Tools and strategies for e-mobility development in a challenging territory

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***Abstract*—In the context of mobility, innovation and digital transformation are gaining a central role for the governance to anticipate, address, and overcome the new challenges and trends of the sector. E-mobility has been identified as a great opportunity towards decarbonization and sustainable development for both the private and public sector. On top of an efficient infrastructure, it is essential to plan tools and strategies that can help public administrations, citizens, and the main players of the mobility and energy sectors to interact, especially in the case of local public transport and last mile logistics management. Considering these objectives, a number of tools are being developed within the European transnational research project e-SMART in the reference territory of the Alpine Space. The final goal is to define Tactical and Operational Roadmaps and analyse heterogeneous e-mobility datasets through ICT technologies collecting models and results in a single digital platform that could be used by tour operators, tourists, and public decision makers.**

***Index Terms*—innovation, smart territory, e-mobility, data platform, local public transport, last mile logistics**

I. Context

Innovation and digital progresses provide e-mobility with opportunities to improve inclusiveness, local community empowerment, and efficient resource management, amongst other objectives within the wider UN 2030 Agenda sustainable development goals (see goal 9 - industry, innovation, and infrastructure and 11 - sustainable cities and communities) [1]. E-mobility has been identified in the European Green Deal [2] as a great opportunity towards decarbonization and sustainable development for both the private and public sectors. Typically, barriers to e-mobility deployment, especially for local public transport (LPT) and last mile logistics (LML), are represented by the lack of coordination among public and private actors, such as a participatory approach based on a smart territory logic and energy and mobility networks integration. A particularly complex case is the development of e-mobility in communities of the Alpine Space, which is strongly affected by relevant fluxes of local and long distance traffic and involves the co-presence of different countries in a small area with extremely variegated geomorphology and delicate environments. These features make the Alpine territory an excellent and challenging laboratory to implement transnational sustainable mobility solutions. The e-SMART project is funded by a European cooperation programme for the Alpine region as part of the policy implementation for low carbon mobility and transport in the Alpine Space. The main aim is to provide a framework to facilitate the cooperation between economic, social, and environmental key players, such as public administrations (PAs), local business sectors, policy makers, and research centers.

Three more European projects are currently working on e-mobility: INCIT-EV [3], USER-CHI [4], and eCHARGE4DRIVERS [5]. The project leaders decided to create a community to exchange results, reflections, and recommendations to deploy infrastructures in cities and territories that meet the expectations of all the users.

The H2020 INCIT-EV project aims to demonstrate an innovative set of charging infrastructures, technologies, and its associated business models, ready to foster and improve the European electric vehicle market share and relative user experience. The project will seek the emergence of electric vehicle users' unconscious preferences relying on neuroscience techniques to adapt the technological developments to their subjective expectations. The consortium is coordinated by the Renault Group with 33 partners and 5 demo environments are planned at urban, peri-urban and extra-urban conditions for the deployment of 7 use cases to address slow and super fast bidirectional charging while providing ancillary services to the power grid and innovative dynamic and static wireless charging for urban and highway roads.

The H2020 USER-CHI project will co-create and demonstrate smart solutions around 7 connecting nodes of the Mediterranean and Scandinavian-Mediterranean Trans European Network-Transport (TEN-T) corridors to boost a massive e-mobility market take-up in Europe. The consortium is coordinated by the ETRA group with 24 partners. The main objectives are: designing electric charging networks around user needs; deploying an interoperability framework and platform; enhancing scalable infrastructure roll-out by means of smart grid integration; developing marketable, innovative and highly convenient charging systems; co-designing and demonstrating novel and sustainable business and market models; and finally making legal and regulatory recommendations for a massive deployment of electric vehicles.

The H2020 eCHARGE4DRIVERS project aims to improve

the electric vehicle charging experience within cities and for longer trips. The consortium is coordinated by the Institute of Communication and Computer Systems (ICCC) with 32 partners. The project will demonstrate additional convenient charging options within cities, a mobile charging service, charge points at lamp posts, networks of battery swapping stations for light electric vehicles and a transportable charging station service to cover temporary needs. It will provide: an Electric Vehicle Charging Location Planning Tool to guarantee the optimum mix of charging options to cover users' needs; recommendations for legal and regulatory harmonisation; and guidelines for investors and authorities for the sustainability of charging infrastructure and services.

