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ZED — Zero Emissions Distribution

Gabriele Panero[1], Augusto Leonida[1], Raffaele Maccioni[1], Fabio Massimo Frattale Mascioli[2], Antonello Rizzi[2]. Arturo Mancinelli[3]

(1. BIP – Best Ideas & Projects, Italy; 2. University of Rome "La Sapienza", Italy; 3. Mancinelli Due, Italy)

Abstract: In this paper it is presented an ongoing project conceived to be applied to urban logistics for consumer goods and physical documents distribution in Limited Traffic Zones (LTZ), through the integrated use of renewable energy sources and innovative technologies. The ZED (Zero Emissions Distribution) project is intended to implement a new logistics model characterized by zero emissions (CO_2), with a break — even energy balance and economic savings. The proof-of-concept application is targeted to the distribution of beverages in downtown Rome. The vehicular fleet will be composed of eight full electric vans, provided of an advanced Battery Management System (BMS) for battery pack optimal management. The warehouse is equipped by fast DC (Direct Current) recharging station powered by PV plant. The management model for ZED project will be supported by a dashboard, capable of continuously monitor the system energy balance and to optimize the distribution activity, planning and monitoring pathways and routes of electric vehicles.

Key words: distribution logistics; electric vehicles; optimal fleet schedule; renewable energy source; fast recharging stations

JEL code: O320

1. Introduction

Transport at European level involves ten million people directly and accounts for 5% of the Gross Domestic Product (GDP). Most vehicles (96%) are still heavily dependent on fossil fuels and represent one of the few sectors where gas-emission and green-house-effect rates have increased almost continually over the past twenty years (with present-day figures over one third higher than those of 1990). To this regard, although technological progress has led to improvements in energy efficiency, the outcome is still insufficient to compensate for increases in the volume of traffic.

The road transport of goods by electrically-powered vehicles, especially those used for physical urban delivery, account today for an irrelevant percentage of total figures and of the GDP, a datum worthy of pre-industrialization (J. Rifkin, 2011). Electrically-powered transport is over 80 years old, while its use for the transportation of goods is only 10; at the end of 2012, the total worldwide number of producers of electrical vehicles, was over 60, mainly Americans, Chinese, and Europeans; of these only 20 produced electrically-powered industrial vehicles for the transport of goods. Of the latter, the European leader is undoubtedly the British Smith Electric firm which has developed two vehicles types, in particular: the 3.5 and the

Gabriele Panero, Dr., BIP–Best Ideas & Projects; research areas/interests: operations & supply chain management. E-mail: gabriele.panero@bip-bestideasprojects.it.

7.5 t pay-load (M. Piecyk & A. McKinnon, 2010). Of the sectors that use electrical vehicles most we find groceries, telecommunications, express delivery services, public administration (e.g., canteens and school busses) and some specific activities within the military field (A. McKinnon, 2010). Some important recent examples in the history of electrically-powered transportation of goods are: Tesco which, in April 2007, launched a fleet of home-delivery, battery-run vans capable of covering over 100 miles and with an energy-saving rate per vehicle of 21 t/p.a of CO_2; Sainsbury which aims, within the next 5 years, at delivering 1/5 of its on-line orders by electric van; ASDA, a member of the Walmart Group which is trying out a home-delivery van with an electric motor capable of covering over 120 miles and whose recharge time is 60 minutes and, last, DAF (one of the world's largest producers of lorries and trucks) has developed a medium-sized hybrid vehicle (diesel-electric) with lithium batteries (A. McKinnon, J. Edwards, M. Piecyk, A. Palmer, 2009). All of these solutions require, however, the batteries to be recharged using electric energy produced by fossil fuels so that the onus of the environmental damage is simply shifted from the vehicle to the up-stream energy-production process (S. Cullinane & J. Edwards, 2010).

