareness toward EVs. - Limited infrastructure.

IV. CONCLUSION

One of the main weaknesses is the high purchase price of EVs and their batteries. Another weakness is the lack of cooperation between stakeholders: municipalities, business enterprises, research and public bodies. Although some of the regions have already developed an e-charging network, further development is required. However, a developed e-charging network does not encourage people to change their ordinary fuel-powered vehicles, mainly because of the high EVs purchase price. On the other hand, countries are adjusting their policies and starting a number of initiatives, which might increase the use of EVs and integration of renewable energy, e-charging infrastructure and ICT.

Additionally, the use of EVs has another vision as energy storage. As REs have been increasing their weight in the energy mix year after year, EVs' batteries can be used to store locally produced RE, and give it back to the city during the hours of highest demand. This shows how the addition of EV to a household equipped with solar panels can greatly reduce the reliance on the grid. Such and similar cases present good practices and innovative policy making through regions, help other cities to reduce greenhouse gas emissions and save money in mobility and energy systems.

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