On The Strategies for the Diffusion of EVs: Comparison Between Norway and Italy

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Abstract -The aim of this work is to estimate e-mobility trends, which are crucial for understanding the market and the infrastructure expansion over the next years and debate which are the persuasive policies to improve the diffusion. At the present time between the numerous and diverse standards and rules there are two charging types for electric vehicles: high power DC and AC charging modes. It will be stimulating to understand which technology will overcome in the following few years and if the charging mode option on a given electric vehicle (EV) affects its sales results. This paper addresses the existing e-mobility scenario in Norway and Italy, in particular evaluating: EV technical and commercial features, EV market connected to national incentive strategies, technical and diffusion connector type and charging mode. In conclusion, based on the existing history and analysis of the informations accessible, this work presents a measured outlook on the probable progress of this expanding niche market.

Keywords Electric vehicles; infrastructure; charging station, e-mobility.

1. Introduction

The focal plan incentives to move customers towards electric vehicles (EVs) are three: direct subsidies, fiscal incentives and fuel and maintenance cost savings [1-3]. Nations, that use direct subsidies, typically provide a one-time repayment to reduce the EV sales price. Fiscal incentives act in reducing taxes for acquisition or drive an EV. Fuel cost savings encourage EV users to drive their cars reducing the charging energy price. Direct subsidies have taken place mainly in France, in UK, in the USA, in Japan and in China [4, 5]. In France, vehicles emitting less than 20 g/km of CO_2 receive a 7,000 EUR bonus. For vehicles that emit up to 50 g/km the bonus is reduced to 5,000 EUR. In the UK, these vehicles receive a bonus of the 25% of the car initial value, up to a limit of 5,000 GBP. In the USA, the one-time bonus depends on the battery capacity; the maximum is 7,500 USD in form of tax credit. In addition to this, in California, the subsidy program offers EV owners another 2,500 USD. In Japan, a bonus is offered depending on the cost difference between the EV and a comparable gasoline car, in China otherwise this depends on the battery range of the vehicle. The bonus is between 35,000 and 60,000 RMB (about 4,200–7,200 EUR).

On the other hands, by considering possible fiscal incentives, VAT is the most significant tax for EVs. It varies from 5% in Japan to 25% in Denmark, Norway and Sweden. A policy that decreases this tax for EVs can drive to a important reduction of ultimate price for consumers. In Norway, for example, battery electric vehicles (BEVs) are excluded from VAT, and the Renault Zoe becomes 4,500 EUR cheaper [6-8], amount approximately equals to the cost of the battery pack. It is significant to understand that deprived of any form of incentives, governments earn more VAT from an EV than from a gasoline car since the battery pack has a non-negligible cost [9]. Certainly, VAT is added to the base value of the vehicle and EVs have a higher base price than regular cars. By considering the fees added at time of purchase, some Countries have also a registration tax as well. In the Netherlands, registration tax depends on the level of CO_2 emissions of a vehicle. Other places with a high outcome of registration tax are Denmark and Norway. In Denmark, registration tax is calculated based on vehicle price, safety equipment on board, and fuel consumption. BEVs are exempt from registration tax. In Norway, registration tax is based on vehicle weight, engine power, and CO_2 emissions, then BEVs are exempted from registration tax [10, 11]. In conclusion, in Germany and the

Netherlands for example, governments consider an economic incentive regarding the company car tax. Thanks to all these incentive policies, final EV price can vary a lot from its initial price and differs from one Country to another.

This study presents the current e-mobility scenario in Norway and Italy, with the aim of understand what are the successful strategies that have allowed the first Country to claim for this technology more than 100,000 all electric vehicles sold (December 2016), and vain ones that put the second Country to vaunt sales less than 0.1% of the total fleet (February 2017).

Specifically, the study includes numerous direct data regarding: EV technical and commercial features, EV market, national realities and incentives, enterprises, technical and diffusion connector type and charging mode. But also other important aspects, such as the network ability to provide the right recharge peak power. Italian houses are still equipped with electric contracts allowing only 3 kW of peak consumption, making home charging of electric cars unsuitable. But also fears on reliability of the products, since the growing spread of EVs has increased the development of innovative electric motors featuring high and uncommon performances [12].

In conclusion, based on the present history and analysis of the data available this work will address a considered opinion on the probable development of this expanding niche market.