It is estimated that goods transportation affects now days more than 8% of CO_2 emissions worldwide; in road transportation, the amount of energy used for moving goods is growing at a rate higher than that of cars and buses, and in the European Union could overcome it by 2020. The ZED project (Zero Emissions Distribution) offers sustainable solutions and new economic prospects for Physical Distribution in the Limited Traffic Zones (LTZ). ZED intends to implement and test a new logistics-distribution model with zero CO_2 emissions, with a break-even energy balance targeted to cost savings. The system is conceived to be applied to consumer goods and physical documents distribution in LTZ areas of Rome, through the integrated use of renewable energy sources and innovative technologies, by building a warehouse with 1,500 square meters roof covered of photovoltaic panels, able to feed 8 electrical vehicles (2.5 t payload, 60 kWh and 140 km when fully loaded, see Fig. 1) and 3 rapid EV charging stations. The management model for ZED project will be supported by a dashboard, capable of continuously monitor the system energy balance and to optimize the distribution activity, planning and monitoring pathways and routes of electric vehicles.

The strategic objectives of the ZED project are:

(1) To validate the model as the best solution for the sustainable logistics in goods distribution in LTZ (zero CO_2 emissions), through comparative analysis between the traditional and the green energy model introduced by ZED, based on key indicators selected during the analysis and pre-qualification phases;

(2) To define a replicable model, to be possibly reproduced at national and international scales in the field of transportation logistics, to increase efficiency and effectiveness in goods distribution networks management;

(3) To promote and encourage the creation and development of national and international public and private green logistics companies, contributing to the creation of spin-offs and new jobs;

(4) To introduce patented technological innovations to increase the autonomy of electric vehicles by 10 to 15% and to reduce the peak power required by energy storage systems by 10 to 20%;

(5) To develop and patent the dashboard system as an operational tool for planning and optimizing logistics, fleet management and fixed installations of renewable electrical energy sources and battery charging stations;

(6) To achieve lower operating costs compared to traditional logistics models by 10-15%;

(7) To begin the process of internationalization of logistic model and systems through the analysis of foreign markets and the pursuit of partnerships with other transportation companies.

Figure 1 The First Electric Van "ZED — Zero Emissions Distribution"

Note: The electric van "ZED" (maximum payload: 2.5 tons; maximum range: 140 km; maximum road slope: 21%; maximum speed: 80 k/h).

2. Project Description

The ZED (Zero Emissions Distribution) project proposes a new model of distribution logistics for the goods transportation in urban areas conceived to eliminate emissions of pollutants into the atmosphere (CO_2, NOX, PMX), to drastically reduce noise emissions and to reduce the costs of distribution of goods.

The Mancinelli Group (Mancinelli DUE) has been operating for more than 50 years in the logistics throughout Italy, especially in the distribution of beverages in the Lazio region. Together with other companies (BLF Multiservices, Zebra, Bucap, Solsonica and Operations Solutions Act) and research institutions & scientific foundantions/associations (University La Sapienza — DIET, CNR — Consiglio Nazionale delle Ricerche, Sapienza Innovazione, and BIP — Best Ideas & Projects), in December 2013 it started a process of verifying the conditions of feasibility concerning the conversion of a part of the vehicle fleet to pure electric ones and the implementation of a logistics-distribution model with zero emissions called ZED — Zero Emissions Distribution. In particular, the adopted vehicles are dedicated to beverages and miscellaneous goods transportation, in the LTZ of Rome, on behalf of companies particularly sensitive to sustainability issues.

The activity of delivery in the LTZ of the downtown of Rome currently involves a number of vehicles from 8 to 15 units, in relation to the volume of goods to be distributed. The testing of the new logistic-distribution model will involve all LTZ areas in Rome. The validation of the new logistic model distribution (industrial model) will require a fleet of just a few vehicles, in the specific case consisting of at least 8 vehicles, which have to be managed simultaneously. Operational activities, in fact, will result in the dynamic scheduling of the fleet, in order to take into account new events, such as new requests coming from customers, changes induced by traffic conditions, and, specifically for electric vehicles, from constrains due to state of charge updated estimations or reduction of charging time due to a delay, and from different morphological characteristics of the area to be served (street slopes). These events, not exhaustive, will require the simultaneous allocation of several interdependent vehicle to LTZ areas, where concurrent vehicle operation is necessary to validate the actual performance of the new industrial model.