II. Project description and outputs

The project [6] is participated by 15 partners (including RSE spa) and 57 observers belonging to 5 different countries (Italy, Slovenia, Austria, Germany, France) and is on-going (start date: 01.10.2019 – end date: 30.06.2022) with a total duration of 33 months. The aim is to support the development of e-mobility smart grid services and charging stations that can be used by local public transport and last mile freight logistics.

Within the project, a number of tools and strategies have been outlined for the e-LPT and e-LML growth and evolution by means of a four-helix approach that involves partners, observers, and territorial stakeholders. In this context, we present the following transnational instruments, which can be designed, tested, and validate also in other projects and/or environments according to the specific needs:

- innovative governance models and a participatory approach, namely Regional Living Labs, that are interactive working groups, one per country, active during the whole project duration. The stakeholders can interact and build solutions customized on their local needs and constraints;
- a tool for policy makers, namely the Tactical Roadmap, that is a ready-to-use guide that supports the cooperation among the PAs and the private sector, by means of a transnational approach;
- detailed tools, namely the Operational Roadmaps, that customize the Tactical Roadmap to find the right solutions to be applied in each territory;
- a Smart Territory Toolkit, that is an ICT tool that technically supports the cooperation among the PAs and the private sector. The Toolkit is designed to be an innovative and multi-level data platform that contains aggregated and elaborated datasets for different territories essential to communicate and share information among different stakeholders, users, and communities. In the case of the Alpine Space, the tool is particularly complex since it must be transnational and should be contextualized with needs and differences coming from 5 countries (Italy, Slovenia, Germany, France, Austria). This translates into a large amount of heterogeneous datasets and high development and deployment costs.

The information flow and outputs are summarized in Fig.1 and the tools will be described in the next sections.

III. Regional living labs

The objective of the living labs is to develop a capacity building environment involving experiential learning based on active inclusion of stakeholders, experts, and end users. This has been achieved through the set up and operation of a transnational network of 5 regional living labs, one hub per country, capitalizing experiences of other European initiatives [7] and activating a four-helix approach by involving partners, observers, and territorial stakeholders in the field of energy, mobility, LPT, and LML (PAs, service providers, utilities, research centers, multipliers, agencies and end-users). The project partners used the labs to collect information with the idea of a co-creation strategy [8] with the stakeholders, i.e. encourage networking of relevant stakeholders and teams working. The model was selected from the most diffuse and appreciated international methodologies [9], and the continuous monitoring of the regional test progress was coordinated by a transnational living lab that sketched the common and local features, checking in addition the link with the European policies on sustainable mobility.

IV. Tactical Roadmap

The Tactical Roadmap is designed to be a ready-to-use guide that supports public and private decision makers to improve e-mobility services in the Alpine Space, identifying and evaluating all the possible measures that could be taken with the related impact, duration, and costs. It will help the governance's planning activity in the deployment of an adequate charging infrastructure to support the diffusion of electric LPT and LML. Moreover, the Roadmap will guide a common transnational approach for national, regional, and local PAs Energy and Mobility Strategic Plans improvement. The main objectives of the Roadmap are:

- contribution to national and regional energy and mobility planning in the Alpine Space region;
- document to support decision makers/planning bodies and stakeholders in the field of e-mobility charging infrastructure planning for public transport and last mile logistics;
- facilitate project processes to achieve the objectives of charging system operational phases and upgrade the regions via digitalization of all the territories with a replicable structure;
- transferable structure to the Operational Roadmaps for the partners' reference territories.

The output will contain a complete scheme of the European regulatory framework and policies, key elements, action fields, governance models and relevant actors' role for the diffusion of e-mobility-in particular for LPT and LML in the Alpine Space.

V. Operational Roadmaps

The Operational Roadmap represents the link between the Tactical one and the territory. Its contents are in line with the

