TeMA

Journal of
Land Use, Mobility and Environment

This special issue collects a selection of peer-review papers presented at the 8th International Conference INPUT 2014 titled "Smart City: planning for energy, transportation and sustainability of urban systems", held on 4-6 June in Naples, Italy. The issue includes recent developments on the theme of relationship between innovation and city management and planning.

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TeMA Journal of Land Use, Mobility and Environment

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This special issue of TeMA collects the papers presented at the 8th International Conference INPUT 2014 which will take place in Naples from 4th to 6th June. The Conference focuses on one of the central topics within the urban studies debate and combines, in a new perspective, researches concerning the relationship between innovation and management of city changing.

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EIGHTH INTERNATIONAL CONFERENCE INPUT 2014

SMART CITY. PLANNING FOR ENERGY, TRANSPORTATION AND SUSTAINABILITY OF THE URBAN SYSTEM

This special issue of TeMA collects the papers presented at the Eighth International Conference INPUT, 2014, titled "Smart City. Planning for energy, transportation and sustainability of the urban system" that takes place in Naples from 4 to 6 of June 2014.

INPUT (Innovation in Urban Planning and Territorial) consists of an informal group/network of academic researchers Italians and foreigners working in several areas related to urban and territorial planning. Starting from the first conference, held in Venice in 1999, INPUT has represented an opportunity to reflect on the use of Information and Communication Technologies (ICTs) as key planning support tools. The theme of the eighth conference focuses on one of the most topical debate of urban studies that combines , in a new perspective, researches concerning the relationship between innovation (technological, methodological, of process etc..) and the management of the changes of the city. The Smart City is also currently the most investigated subject by TeMA that with this number is intended to provide a broad overview of the research activities currently in place in Italy and a number of European countries. Naples, with its tradition of studies in this particular research field, represents the best place to review progress on what is being done and try to identify some structural elements of a planning approach.

Furthermore the conference has represented the ideal space of mind comparison and ideas exchanging about a number of topics like: planning support systems, models to geo-design, qualitative cognitive models and formal ontologies, smart mobility and urban transport, Visualization and spatial perception in urban planning innovative processes for urban regeneration, smart city and smart citizen, the Smart Energy Master project, urban entropy and evaluation in urban planning, etc..

The conference INPUT Naples 2014 were sent 84 papers, through a computerized procedure using the website www.input2014.it . The papers were subjected to a series of monitoring and control operations. The first fundamental phase saw the submission of the papers to reviewers. To enable a blind procedure the papers have been checked in advance, in order to eliminate any reference to the authors. The review was carried out on a form set up by the local scientific committee. The review forms received were sent to the authors who have adapted the papers, in a more or less extensive way, on the base of the received comments. At this point (third stage), the new version of the paper was subjected to control for to standardize the content to the layout required for the publication within TeMA. In parallel, the Local Scientific Committee, along with the Editorial Board of the magazine, has provided to the technical operation on the site TeMA (insertion of data for the indexing and insertion of pdf version of the papers). In the light of the time’s shortness and of the high number of contributions the Local Scientific Committee decided to publish the papers by applying some simplifies compared with the normal procedures used by TeMA. Specifically:

- Each paper was equipped with cover, TeMA Editorial Advisory Board, INPUT Scientific Committee, introductory page of INPUT 2014 and summary;
- Summary and sorting of the papers are in alphabetical order, based on the surname of the first author;
- Each paper is indexed with own DOI codex which can be found in the electronic version on TeMA website (www.tema.unina.it). The codex is not present on the pdf version of the papers.