The use of renewable sources for the power supply of electric vehicles and the implementation of advanced methods for electric vehicles optimization, represent highly innovative and specific aspects of the project. Indeed ZED aims fundamentally at changing the process of physical distribution of goods related to the so-called “last mile”, by reducing both the environmental impact and the economic advantage for operators, achieved thanks to the energy balance and optimal freight flow.

2.1 The Logistic Distribution Model

ZED is conceived to test and deploy the first distribution-logistics model in the world with zero emissions, characterized by a break-even energy balance and prospects for economic savings. ZED will be tested and implemented in the city of Rome, since with its 4.2 sq. km of traffic restricted areas includes one of the largest and most complex LTZ in the world. In the historic center of Rome more than 25,000 vehicles circulate daily, with 60% of these (15,000) generating 35,000 goods loading and unloading events, while the remaining 40% cross the area inside the city without stopping (A. Stathopoulos, E. Valeri, E. Marcucci, V. Gatta, A. Nuzzolo, A. Comi, 2011). The logistic model-distribution of ZED works integrating their systems and environmentally friendly technologies, in particular through a central warehouse, located about 15 km from the city center (close to Via Tiburtina), from which the electric vehicles start their trips. The warehouse will be equipped with 1,500 square meters of photovoltaic modules which will feed 4 charging stations, serving 8 electric vehicles. Since electric vehicles can be used properly if the average mileage of delivery rounds is reduced, the ZED distribution model is geared to be able to decrease the average radius of coverage by each electrical vehicle and to optimize the use of such resources, through mathematical modeling, and the recharging cycles of the batteries. The current average distance covered daily by each vehicle is 95 km.

The validation of the new logistic-distribution model for green energy management, aiming at a complete eco-sustainability, will be performed through a comparison of the energy management techniques in traditional logistic systems and with the one introduced by ZED, according to suited indicators selected during the project. The validation of the proposed logistic-distribution model is the main action to ensure environmental sustainability and, therefore, to provide one of the main elements of replicability of the model, ensuring the connection with the key themes of the green economy with other important issues (social acceptability of the freight transport, new markets, effects on the organization of the PA, environmental sensitivity of private individuals, etc.).

Figure 2 The ZED Model Representation

2.2 Infrastructures

Currently the installation of photovoltaic systems on the roofs of buildings used as warehouses for industrial purposes relating to electric mobility of goods are very rare. Photovoltaic systems, where present, are often connected to the main grid, in order to sell energy for immediate income or they are used to serve local loads, other than recharging stations. The possibility of using the direct current produced by photovoltaic systems to recharge the batteries, thus avoiding the double conversion (DC/AC and vice versa), when operational requirements allow it, has never been considered. However, the installations of direct current distribution have long been used in some fields of application (H. Zhang, F. Mollet, C. Saudemont, & B. Robyns, 2010; Yu Du, Xiaohu Zhou, Sanzhong Bai, Srdjan Lukic & Alex Huang, 2010). In the case of the project ZED they are particularly attractive because the most of the electric loads of fixed installations requires energy in direct current: the charging stations of the vehicles intended for the distribution, LED illumination (Bin-Juine Huang, Chun-Wei Chen, Po-Chien Hsu, Wei-Min Tseng, & Min-Sheng Wu, 2012; M. Simpson & T. Markel, 2012) and the battery charging systems of forklifts for the movement of goods within the store.

The state of the art systems for battery recharging are available with different technologies and related devices, and even more numerous are announced next-to-market. Only recently systems based on DC/DC converters have been presented in the technical literature (J. Traube, 2012; S. Bai, S. Lukic, 2013; M. Simpson, T. Markel, 2012), characterized by high performances (95-97%) and able to withdraw energy from renewable sources such as photovoltaic modules, avoiding the double conversion DC/AC and AC/DC that presents an overall efficiency slightly over 80%.