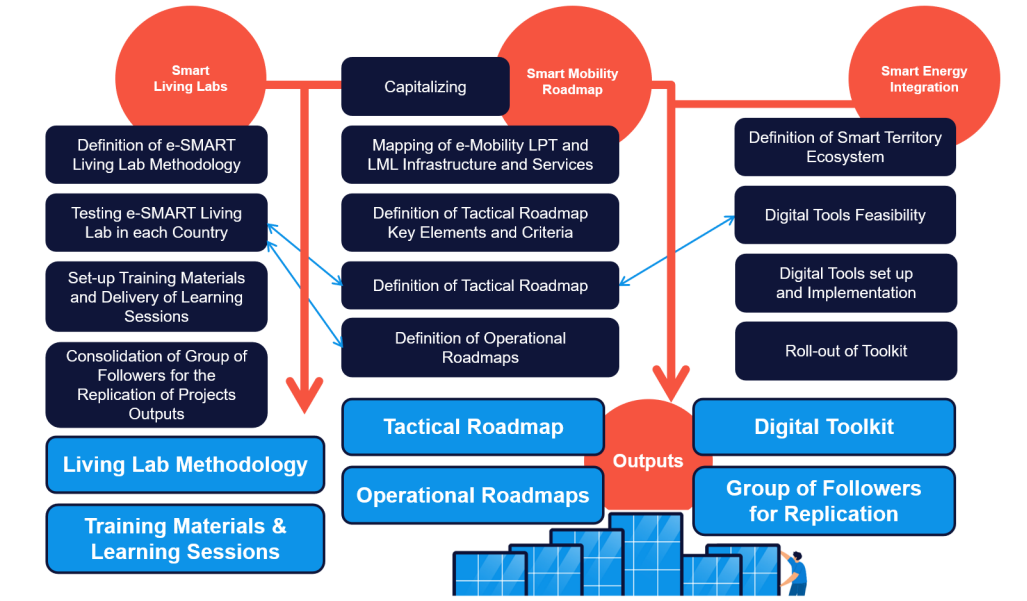

Fig. 1. Information flow and outputs of the project.

Tactical Roadmap, with a customization of regional and local objectives, business models, and financial sources. Hence, each country develops its own Operational Roadmap, based on a common methodology, taking into account all the elements emerged during discussions between the local project partners and related stakeholders to identify what a territory needs (territorial needs) and what it lacks (territorial gaps) to reach an integrated planning of charging systems and e-mobility services in LPT and LML. The main objectives of the Operational Roadmaps are:

- support national and regional energy and mobility planning at local level;
- support local decision makers, planning bodies and stakeholders in the field of e-mobility charging infrastructure planning for public transport and last mile logistics;
- facilitate the emergence of local projects/initiative aimed at increasing e-mobility deployment in public transport and last mile logistics sectors.

The elaboration of the Roadmaps is grounded on a participatory approach through the Regional and Transnational Living Labs. It was based on the following steps:

- identify all the actors that could play a significant role in achieving an integrated LPT/LML charging network planning to highlight any critical or relevant situations;
- gather information about the level of interest/influence of each local actor;
- use the Living Labs findings to take into account the stakeholders' point of view;
- cluster the needs and gaps identified by the stakeholders in 3 main European policies categories: Green Deal - Green Europe (innovation for LPT, LML, and energy sector), Digital Europe - Smart Europe (smart city/village elements of PA digitization and data sharing in a Public-Private Partnership framework), Europe for Citizens - Smart PA (policy cycle management, policy instrument, participatory approach, new governance model);
- a SWOT analysis to identify gaps and opportunities;
- measures and actions to effectively apply the identified solutions.

The output is a document containing the basic elements for each territory, needs and gaps, existing instruments, operational measure description and measures.

VI. Smart Territory Toolkit: a platform of platforms

Finally, the e-SMART project aims to develop a smart territory Toolkit: a data platform that is meant to facilitate decision-makers increasing the effectiveness of their analysis and measures, becoming a Decision Support System (DSS) for specific territories. To create an effective e-mobility platform, it is fundamental to gather data on: electric technicalities, road network, road traffic data, people habits, freight mobility, existing infrastructure for alternative fuels and electric infrastructure, spatial planning issues (digitalization). The main goal for e-SMART is to estimate the needs and opportunities related to the infrastructure (electric charging station) for LPT and LML in the Alpine region. There are two types of relevant data:

1) those directly relevant to the purpose, such as the flows (goods and people), the characteristics of the vehicles, and the capacity of the energy grid;
2) those that refer to related systems and could provide information indirectly (e.g. network of charging stations for electric cars or population density).

For this project, a further challenge is given by the heterogeneity of partners and stakeholders and by the peculiarity of

