Energy 95 (2016) 494–503

Contents lists available at ScienceDirect

Energy

journal homepage: www.elsevier.com/locate/energy

Local promotion of electric mobility in cities: Guidelines and real application case in Italy

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ARTICLE INFO

Article history:
Received 6 November 2014
Received in revised form
2 December 2015
Accepted 12 December 2015
Available online 6 January 2016

Keywords:
EV (Electric vehicles)
Charging stations
Urban mobility
Electric mobility plan
Local energy planning
Smart cities

ABSTRACT

In the contest of European and National choices regarding energy and mobility policies, the goal of this paper is to introduce reasonable guidelines for the local promotion of electric mobility in an area of central Italy and possibly to extend the methodology to other regions/countries. In fact, the path towards car electrification is started worldwide, but the rate of increase of electrically powered cars will depend primarily on charging stations availability. In this respect, utilities that manage/own local grids may be key actors by investing on infrastructures and thus locally creating the conditions for the spreading of electric cars. A techno-economic analysis of the investment of a local utility has been performed taking into account medium- and long term-forecasts of electricity and fuel prices, as well as electric cars market share and economic risk. The study proved that an investment in urban charging station infrastructure in Italy can be profitable even without incentives, with a payback period of 4–5 years. The results of the analysis have been exploited by an Italian utility which owns/manages the local electric grid in two municipalities. The first steps of the plan implementation, which started in 2014, are reported in the paper.

1. Introduction

The transport sector is one of the largest energy consuming sectors worldwide [1] and one of the main causes of urban pollution [2,3]. Colvile et al. [2] investigated the effects of local air pollution emissions from road transport on the health of urban human populations and highlighted the need for more efficient integrated transport systems that will be required to meet demand for mobility of people and goods over short and long distances. Oxley et al. [3] evaluated a variety of pollution abatement strategies in road transport in UK investigating the implications for alternative strategies (e.g. electric of hydrogen powered vehicles and the uptake of biofuels), including: additional power generation requirements for electric vehicles; infrastructural developments necessary for hydrogen distribution and storage; and cross-sectoral impacts emerging from lifecycle analyses of biofuels and hydrogen production and usage. In Italy, the transport sector accounts for a share of 29.7% of the whole energy consumption [4]. In the last few years several studies have been carried out on sustainable mobility technologies [5–10] but only few experiments analysed the problem at a local scale [12–15]. Puksec et al. [5] they analysed four long-term energy demand scenarios till year 2050 for the Croatian transport sector; they found that with heavy electrification of passenger vehicles, transport sector energy consumption can be cut by half. Al-Ghandoor et al. [6] proposed an approach to model and predict transport energy demand in Jordan from 2010 to 2030; their work was based on ANFIS (Adaptive Neuro-Fuzzy Inference System) and on double exponential smoothing techniques and they found that Jordan's future transport energy demand is expected to increase of 103% by 2030. Smith et al. [7] investigated the electrification of the Irish private car fleet and they found that the spread of EVs (Electric vehicles) in urban-type driving cycles would yield significant GHG benefits, in addition to increasing security of supply, and improving urban air quality. Hu et al. [8] presented an overview of the initiatives launched in energy supply, consumption and challenges encountered in sustainable road transportation development in China; they found that if China's fuel intensity could reach the EU (European Union) level proposed by 2012, the total energy savings would reach 60% by 2030. Gonzalez-Palencia et al. [9] studied the potential for energy consumption and CO2 emissions reduction of ZEVs and lightweight materials in the Colombian passenger car fleet from 2010 to 2050; their study showed that electric powertrains have larger impact than

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http://dx.doi.org/10.1016/j.energy.2015.12.038
0360-5442/

lightweighting on energy consumption and CO2 emissions. Hedegaard et al. [10] analysed how large-scale implementation of PHEVs (plug-in hybrid electric vehicles) and battery electric vehicles towards 2030 would influence the power systems of five Northern European countries; they found that EVs can contribute in meeting peak power demand thus reducing the need for new coal/natural gas power production capacities in most of the countries investigated. At local scale, Comodi et al. [11] presented medium term energy scenarios for an Italian municipality also considering transportations; they found that at local scale, municipalities have limited room of manoeuvre for promoting clean transportation technologies. Colmenar-Santos et al. [12] assessed the use of sustainable transport models based on electric mobility in the Spanish city of León; they showed that it is possible to make electric mobility profitable for EV users, Government, aggregators and electricity companies, through the use of adequate regulatory policies. Raslavičius et al. [13] investigated the transition towards sustainable mobility through the use of full EVs in the city of Kaunas in Lithuania; they found that EVs can cover approximately 75% of all daily driving (commuting) thus improving the efficiency of transport system. Jian [14] estimated the charging demand of an early electric vehicle (EV) market in Beijing and proposed a model to distribute charging infrastructures in order to offer a reliable service. Perujo et al. [15] investigated the possible impact of the EVs charging activities on the electric supply system for the Province of Milan (Italy) with a 2030 time horizon; they showed that EVs contribute to CO2 abatement in the transport sector even though they could heavily impact on the daily demand of electric power. In addition to this, Perujo et al. [15] also highlighted that the estimate of the future market share of electric vehicles is a big question mark in electric mobility studies. A wide range of factors such as national incentives plans, development of new alternative technologies and oil price, are changing transport policy agenda in the European Union (EU) thus “influencing the reliability of any forecasting” [16]. The roadmap towards electric mobility apparently faces a catch-22 situation that can lead to an impasse: indeed, without electric infrastructure the spread of EVs will be very slow, but without EVs an electric infrastructure will certainly be unprofitable.