The charging stations available on the market offer the possibility to perform the energy storage process with different rates. The charging mode can be very rapid (less than 60 minutes to a state of charge around 80% of the total nominal capacity), or slow until the desired state of charge, according to constraints given by devices (for example due to battery state of health or maximum currents allowed). In particular, in the ZED project will be employed charging stations already on the market.

2.3 Dashboard and Optimal Fleet Management

The system to be design and develop will be based on WEB applications, in the form of a dashboard, in order to enable remote data reading and control, avoiding the physical presence of technical personnel in the warehouse. The system is composed by two subsystems, the first related to the energy production management and load requests for the current day, the second related to the prediction of productivity and loads for the next day. All data are shared on the cloud by the dashboard for continuous monitoring of plant's performance.

2.3.1 Current Day Subsystem

Recharging stations will be connected to both a DC bus (powered directly by the PV plant) and to an AC bus (connected to the main grid), since renewable sources are inherently stochastic. For this reason, the control system will necessarily have to monitor and optimize energy flows in the microgrid either on the DC and AC buses. Data coming from the PV plant and from telemetry devices on electric vehicles will be gathered in a suitable data base on the cloud, in order to manage and optimize in the most efficient way the charging schedule.

Data to be monitored are the classic ones of a PV system: voltage and current on both the AC and DC buses and the corresponding powers. Since the charging stations will pick up most of the necessary energy from the DC bus of the system, it will need to monitor related quantities, as well as the state of charge of the battery pack. While these quantities can be measured and stored by exploiting systems already on the market, the control and management algorithm for the energy system will be designed ad hoc for the project ZED. As an instance, possible correlations between the data related to the instantaneous power delivered by the photovoltaic system with the data related to the power required by the batteries can be exploited for designing the control algorithm, by determining if and to what extent is convenient to take energy from the main grid. The data recorded on vehicles are stored in a data logger and sent in digital format by the mobile network (GPRS-UMTS-LTE) to the control center. One of most important data to be estimated is the State of Charge (SoC) of the battery pack. These quantities will be recorded at a fixed rate (frequency) to be established during field testing. Emergence of possible failures will instead be sent as an asynchronous event to the control center. Thus, the data logger is a fundamental device to be designed.

2.3.2 Forecasting Subsystem

The availability of precise estimation for energy production by the PV plant in the next day is of strategic importance from the economic viewpoint. Indeed, this is a fundamental information to improve the effectiveness of management strategies and fleet optimal schedules. To be able to predict the amount of solar energy produced by the plant weather forecast data such as cloud cover, wind, temperature and solar radiation on the installation site of the photovoltaic system are needed. This data must be as reliable as possible. To this aim, it is possible to use the service offered by the Geomodel Company. The analysis of the daily performance, the comparison with historical data, as well as the correct processing of error events from the inverter will give the possibility to plan the proper operation of the system in real time with the goal of operating a predictive maintenance, able to intervene selectively and timely, thus obtaining high performances stable over time.

In ZED project we will study and define a suited charging strategy and fleet optimal management of the supervision system, in relation to operational needs and energy availability, to the current production of renewable energy and to forecasting results.

The dashboard will incorporate the optimal Fleet Management scheduler, integrating a georeferencing system (GPS) with a module for planning and route optimization of electric vehicles used for goods distribution.

In order to apply mathematical models underlying the management software to green management procedures it is necessary to include the all the considered constraints; this should be handled in an appropriate manner in order to design the optimization algorithms that can generate turns of delivery of goods within a reasonable time and in any case compatible with the operating times of logistics organizations that use electric vehicles (average speeds considerably lower). The ZED project will allow to develop models more appropriate to a context of urban LTZ, exploiting appropriate metaheuristics procedures for the management of electric fleets.