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SPECIAL ISSUE

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Smart City - Planning for Energy, Transportation and Sustainability of the Urban System

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ZERO EMISSION MOBILITY SYSTEMS IN CITIES

INDUCTIVE RECHARGE SYSTEM PLANNING IN URBAN AREAS

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ABSTRACT

In the last few years, “Sustainable” and “Smart” mobility became concepts of fundamental importance and led national government to adopt programmes and measures aimed at reducing the carbon emissions of private and commercial vehicles. The final goal is to pursue the EU objectives of reducing the greenhouse gases emission in transportation sector. The progressive electrification of the circulating vehicles represents a possible solution to the air pollution relating problems.
A recent innovative research field, which could significantly contribute to the diffusion of the electric vehicles, consists of the inductive recharge systems for electric vehicles. This technology could also bring to considerably environmental and logistic advantages, especially in urban areas. Starting from the analysis of the main ongoing experimentations of these innovative systems in the world, the present paper proposes a possible application of the inductive recharge technology to the public transport vehicles, through the presentation of the case study of Brescia.

KEYWORDS

Inductive recharge systems, electric vehicles, electric ways, Brescia

1 THE INDUCTIVE RECHARGE TECHNOLOGY FOR ELECTRIC VEHICLES

In the last few years, “Sustainable” and “Smart” mobility became concepts of fundamental importance and led national government to adopt programmes and measures aimed at reducing the carbon emissions of private and commercial vehicles. The final goal is to pursue the EU objectives of reducing the greenhouse gases emission in transportation sector. The progressive electrification of the circulating vehicles represents a possible solution to the air pollution relating problems.

A recent innovative research field consists of the inductive recharge systems for electric vehicles. This recharge system has been mainly deployed in small household electric appliances and is based on the electromagnetic induction physical phenomenon, discovered at the beginning of the nineteen century by Faraday. As application to the mobility sector, both private and collective, wireless systems allow to recharge vehicles passing or waiting over an equipped facility (the so called “Electric ways”), without physically plugging into recharging devices.

An Electric way for the recharge of vehicles on the move is composed of a series of segments of different length, able to generate magnetic fields thanks to the presence of coils; and of a device installed aboard the vehicle able to convert magnetic fields into electricity, allowing the batteries to be recharged.

The development of this technology could accelerate the diffusion of electric vehicles, leading to significant environmental and logistic advantages, such as the absence of local carbon gases emission or the possibility to count on higher autonomy levels and shorter batteries recharge times.

However, there are some important aspects to be taken into consideration. First of all, when an electric vehicle circulates outside the electric ways, it cannot be charged, therefore, it just can count on the batteries endurance. Batteries should be accurately dimensioned in relation to the itinerary and to the existing facility. The second aspect is about the fare system to apply: the recharge process takes electricity from the electricity grid. This implies some costs and it is not easy to quantify the amount of energy taken by each single vehicle, as vehicles significantly vary in dimensions, weigh and kind (passenger cars, buses, trams, etc.). A third aspect concerns the efficiency that this system is able to grant: it is not possible to reach a 100% efficiency in electromagnetic induction, as the Joule effect always produces dissipation of energy under the form of heat. As a consequence, the levels of efficiency granted by the recharge system should be deeply evaluated. Other aspects relating to the safety standards of the inductive recharge technology should be taken into consideration in e-mobility: radiations produced by electromagnetic fields generate overheating in the crossed bodies, therefore there are some concerns for the potential effects on the human body and for the interferences with other devices.

2 MAIN APPLICATION OF INDUCTIVE RECHARGE SYSTEMS IN THE WORLD

In the last five years, different research groups started experimentation of the inductive recharge systems for electric vehicles all over the world, pushed by the necessity of going beyond the traditional charging systems and of increasing the vehicles autonomy and by a growing interest toward the development of innovative sustainable vehicles.

At the moment some of the most significant experimentation projects in the field of the inductive recharging system for vehicles on the move are the following:

- OLEV project, carried on by the KAIST Group in South Korea;
- Primove system, carried on by the Bombardier Transportation Group in Canada;
- Hevo Power project, carried on by the Hevo Group in the United Stated (New York).