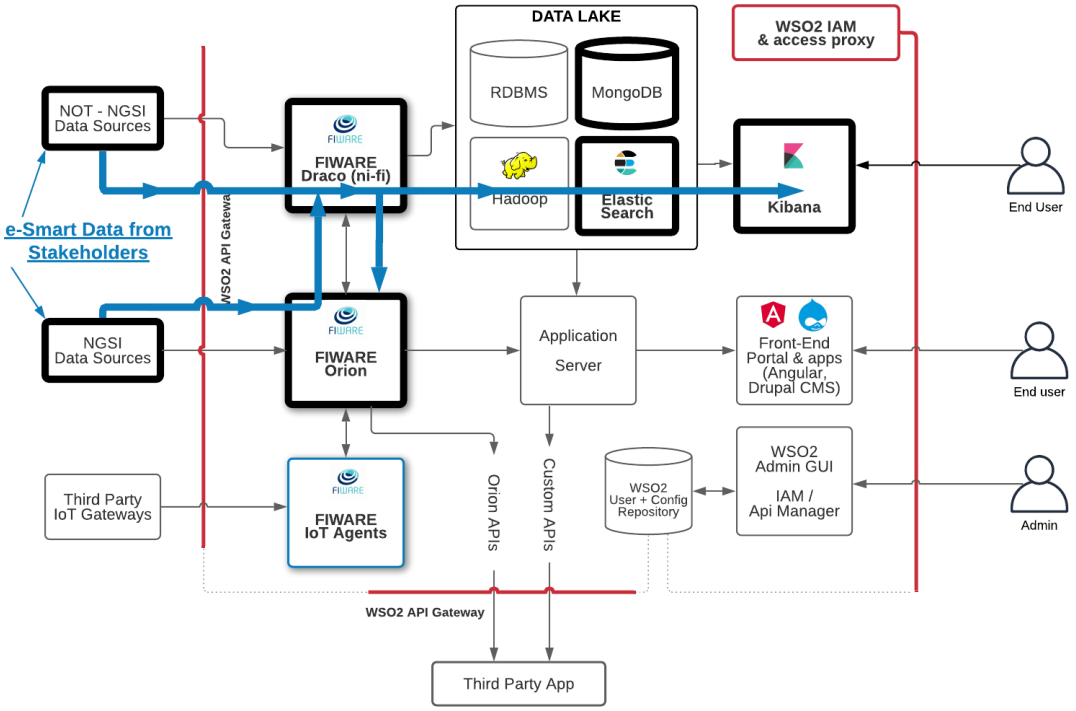

Fig. 2. The diagram shows the main technologies that compose the data platform. The blue arrows represent the flow of data coming from stakeholders and ingested in the data platform. The bold black boxes represent the platforms involved in the process, up to the visualization tool Kibana. The ingestion will be mainly managed by the Fiware Draco component, as the stakeholders contacted so far do not directly expose NGSI data sources; anyway, a direct NGSI connection is possible, through the Orion context Broker.

each territory, e.g. many small villages close or far from big cities have different needs in electrification. Hence, important issues that must be taken into account are that partners and stakeholders will provide varied data laborious to standardize and integrate and that many data will be of an ”indirect” type and related to specific and partial territories. The project priority is to create a tool able to interact with all the stakeholder systems to develop new services in the future. At the time being, the first release of the tool could provide procedural and technical confirmation of the feasibility study, but so far it does not guarantee its full operation. The e-SMART final goal is the set up of a tool that will be integrated with others territorial platform: a platform of platforms that is complementary to the existing digital instruments that can be called data platform or tool with similar characteristics. Hence, the Toolkit will be able to collect datasets from the integrated platforms, and elaborate proper indicators to support decision making and can be accessed both from the Toolkit and the individual platforms. The main function of such a platform is to extract useful information from a large amount of data in a short time and in a versatile way.

The tool will be developed using open source platforms (which are described in the next section) with a central role for platforms in the FIWARE ecosystem (www.fiware.org). FIWARE brings a curated framework of open source platform components which can be assembled together with other third-party platform components to build Smart Solutions. The Toolkit is powered by Fiware: it will use the Orion and Draco Fiware modules to support data ingestion from multiple sources and formats, data transformation and normalization, and distribution with the FIWARE NGSI API. The storage layer will be implemented by both RDBMS and NoSQL technologies, including MySql, MongoDB, and the open source version of ElasticSearch; these components will store data coming from the stakeholders, as well as configuration data, and will provide the computational layer for the data visualization tool (open source Kibana). The diagram in Fig. 2 shows the main technologies that compose the data platform.