To date, objective function of optimization models for the vehicle routing and scheduling are usually based on the following variables: running costs, vehicle activation costs and fleet saturation (to take into account the possible reduction of the number of available vehicles). When dealing with electrical vehicles it becomes important to include in the optimization model also variables related to the state of charge of the vehicle, the number of charging procedures (in order to optimize battery life), the incidence of the type of route on estimated consumption. In fact while with traditional vehicles fuel supply is always possible, management of electric vehicles needs the estimation of the time interval for needed for charging, thus avoiding that the vehicle gets exhausted during delivery operations, or to avoid too much frequent recharging stops. This important issue requires that for long trip scheduling both the charging times and the impact on batteries will be suitably taken into account. Moreover it is essential a real time monitoring of vehicles SoC, checking if the planned conditions are met, in order to generate timely alerts and reschedule on the fly the next rounds in the event of path changes.

It is therefore expected that the planning module receives, every 5 minutes, signals from the onboard monitoring device about the following measures:

- vehicle position (GPS coordinates);
- average speed during the last minute;
- SoC;
- outcomes of deliveries (integrating an hardware data scanning module based on NFC tags, for instance)

This information will be visible and manageable in dashboards shaped as web pages, including important embedded functionalities, such as views to the scheduler, transport orders, route waypoints, fleet monitoring and control, delivery outcomes.

2.4 On Board Management of Vehicle Battery Packs

In order to fully deploy next-generation electric vehicles and advanced systems for optimal management of electrical energy flows in micro grids (E. De Santis, A. Rizzi, A. Sadeghian, F. M. F. Mascioli, 2013), efficient and reliable energy storage systems (ESSs) are needed. One of the most promising technology is based on Li-ion cells, in both automotive and stationary applications. ESSs performances can be greatly enhanced by properly designing dedicated electronic devices aiming to monitor and manage the set of cells in the ESS. This fundamental component (Battery Management System — BMS) is mainly in charge to perform safety related monitoring procedures, to evaluate the available energy stored in the system, to track batteries' aging and to perform cell balancing procedures (M. Gholizadeh & F. Salmasi, 2014). State of Charge (SoC) estimation algorithms have a fundamental role in reducing managing risks, in evaluating the State of Health (SoH) of cells and to exploit reliably the stored energy, thus improving the overall efficiency. An important work package of the ZED project is therefore the design, development and realization of a complete ESS, equipped with and advanced modular BMS based on a Master/Slave architecture, for automotive storage applications. In particular, the definition of an appropriate battery model (M. Paschero, V. D. Giacomo, G. D. Vescovo, A. Rizzi, & F. F. Mascioli, 2010) and the development of reliable algorithms for model parameters' estimation (R. Xiong, X. Gong, C. C. Mi, & F. Sun, 2013) is the main research task.

A BMS should include the following functions:

- overcharge and undercharge cell protection
- Sate of Charge (SoC) estimation
- Sate of Health (SoH) estimation
- cells balancing
- thermal management
- communication with the other devices

Major concerns in both academic research and industries are focused on SoC estimation and cells balancing (M. U. Rehman, M. Evzelman, K. Hathaway, R. Zane, G. L. Plett, K. Smith, E. Wood, & D. Maksimovic, 2014). Poor estimation of SoC, especially in an over-charge or over-discharge condition, can lead the battery to work outside safety states, increasing the risk of dangerous situations and reducing the life time. Moreover, cell balancing allows to increase the overall ESS performances.

The research activities will be focused on the following two main goals:

- Building, developing and testing an appropriate hardware solution.
- Implementing a suitable SoC estimation algorithm.

3. Logistic-distribution Model Validation

The evaluation of the environmental sustainability of urban distribution was addressed by studies in the 1970's, aimed at "minimizing" collateral effects (P. Fawcett, R. E. McLeish, I. D. Ogden, 1992), together with efficiency and economic issues, whereas, in later years (J. Whitelegg, 1995, 2012; European Environment Agency, 2010) the emphasis was placed on emissions, with a view to improving the quality of air, and, later, the mitigation of climate change. However, while "Green logistics" is widely studied at international level, research has focused very little on linking the technological challenge with environmental improvement at local level (European Environment Agency, 2010).