2.1 THE OLEV PROJECT IN SOUTH KOREA

The experimentation of the OLEV technology, carried on by the South Korean Group KAIST (Korea Advanced Institute of Science and Technology[1]) started in 2009 and is based on the innovative technology called SMFIR (Shaped Magnetic Field in Resonance). The main goals of the research are to minimize the batteries size, to reach high levels of autonomy (10 km for buses and 30 km for cars) reducing the distances covered recurring to the batteries alimentation and to cut down the harmful emissions for the environment, aiming at increasing the quality of life in urban areas.
KAIST, according to some recent studies, estimated that if about the 30% of the Seoul road network (where one of the applications is under experimentation) was equipped with electric coils underground, electric vehicles would be able to circulate throughout the city without the need of stopping to recharge them.
SMFIR technology, which allows vehicles to recharge the batteries both in static and dynamic ways, consists of installing the AC power lines directly under the road surface (see figure 1).

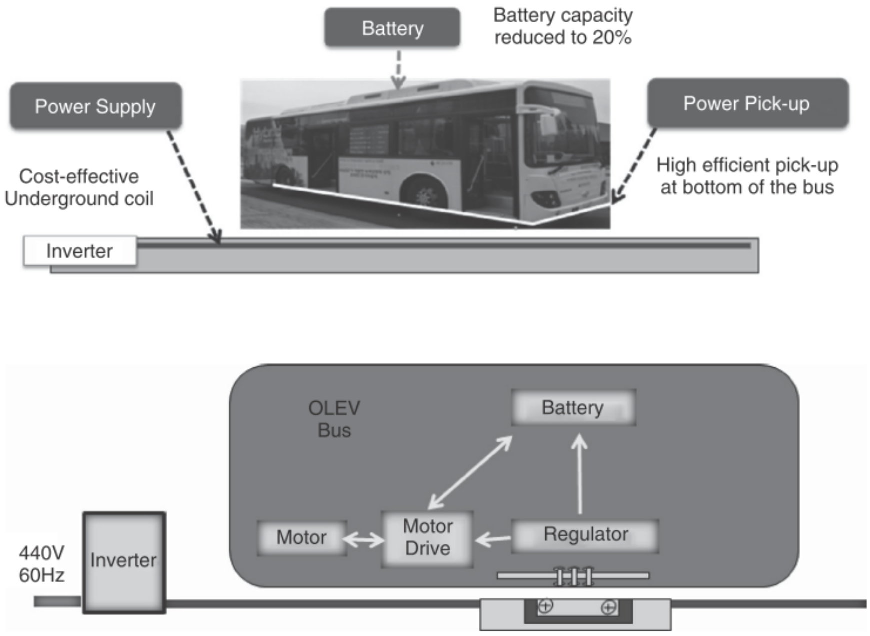

Figure 1 KAIST OLEV bus and the main component scheme

Underground coils generate electromagnetic fields which are then converted into electric power by apposite devices installed aboard the vehicles (Pick-up devices).
The first experimental application of the SMFIR technology started in 2009 at the Seoul Grand Park in Gwacheon City, in the north-western South Korea. The installed system is composed of an electric tram composed by a locomotive and three wagons. The tram circulates wireless along a certain path in the Park, powered by the underground devices.
In order to manage the problem of the radiations generated by the electromagnetic fields in the surrounding space, two kinds of shielding have been implemented: a first shielding system is located underground, a second one aboard the vehicle (called “passive cancel system”). In terms of power transmission efficiency, the KAIST tram reaches the value 74% by keeping a distance of 13 cm between the road surface and the lower surface of the vehicle.

[1] The KAIST Group was founded in 1971 by the Korean Government for researches in the field of science and engineering. The Institute is located in the City of Science of Daejeon, in South Korea.

A second experimentation of the SMFIR system is under experimentation in the city of Gumi, in South Korea. The experimentation started in July 2013 and regards the equipment of two buses running along an urban itinerary. The goal is to evaluate the reliability and the efficiency of the system in urban operational conditions. The line segment under experimentation links the Gumi train central station and the southern part of the city and is 24 km long. The electric ways are 3,5 km long, corresponding to the 15% of the total segment length.