2. Norway

Norway excels in Europe since is the State with the largest number of EVs. This is not the only remarkable primacy. This Country generates almost 100% of its electricity from hydroelectric power stations. It seems a no-sense, polluting with vehicles provided of internal combustion engines, in the absence of other emissions. In such a way, the turning point to battery cars will result the final reduction of Greenhouse Gas (GHG) emissions.

A part of the Country plans expected to reduce emissions by at least 40% by 2030 compared to 1990. The main incentives enjoyed by Norwegian citizens are:

- Exemption from tax on CO_2;
- Discount of 25% VAT;
- Free use of ferries, car parks and public charging stations;
- Free movement of streets dedicated to buses and trams.

Table 1 reports all the incentives and legislation active in the Norway.

A study conducted in Norway established that 41% of the holders of an EV has purchased with the principal motivation of “save money”. This can be explained by considering that the traditional small car with an internal combustion engine costs almost double compared to other States of European Union, due to import taxes. Such specificity of the Country is not easily found in other nations.

Table 1. Incentives ad Legislation

Purchase subsidies	☐
Registration Tax Benefits	☑
Ownership Tax Benefits	☑
Company Tax Benefits	☑
VAT Benefits	☑
Other Financial Benefits	☑
Local Incentives	☑
Infrastructure Incentives	☑

Another motive since of more and more Norwegians are adopting EV concerns the possibility of homely charging. The EV owners have access to charging in the first place in their home, and secondly on the job and finally at public charging stations.

The extensive use of EVs in Norway was made possible thanks to the fact that citizens have one of the highest incomes in Europe, the incentives and charging stations are easily accessible to all, and last but not least, the production of electricity is entrusted almost entirely by hydropower plants without polluting emissions. For a Norwegian citizen it is ethical and it is possible to buy a Tesla EVinstead of an internal combustion Volkswagen golf, and at virtually the same price.

In the first half of 2015, 11,273 electric cars were registered (about 20% of total registrations) in a population of over 5 million inhabitants. Since May 2015 more than 50,000 electric cars in circulation were counted in the Country, corresponding to 33.1% of registrations. In December 2016 EV reached 100,000. Figure 1 summaries the association between the incentives and the relative diffusion EVs and charging stations.

Norway is certainly one of the leaders on this front. It is building a very strong network of EV charging stations. This great success has certainly been obtained, in part, due to the high wealth per capita of the Country.

On the other hand, two main features make Norway an ideally inappropriate country for EVs. The Country is geographically very wide and cities are far apart. This means there are extended distances to be covered and there are no large metropolitan areas where an e-mobility system would certainly be fitting. It is also a very cold and snowy country. Because of that, higher power is required for heating and for driving, vehicles characterized by a higher powered engine and longer lasting energy storage, so fuel sources seem be more appropriate [13].

As a testimony to the strong diffusion of EVs, but without falling into dilemma before chicken or egg, Figure 2 shows the spread of charging, respectively, for the CHAdeMO charging and Tesla Supercharger stations.

CHAdeMO offers a quick charge characterized by a power output of up to 62.5 kW (125A and 500V). In recent years, these stations have been installed all around the world but mostly in the USA, Europe and particularly in Japan. Tesla's first six Superchargers were energized in California in September 2012. As of today, 710 Supercharger locations are energized worldwide.