The goods distribution not only can permeate the city system, but must enter in synergistic relationship with the evolution of the urban environment. It is therefore fundamental to pursue the environmental optimization of the entire distribution chain with assessment methodologies capable of providing indicators relevant to precise sustainability evaluation. With this in mind, during the ZED project will be performed an intensive energy model certification conducted by the National Research Council.

The environmental assessment methodologies established in different areas (SEA, LCA, product evaluations, ecological footprint, environmental balance, sustainability indicators) provide the starting point. To highlight the sustainability of the transportation system evolution proposed by ZED in the urban environment, the development of a methodology shared with operators will be carried out, including a special system for model monitoring and benchmarking, comparing it to the traditional distribution through indicators designed by considering the environmental data collected during the experiments.

The validation of the new logistics-distribution model proposed is the main action to verify environmental sustainability and therefore to provide one of the main elements of replicability of the model, ensuring the connection with the key themes of the green economy and green logistics and other fields (social acceptability of goods transportation, new markets, effects on the organization of the PA, environmental sensitivity of private individuals, etc.).

This validation will be performed mainly through the development and application of a system to monitor environmental parameters evaluated by suited indicators, with a methodology that takes into account:

- Emissions: emission parameters of vehicles, energy consumption by type of vehicle, energy produced by the PV plant, kilometers traveled by type of area (urban, suburban and green areas);
- Effects on congestion (average speed, number of circulating vehicles, of loading and unloading times);
- Specificity of the urban area (characterization of the differences in performances between different areas);
- Reduction of environmental noise;
- Energy use against energetic autonomy targets of a given territory;
- Social and environmental sustainability (final sellers and citizens), including the possible effect of promoting 0 km distribution;
- Effects on public governance.

4. Expected Results with Respect to Traditional Logistic Models

Today road transportation of goods by electric vehicles and in particular the delivering physical goods in LTZ urban areas covers irrelevant percentages of the total cargo handled, since such transportation systems are still in a pre-industrialization phase. Electric transport has more than 80 years of history, while electric transport of goods less than 10; the global manufacturer of electric vehicles at the end of 2013 were over 60, mainly American, Chinese, and European, of which only 20 producing industrial electric vehicles for goods transportation. Among the sectors that mainly use the electric freights there are the grocery, telecommunications, courier, public authorities (such as for public canteens delivery); all the solutions adopted in these areas, however, expect that the batteries are recharged using electricity from fossil fuels, and the burden of environmental damage is simply transferred from the vehicle to the process of producing electricity in the chain. For this very reason, the ZED project aims basically to overcome this issue.

The main expected results of the ZED project are:

(1) Validate the model as the best solution for the sustainable logistics distribution of physical goods in LTZ (CO_2 = 0), through comparative analysis between the traditional and the environmental energy model introduced by ZED, according to key indicators selected during the phase analysis and pre-qualification;

(2) Design a replicable and reproducible model, to be possibly applied in both in national and international areas, to increase efficiency and effectiveness in the management of the distribution networks of the goods;

(3) Promote and encourage the creation and development of public and private companies on green logistics at national and international scope, contributing to the creation of spin-offs and new jobs;

(4) Introduce patented technological innovations to increase the autonomy of electric vehicles by 10 to 15% and to reduce energy absorption of warehouse systems and recharging stations by 10 to 20%;

(5) To develop and patent the dashboard as an operational tool for planning and optimizing logistics, fleet management and fixed installations of renewable energy generators and battery charging;

(6) Achieving lower operating costs compared to “traditional logistics model” by 10-15%;

(7) Begin the internationalization process of logistics through the analysis of foreign markets and the pursuit of complementary partnerships.