Cables are placed 13 cm under the road surface, while the distance between the road surface and the lower surface of the vehicle is of 17 cm. The two buses receive a power of 100 kW at a frequency of 20 kHz. Along the observed itinerary there are devices able to recognize the two OLEV buses among the circulating buses. When OLEV buses pass over the electric way the involved segment is activated, starting the recharge process. When traditional buses pass over the coils, the system is not activated, limiting the electromagnetic radiations emission and optimizing the energy consumption.

2.2 THE PRIMOVE PROJECT[2]

Primove is a project promoted by Bombardier Transportation Inc.. The Primove technology regards various kind of transport vehicles (trains, trams, buses and cars) and is based on the induction power transfer principles: through the installation, underneath the road surface, of devices which are able to transfer wireless the energy to vehicles and of specific devices aboard the vehicles which are able to receive the electromagnetic radiations. The system is composed by two coils: a first coil generates a magnetic field thanks to the presence of alternating current circulating in it, while a second coil, immersed in the field generated by the first one, absorbs the magnetic energy and convert it into electric energy.

Alongside the dynamic recharge process, Primove is characterized by the presence of devices for the static recharge of vehicles installed at the collective transport stops. The Primove model is based on recharge intervals: at the beginning of the service batteries are totally full; as the vehicle begins to move, batteries start to decrease their charge level until the vehicle reaches a recharge station, where during the stop, batteries are partially recharged in static mode. The battery levels should be constantly monitored along the itinerary and the recharge stations should be accurately placed and dimensioned in order to prevent the complete or an excessive discharge of the batteries.

The presence of double layer capacitor aboard the vehicles allows to regain energy during the braking phase, reducing the energy consumption and costs. The electric power the system is able to provide ranges between 100 and 500 kW, depending on the itinerary length, the number of circulating vehicles and the road longitudinal layout (presence of slopes).

A first application (still ongoing) of the Primove technology was presented in Germany in 2012. The experimentation was made in a test area of the tramway network in Augsburg. The first demo-vehicle was a tram and then the experimentation was extended to electric buses. This application allowed a validation of the wireless energy transfer system. As regards the tram experimentation, the involved line is the n. 3 which links the city to the exposition area. The road segment object of the experimentation was 0,8 km long and was characterized by a 6% maximum slope. The tram, realized ad hoc for this tests, had a variable length ranging between 30 and 42 m and was able to reach a 50 km/h maximum speed.

Another ongoing application of the Primove technology was made in the german city of Braunschweig. The experimentation tested for the first time the installation of a demo-station for the recharge of 2 buses (12 and 18 m long and with a weigh of 13 and 18 tons). Primove buses were introduced on the M19 line in

[2] Sources: www.bombardier.com and www.primove.bombardier.com.

Braunschweig, which is 12 km long and with 26 stops and characterized by an average operational speed of 18 km/h. This line was considered ideal to test the opportunity of charging buses along urban lines.

Since 2010 Bombardier has been participating to another experimental application of the Bombardier technology, in the framework of the project called “Flanders’ Drive” in the Belgian city of Lommel. The objective of this project is to test the inductive recharge system in relation to different kind of vehicles and road surfaces (concrete and asphalt).

The experimentation interested two different line segments, respectively 3,6 and 8,1 m long and involved both buses and passenger cars. The system was tested in two different phases: during the first phase, the required facilities were designed and installed along the line, which is characterized by road surface covered with concrete. A traditional bus has been re-designed according to the Primove system requirements, coils were installed underneath the road surface and a first series of test was made. During the second phase, the road surface has been re-covered with a new layer of asphalt and a second series of tests was made, using a passenger car, with the objective of evaluating other vehicles besides buses, characterized by different sizes and masses.

2.3 THE HEVO POWER PROJECT

The Hevo Power project was launched in November 2011 in the city of New York by the Hevo Group in collaboration with the University of New York. The system, which is described at the moment only at theoretical level, consists in the realization of manhole at car parking spaces for the wireless static recharge of the parked vehicles. The project aims at encouraging the diffusion of the electric vehicles, at reducing the transport related costs and the pollutant gas emissions, through the promotion of the energetic independency in the mobility sector.