A. *Existing platforms*

Information on the following data platform have been collected:

- Roma data platform [10], that is a prototype aiming to redesign the public dimension of the city, based on European and open-source technology, and is currently populated internally by a first vertical system. This is the dashboard of the Economic Development sector where data, both geographical and administrative, from Info-camere, a telephone operator, and the mobility sector converge. The platform is able to analyze territorial data under a quantitative and qualitative point of view;

- E015 Digital Ecosystem [11], that is an initiative promoted by Regione Lombardia together with many relevant Italian stakeholders, such as Confindustria, Confcommercio, Assolombarda and Unione del Commercio. It encourages the creation of digital relationships between different subjects, both public and private, interested in enhancing their digital assets by sharing them or enriching software solutions for their users with the features and information shared by other participants. The sharing of functionalities and information in E015 takes place through the publication of APIs, according to the guidelines and with the coordination of the Technical Management Board;
- Sentilo [12], that is the piece of architecture that isolates the developed applications to exploit the information generated by a network of sensors across the city of Barcelona which aims to become a Smart City. Sentilo is an open-source software designed to fit in the Smart City architecture of Barcelona but potentially of any city who looks for openness and easy interoperability. To avoid vertical solutions, Sentilo is designed as a cross platform with the objective of sharing information between heterogeneous systems and to easily integrate legacy applications. The network of sensors knows the flow of people and bicycles along the city's biggest roads and arteries, the decibel levels on each street, the temperature of each neighbourhood and the quality of the air being breathed;
- Smarter together [13], that is a project through which the city of Munich is implementing smart city solutions for 30'000 citizens with the aim of reducing fossil fuel consumption and improving residents' quality of life, cutting CO_2 emissions by more than 20%, raise the use of renewable energy to above 20% and increase energy efficiency by more than 20%. The city of Munich is cooperating with 11 partners in the business and academic communities, and one of the project targets is the development of a data management platform;
- Smart Control Room [14], that is the most modern operations center in Europe, and is located in Venice. It collects data and video streams from the various centers and sensors located in the Venice area. Once collected, the data provided are harmonized with those coming from telephone cells and cameras. All the information is then visually represented on the smart control room's video walls, allowing operators to check any intervention needs in real-time. Through this platform, it will be possible to know e.g. the flow of people/turists in the city, the traffic situation, and the public transport availability;
- Gaia X [15], that is a proposal for the next generation to build a European data infrastructure that is a secure, federated system that meets the highest standards of digital sovereignty while promoting innovation. This project is the cradle of an open, transparent digital ecosystem, where data and services can be made available, compared and shared in an environment of trust;
- YUCCA [16], that is the platform of Piedmont Region, designed to offer to public and private actors tools to experiment and create technological solutions and innovative services connected to data. It is a self-service cloud platform that enables the user to develop applications based on Big Data. It allows aggregating data from the IoT, the IoP (social network), the systems and from public and private institutions. It was designed and implemented by CSI-Piemonte starting from open-source technologies, in modular logic and adhering to the reference standards in the IoT and Big Data;
- TerriSTORY [17], that is a decision-making, educational and multi-thematic tool (energy, climate, economy, etc.). It was created in 2018 at the initiative of the regional agency Auvergne-Rhône-Alpes Énergie Environnement (AURA-EE). Thanks to a dynamic and interactive visualization interface, the tool makes possible to understand its territory, identify its potential and the priority action levers. It simulates prospective scenarios by measuring their socio-economic and environmental impacts to build a territorial trajectory up to the challenges. Since 2020, TerriSTORY has been a project led by an open community of public and general interest actors committed to the climate challenge so that data is managed as a common good. This new governance provides a concrete response to the challenges of harmonizing and aggregating multi-level objectives. This allows the tool deployment in other regions and promotes the pooling of resources for the development of new functionalities and the provision of additional data for each region, and a vast compilation of multi-thematic territorial indicators for the transition of territories such as: a) energy bill; b) jobs in the construction sector; c) air pollution; d) share of dwellings served by a district heating network; e) commuting flow; f) anaerobic digestion facilities.

VII. Preliminary results

The outlined activities demonstrate the concrete possibility to support the public administrations in the e-mobility deployment, in particular in planning of the charging network for e-LPT and e-LML. The e-SMART project designed a transnational in-depth analysis and identification of best practises, critical issues, requirements, and expectations of a specific territory and local e-mobility sector, based on a constant exchange of information among the local public and private sectors, via Living Labs, interviews, surveys, and participation to events. The dialogue among the differents actors and stakeholders allow the partners to develop strategic tools, such as the Tactical and Operational Roadmaps, that cointain measures in line with the territory needs and with the European policies. Finally, e-SMART aims to deploy and test a smart territory meta-platform to technically support the cooperation process among public and private sectors, based on standards and specifications for interoperability. The platform will be able to collect heterogeneous datasets from different territories and elaborate indicators that are necessary to the policy makers

to identify proper policies and measures. The final goal of e-SMART is to design a common transnational approach and method for national, regional, and local public energy and mobility strategic plans improvement.

ACKNOWLEDGEMENTS

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