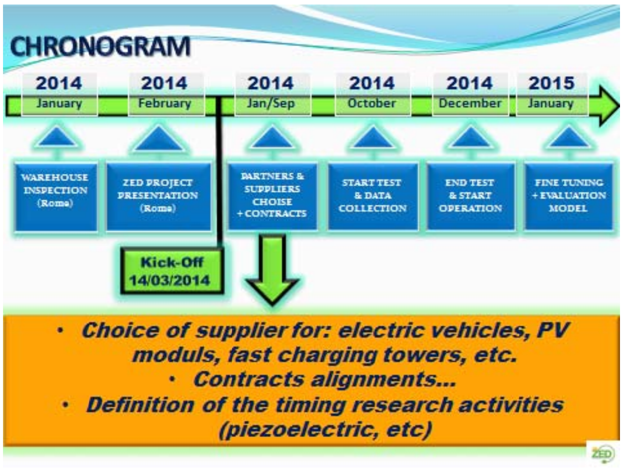

Figure 3 Chronogram

5. Results Dissemination

The ZED project includes a series of actions aimed at improving in particular the conditions of replication by acting on the “demand” and the environmental awareness of governments, workers and citizens; no transformation of “city system” is possible without a PA capable of welcoming the innovations proposed by the private sector and steering development towards collective goals.

In particular, thematic meetings with operators of public administration will be arranged, technical and scientific discussions on the developed evaluation methodology and on environmental aspects of urban logistics. Soon before the end of the project, it will be proposed the establishment of an Environmental Observatory of Urban Logistics, between the City of Rome, Lazio Region and ZED partners, promoting the participation of stakeholders, in order to complete the feedback analysis and the development of “guiding principles” for the inclusion of the model in several urban areas. The dissemination activities will be organized by Sapienza Innovation with the contribution of all partners of ZED.

The planned activities are:

- Maintenance and supply of ZED project website;
- Organization and participation at conferences, forums and workshops for the promotion of the ZED logistic model and for the dissemination of results;
- Rome and Lazio Environmental Monitoring of urban logistics;
- Publications in scientific journals.

Finally, special attention will be paid to the national level by a establishing an interplay link with the National Observatory on Smart Cities (managed by the ANCI-National Association of Italian Municipalities and by the Forum PA) and the National Cluster “Smart Cities & Social Innovations” of Torino Wireless.

5.1 Technology Transfer Potential

Concerning the goods transportation in urban areas, there are no precise statistics on the volumes handled, but it is possible to estimate its value by considering distances (point to point) under 50km. These constitute over 54% of total cargo handled and exceed the figure of 700 million tons. According to the Ministry of Infrastructure and Transport, the sector represents over 27 billion of GDP. With the technology now available, making a simple transposition of the ZED project on different geographic areas and considering additional product categories and production activities, taking into account a very prudent estimate, we can assume that over 60% of the volumes could immediately apply the ZED model without no significant difficulties without any reduction of quality of service to customers and citizens.

The number of registered trucks in Italy during 2012 has exceeded 125,000 units. Of these, 0.3% was made up of electric vehicles. Initial estimates for 2013 see similar figures that remain around 0.4%. The meager results of the sale of electric vehicles in recent years is mainly due to:

- lack of an overall system in which integrate the vehicle;
- lack of suited technical assistance;
- lack of charging points for the vehicle;
- high cost of vehicles, representing a barrier to entry.

ZED addresses these factors enabling the practical use of electric vehicles in a mature operative framework, to be used into activities that are congenial, as urban distribution. In this way the scope of operations is not changed and the transition occurs in a simple, fast and effective way. Considering the newly registered vehicles dedicated to goods distribution in urban areas or on short-distance delivering operations, stakeholders face a potential market of more than 100,000 vehicles per year. The potential arising from replacing an obsolete and more polluting fleet exceeds 2 million vehicles. At the same time, the impact for citizens translates into the possibility to receive deliveries in urban areas with non-polluting vehicles. Delivery by electrical vehicles can also be done during the night or evening without noise impact. Evaluating the concentration of population in Italy

(ISTAT 2013), no less than 17 million people could now be immediately served by a distribution network such as that conceived for the ZED project.