A first test phase is scheduled for the first semester 2014, when a pilot project will be activated. This pilot activity consists in the realization of 2 manhole in Washington Square Park, in the city of New York.

The Hevo recharge system is based on the “resonance” principle: the 2 coils (a transmitting one is located inside the manhole, while a receiving one is installed aboard the vehicle) resonate at specific frequencies and this feature allows to transfer energy with low dispersions. The Hevo power system is composed by three main components: a wireless recharge manhole, called HPS (*Hevo Power System*), integrated to the road surface and linked to the electricity grid; a receiver installed underneath the vehicle floor and linked to the battery; and a smartphone application, appositely developed by Hevo, which allows the user to access to an interactive map (where the available manhole are displayed) and, once the vehicle is aligned to the manhole, to activate the wireless battery recharge process (the application provide a park assist service to help the user in the alignment phase, which is crucial for a correct recharge). The application is also able to manage the aspects relating to the fares payment: during the recharge phase, the amount of energy taken from the electricity grid is instantly monitored and the user is able to pay for it directly from the application.

3 THE CASE STUDY OF BRESCIA

Taking inspiration from the analysis of the most relevant technologies under experimentation worldwide, the present study envisages a possible application of the inductive recharge technology for electric vehicles in the city of Brescia, a medium sized city (about 200,000 inhabitants) located in the North of Italy.

The city of Brescia seems to be sensitive towards the issues relating to the quality of the urban environment. As a matter of fact, in the recent past, the administration underwent a series of initiatives aimed to the improvement of the urban mobility, through the implementation of measures for the promotion of sustainable transport modes. With the collaboration of the local transport company, a "Green mobility plan" was drafted, with the intention of introducing CNG and hybrid buses[3] in the local transport network.

In this framework, the implementation of the inductive recharge system for electric vehicles could bring significant contribution to the local policies.

Overlooking the mere technological aspect relating the wireless recharge system, the goal of this paper is to plan a possible introduction of the inductive recharge system facilities in the existing road system of Brescia, taking into consideration both the constraints and the peculiarity of the city.

Urban buses have been selected for the wireless technology implementation, as the more "reliable" results derive from the experimentations, already implemented worldwide, which all deal with this kind of vehicle. Alongside this, experimentations on cars are not mature yet and, therefore, do not provide substantial results.

The mobility system of Brescia is mainly composed by 18 urban bus lines, by an automated light metro line (since March 2013) and by a bike sharing service. The existing facilities, from the bus stops to the metro stations, from the bike sharing stations to the underground structures for the municipal heating system, represent a strong constraint, able to hamper the implementation of this technology in the urban space. Even if the existing parking, some bus stops and the presence of dedicated bus lanes could host the required facilities, it is of extreme importance to analyse the local peculiarities and the available spaces before introducing such systems.

The main advantages for the city deriving from the new system implementation are mainly from the environment viewpoint. As already highlighted in the chapter dedicated to the international case studies, the implemented technology is first of all characterized by a good visual impact: as a matter of fact, the most part of the devices is installed underneath the road surface, therefore is invisible. This feature allows to better introduce this technology in the urban environment, especially in the city cores. Another advantage consists in reducing the pollutant gas emissions from local public transport: the progressive replacement of the vehicles using endothermic engines (hybrids or CNG vehicles) with exclusive electric powered vehicles would allow to cut down the greenhouse gases emissions. From the noise viewpoint, electric engines are silent, making the proposed technology suitable for urban areas.

3.1 APPLICATION PROPOSAL FOR AN URBAN BUS LINE IN THE CITY OF BRESCIA

The most suitable system for the city of Brescia seems to be the Primove technology by Bombardier Transportation Inc.: first of all, respect to the SMFIR system or to the OLEV vehicles, the Primove technology has been tested in European cities (such as Lommel in Belgium or Brauschweig in Germany) which can be considered similar to the Italian cities (or, which are more similar to Italian cities than the Asiatic ones); second, the Bombardier solution has been tested with two applications on buses, while the Korean system just with one application. This aspect is important because Bombardier can count on the results and the experience coming from two different contexts in the view of the potential exportation of the system in Brescia. Alongside this, in the near future, the Primove technology is going to be implemented also on trains and metros, unlike the other two technologies.