In this context, this paper presents a feasibility study of electric mobility at local scale. In particular, it illustrates the approach used by the Italian local utility ASTEA to define, in collaboration with the Università Politecnica delle Marche, its strategies in this sector.

The rapidly evolving market of charging infrastructures was approached at local scale, considering different aspects, such as: i) building infrastructures, ii) charging services starting operation iii) data analysis and iv) techno-economic validation of the results.

The study was carried out under an economic point of view only, leaving out other non-technical issues. As a result, a business plan was drawn and submitted to the municipalities of Osimo and Recanati – both located in the Marche Region of Italy where ASTEA operates – in order to start off a project consisting in the installation of several electric vehicles charging stations through the years. The project has been indeed approved and started at the beginning of 2014.

The paper is organized as follows: after the Introduction, section 2 presents the materials and methods used to carry out the feasibility study; section 3 presents the results with some comments; section 4 presents how the plan was actually implemented by the local utility; eventually, section 5 reports the conclusions of the work. For the sake of completeness an overview of the electric cars market is given in Appendix A.

2. Materials and methods

This work substantially carried out a payback analysis for both the investor in charging station and the potential buyer of an EV. The main challenge of the study was to properly consider the uncertainties related with a market at its very first stages of development. For this reason, a medium-long term payback analysis was carried out with a parametric approach setting the boundary conditions referring to official documents such as: i) present regulatory framework; ii) official studies on electric mobility in Italy; iii) official projections of energy commodities prices.

This section presents the main material used to set boundary conditions of the study (sections 2.1 and 2.2) and then the methodology used for the pay-back analysis (section 2.3).

2.1. Regulatory framework

The Italian EV market is significantly influenced, both from the technical and non-technical points of view, by the indications of some European Directives, Regulations and Resolutions; the most important are: i) the European Parliament Resolution (P7_TA2010 0150) on the Electric Cars [17], referring to Directive 2009/28/CE [18], which helped paving the way for the establishment of a single EV market – capable of reducing space, congestion, total energy consumptions and CO_2 emissions – and ii) the Directive 2009/33/ECon the Promotion of Clean and Energy Efficient Vehicles [19], which promotes clean and energy–efficient road transport vehicles in the EU by encouraging their sales and consequently their market. Accordingly, Italy has issued some guidelines [20–24] with the aim of building a framework of incentives and tax reduction for low-emission vehicles including electric ones. Under the technical point of view, safety requirements for charging systems are outlined by IEC (International Electrotechnical Commission)/EN 61851-1 ed. 2.0 [25]. This regulation applies to on-board and off-board equipment used to charge electric road vehicles at standard A.C. supply voltages (as IEC 60038) up to 1000 V and D.C. voltages up to 1500 V, and to provide electrical power for any additional vehicle (if required) when connected to the supply network. Settings of electrical connectors, plugs, socket-outlets, inlets and cable assemblies for electric vehicles, are defined by IEC 62196-2 [26] which contains categorizations on plug types, dimensional compatibility and interchangeability requirements for AC pin and contact-tube accessories and it is the standard reference adopted by the most common EV-connectors.

2.2. Reference studies for the perspective analysis

To perform a techno-economic analysis regarding an investment in EVs charging stations, reasonable boundary conditions have to be set, taking into account the regulatory framework in force and its possible evolutions. In particular estimations are needed for parameters such as: – mileage of drivers, – consumption of typical cars, – car fuels prices, – electricity price, – number of circulating EVs and obviously –charging stations costs. In the remaining part of this section the references used for the estimation of these boundary conditions, in the short- and medium/long-term, are briefly summarized. The Italian Mobility Research Centre states, as a result of one of its studies based on national surveys [27], that the most important factors influencing the diffusion of EVs are related to the traffic congestion of urban centres and to the environmental issues of fossil fuels powered vehicles. Reduced pollution, low noise and the image of modernity created by electric vehicle are in fact the three elements that most of the Italians indicate as essential. The same study reports that the high selling price is a major obstacle to electric vehicle sales. In this sense, support policies including incentives for EVs over the long-term (to 2020 and beyond) will be extremely important. Fig. 1 shows in detail the results of the national survey aimed at establishing the Italian's willingness to buy an electric vehicle. UNRAE (Unione Nazionale