5.2 Spin off

The exploitation of the ZED project results is focused on the creation of a spin-off, which will be called GEL-Green Energy Logistics and will provide a complete package consisting of vehicle charging stations, photovoltaic system and supply chain management system (dashboard). The integration of technologies for green logistics of the GEL spin-off occurs at different levels of negotiation:

- Technological solutions (data collection, solution design and definition of the integrated model, implementation) to satisfy the specific needs of the customer (public/private) in terms of energy consumption and physical flow distribution (e.g., In-time delivery, quantity, products range);
- Electric vehicles with energy recovery systems on board, according to the metropolitan areas considered;
- Charging stations calibrated to the specific energy and logistics flows of the customer
- Power systems for the charging stations from renewable energy sources, according to warehouse characteristics and location;
- Management system of the entire supply chain by optimal remote control, via web based applications, of energy balance and flow distribution.

In addition to logistics operators interested in making distribution in the LTZ and historical centers, other potential customers of the spin-off GEL are the public and private stakeholders interested in specific solutions for transportation with zero environmental impact in urban areas (e.g., elderly and disabled people transportation, school buses, and waste collection door to door). The commercial offer, which will emerge from the project, will be appropriately calibrated on the results of the trial, in the light of careful cost-benefit analysis to start a suitable marketing strategy and communications.

5.3 Project Model Internationalization

The opening to foreign markets is a complex strategic process that a specifically formed temporary joint venture (TJV) will undertake after a preliminary analysis. In the planning actions for exploiting the ZED model on international markets, the main steps will be:

(1) the preparation of a feasibility study, with:

(a) an overview of the results, technological and market potential analysis

(b) the segmentation of the potential demand based on the identified areas, potential recipients and geographic preference

(c) an indication of at least four companies for establishing and developing B2B contacts;

(2) Scouting actions, based on the operational plan agreed with SMEs composing the TJV, integrated with the actions of the advisory group for additional potential contacts;

(3) Planning and implementation:

(a) internationalization activities in one or more European countries;

(b) the organization of a workshop, involving all the TJV companies.

5.4 Intellectual Property Management among the Partners

It is considered necessary to establish soon from the start of the project a set of rules to define “consortium agreement” between partners involved in the project, as a network contract and to define the rules regarding ownership, use, information dissemination and dissolution. To this aim the key issues are:

- ownership of the results (foreground), taking into account the efforts of partners performing the tests;

- access of individuals who are part of the partnership, at the background and at the foreground, for both internal use and for commercial use in favorable conditions;
- the rules for granting licenses to third parties;
- the inability to block the use of results from other partners;
- the management in the case a subject is exiting the TJV.

6. Conclusions

In the historic downtown Rome 25.000 vehicles are operating daily; 60% of those vehicles (15.000) perform 35.000 loading/unloading activities, while the remaining 40% cross the inner-city area without stopping (*Valeri e Stathopoulos 2010); this represents one of the a major cause of pollution and ZED wants to solve this problem through a technological approach.

The ZED project aims to deliver more than 1.000 shipments per day in the LTZ zones of Rome by a warehouse located at 15 km from the city center (GRA-Tiburtina area) by n. 8 electric vehicles. The electric vehicles (2.5 tons of payload and 60 kWh) have an autonomy of 140 km and the possibility to exceed slopes greater than 21%. The electric vehicles are able to deliver in the LTZ even 2 times per day. The warehouse will be covered by 1.500 square meters of photovoltaic panels and it will supply energy by a DC bus to 8 electric vehicles by fast-charging towers. The ZED management model will be supported by a dashboard, capable of: a) continuously monitor the energy balance of the system (the warehouse and vehicles); b) optimize fleet's schedule, planning and monitoring the activities of electric vehicles.

In October 2014, the first electric vehicle started the distribution service in the historic center of Rome (LTZ), the second started in March 2015, while the whole fleet (6-8 vehicles) will be deployed in full operation in November 2015. ZED won in the 2014 the "Il Logistico dell'anno" prize, as the best Italian green logistics project; this prize is a national award assigned by Assologistica (www.assologistica.it).

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