The selection of an urban bus line going through the city core (instead of a suburban line) has been a pondered choice, as it was important to find out a location able to completely exploit the advantages offered

[3] The use of CNG buses allows to reduce the pollutant gas emissions by 10%, respect to an equivalent vehicle powered by a traditional endothermic engine and significantly reduces the emission of CO_2, CO, NO_x, HC and PM_{10}. Finally, CNG powered vehicles reduce the fuel costs, the noise emissions and the vibrations aboard.

by the proposed system. Respect to peripheral areas, in city cores it is possible to find the most binding situations for the installation of the required facilities (dense residential and commercial areas, historic buildings, monuments, pedestrian areas), but is the ideal context where the electric mobility and the inductive recharge systems are able to offer the most relevant advantages: for example, the good visual and environmental impacts highlighted in the international case studies, as described in the previous paragraphs, could significantly contribute to the improvement of the quality of life in city cores. Within the Limited Traffic Zones, where shops, bars and vulnerable road users are present, such as Piazza della Loggia or Piazza del Duomo in Brescia, the circulation of silent sustainable electric vehicles would have a better impact in city centres respect to peripheral areas, where, in terms of pollutant gas emissions, the impact of Local Public Transport is less significant compared with the individual means of transport.

The proposed system for Brescia takes inspiration from the applications experienced so far in Europe and Worldwide.

For the static mode recharge process, the idea is to equip some of the existing bus stops by installing the required wireless devices, while, for the dynamic mode recharge process, it is necessary to identify a road segment along the itinerary which can be considered suitable for the electric way installation and for the experimentation purposes.

It is quite easy to adapt existing bus stops to the new technology and the system offers a good level of intermodality: the Primove system facilities at bus stops can be exploited not only by urban buses, but also by other electric vehicles, such as commercial vehicles for the last-mile freigth distribution in central areas or taxis and private passenger cars properly equiped with devices able to receive the batteries inductive recharge.

The Local Public Transport lines which could be selected for the experimentation purpose are the n. 15 (Noce-Montini), n. 17 (Castel Mella-Ospedale) and n. 18 (Castellini-P.le Beccaria), as they all go through the city core. Among them, the line n. 18 is considered ideal, as the 75% of its itinerary is located in the Brescia core.

Figure 2 Piazzale Beccaria in via Volturno a Brescia, partenza della linea 18 del servizio TPL

The northern terminus is located at the Piazzale Beccaria, located in Via Volturno, while the other terminus is located in Via Castellini. Piazzale Beccaria, which is close to the city core, is characterized by the presence of a large parking, where it is possible to dedicate part of the area to the installation of the facilities for the inductive recharge of the vehicles. The idea to separate the different parking users derives from the necessity to avoid interferences and dangerous situations relating to the exposition to radiations.

Line n. 18 is characterized by a fleet of 12 buses covering the 65 rides. The service starts every day at 7:28 and finishes at 20:03 and the time spent to make a complete tour of the line (go and back) is about 54 minutes.

As in the case of the German city of Brauschweig, Solaris Urbino buses, produced by the Polish company Solaris Bus & Coach are going to be considered for the application proposal. The above mentioned bus model is 8,9 m long, therefore it is ideal for the narrow road sections and the small curve radius of the Brescia city core.

According to the findings published by Bombardier, on average, the time required for the complete recharge of the batteries in static mode at the depot is of about 10 minutes. In order to grant the autonomy of the vehicles along the line n. 18 itinerary, which is 9,3 km long, it should be enough to place two intermediate recharge points[4]. In addition to the recharge stations, it is proposed to realize an electric way for the dynamic wireless recharge of the vehicles, as auxiliary source of energy during the only sloping road segment along the line.

The two recharge station would be placed at two intermediate bus stops along the itinerary. The selection of the bus stops to be equipped should be made with the objective to grant the buses autonomy for the whole service duration: the selected stops should be neither too close each other (in order to avoid idle recharges, i.e. when batteries are still full), nor too far each other, in order to prevent the premature batteries discharge (see Figure 3).

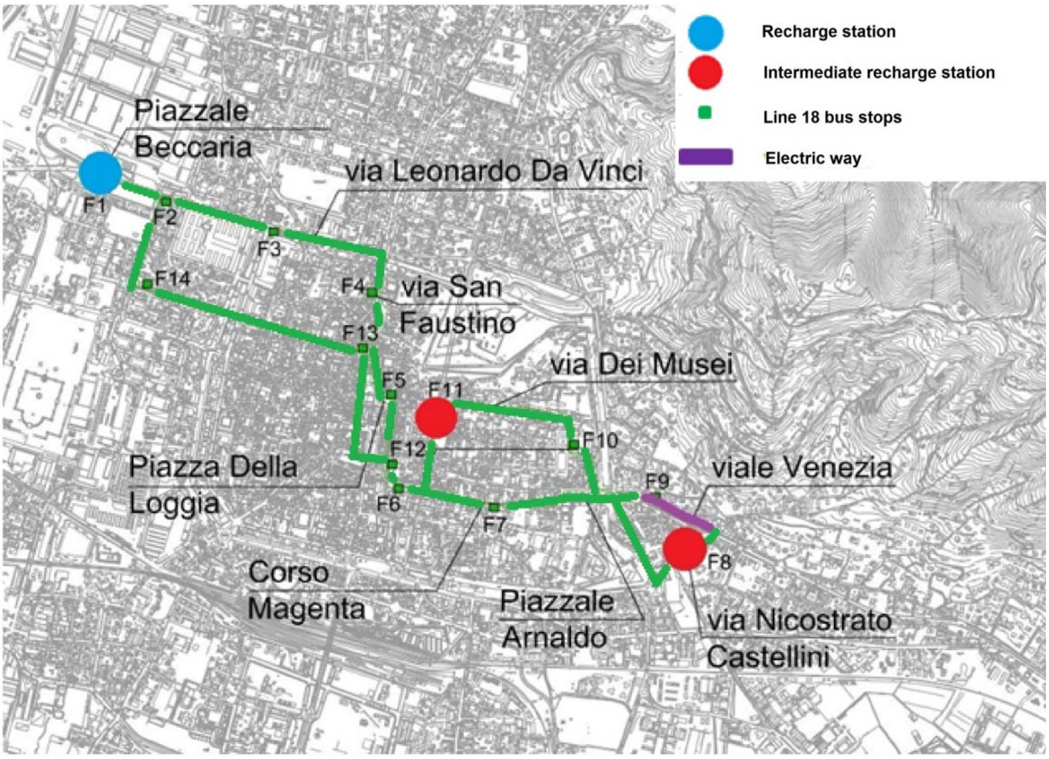

Figure 3 Localization of the recharge stations in static mode (intermediate stations) an in dynamic mode (electric way) for the line n. 18 according to the application proposal of the Primove system in Brescia

[4] In the case study of Brauschweig (Germany), where Bombardier tested a wireless recharge system for busses, the bus line was 12 km long and with 26 stops. In that case two recharge station were enough to cover the whole length. According to the Bombardier findings, theoretically just one station was enough, but a second one was introduced as precautionary measure in case of emergency.

A further constraint in the selection of the most suitable bus station along the itinerary is represented by the necessity of granting as much as possible low interferences (in terms of electromagnetic radiations) with the other road users, especially the vulnerable ones.

According to these considerations, the first recharge stations is located at the F8 stop at the Castellini parking, which is also the line terminus. The second recharge station has been placed at the F11 stop in Via Martiri di Belfiore, sufficiently far from the first, along a road which is characterized by two lanes per direction and there where the platform allows the simultaneous stop of two buses. This last feature mainly generates two positive effects: on the one hand, if the recharge duration lasted more than the scheduled, traffic would not be hampered; on the other hand, a part of the platform could be dedicated to the inductive recharge of buses.

The two intermediate stations just allow a partial recharge of the bus batteries, therefore, in order to prevent delays and long waiting times, stops could last 30 seconds, corresponding to the time required for the batteries to recharge and for the passengers to get on/off the vehicles.

As regards the installation of the electric way, the selected road segment is located in Viale Venezia. This choice was made mainly for two reasons. First of all, the segment is located outside the city core, where there's more available space for an easy installation of the necessary facilities. The second reason is related to the line layout: the main function of an electric way is to assist the electric vehicle during the most critical phases of the motion, as for example during the acceleration phase or along a road with an upward slope. In these circumstances, buses requires a stronger traction effort, which corresponds to higher energetic requirements for the electric vehicles.

Along line n. 18 there are some road segments with an upward slope (like the one in Viale Venezia) and other segments with a downward one (like for example in Via Mazzini). The ideal solution is to place the electric way (which is 200 m long) at the road segment characterized by an upward slope, which represents the most critical operational condition from the energetic consumption viewpoint. Its position does not generate particular interferences with the presence of pedestrian or cyclists, due to the geometric and functional features of the road.

The trend of the batteries charge level along the itinerary should be analysed, taking into consideration the most adverse operational conditions, including the meteoric conditions or the accidental temporary malfunctioning of the recharge stations, in order to assure the energy autonomy for the whole service duration. Figure n. 4 shows the qualitative trend of the batteries charge levels along the line: the distance covered by the vehicle along the line is displayed along the x-axis and it is put into relation with the batteries charge level (displayed as percentage in the y-axis). The green segments represents the recharge phase of batteries (which corresponds to the presence of recharge stations or electric ways).

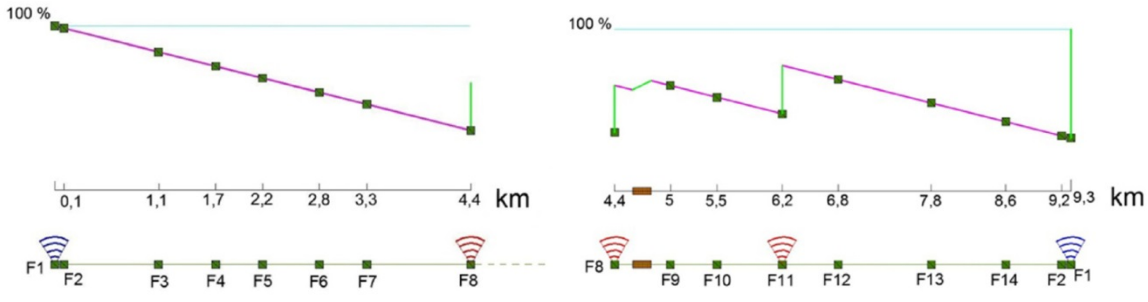

Figure 4. Qualitative trend of the batteries recharge phase along the bus line n.18 (go and back)

4 CONCLUSIONS AND POSSIBLE DEVELOPMENTS OF THE RESEARCH

The inductive technology for the recharge of the electric vehicles represents a great opportunity in the view of the improvement of the life quality in urban areas.

The observed international case studies pushed to new researches and experimentations which will led to optimistic results in this field.

Aiming at promoting and spreading this technology, it is fundamental to get the final results of the ongoing experimentations, so that consolidated best practices will be available for the formulation of new application proposals. For example, the system management costs and reliability or the vehicles maintenance/broken down frequency are aspects to be better assessed once the experimentations are finished, in order to establish the actual potentialities and the prospects of such systems.

The analysis of the case studies and the formulation of the application proposal for Brescia showed that it is fundamental to match the necessity to promote these technologies and, at the same time, to adopt policies for the diffusion of intelligent mobility forms and for the transport system improvement.

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IMAGES SOURCES

Fig. 1: www.kaist.edu;

Figs. 2, 3 and 4: self-elaboration.

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