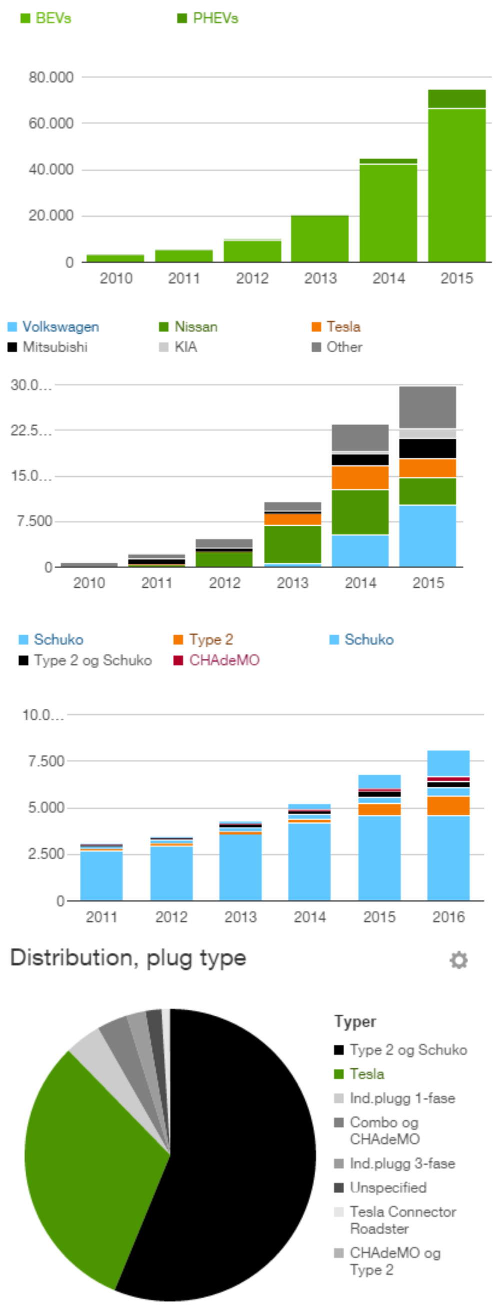
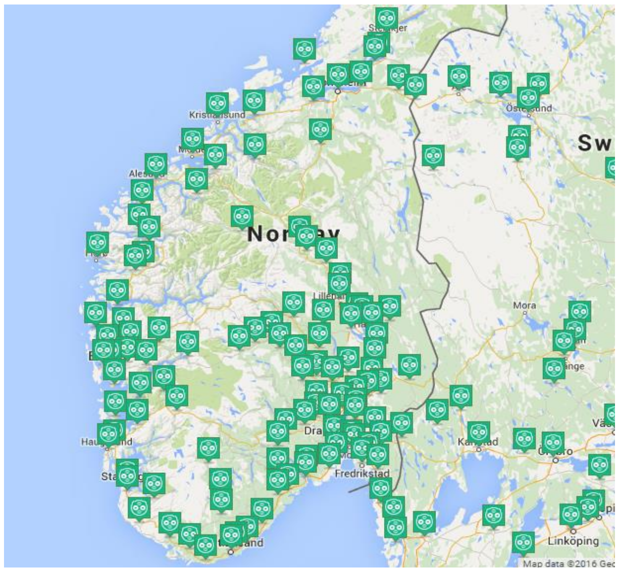
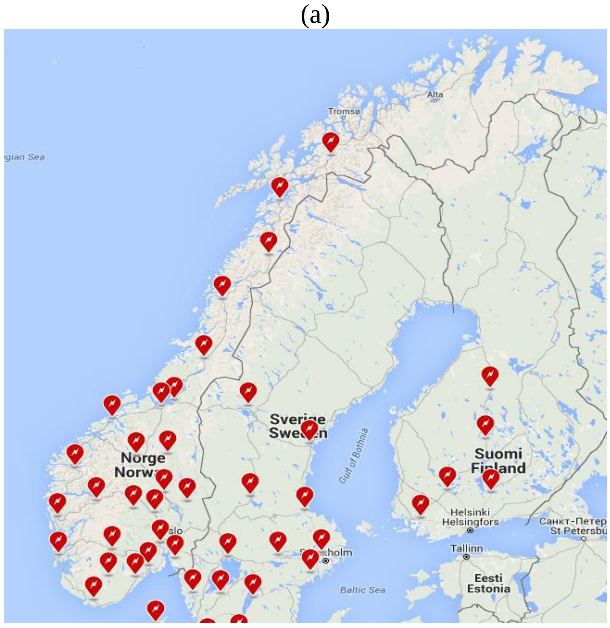


Fig.1. Outlines the correlation between the incentives and the relative diffusion EVs and charging stations [12].



(a)



(b)

Fig. 2. Diffusion of charging station, in particular a) CHAdeMO and b) Tesla [14, 15].

3. Italy

The opportunity to choose EVs, powered by renewable energy sources, could make a change to the Country from the point of view of reducing direct pollution caused by traffic, enforce sustainable mobility and fight against climate change. A proposed draft law in 2013 included some changes that were aimed at promoting the spread of electric cars and sustainable mobility in the Country. Highlights were:

- Reduction of VAT from 22% to 4%;
- Deduction of the taxes on the purchase of EVs, for the first year of entry into force of the law of 100%, 90% the second and 80% for the third and so on to fall by 10% for 5 years;

- Tax credit of 50% in 5 or 10 years for direct zero-emission vehicles used for public service;
- Funding for the construction of infrastructure for fast charging of zero emission cars, without which it would be impossible to be used easily and thus a wide spread of such means;
- Credit Tax of 41% up to a cost of 75,000 EUR for the construction of the systems fast electric charging.

The draft law also born from the need to reduce pollution to protect the health of the population (in fact, in Italy every year about 8000 people die for complications due to air pollution), with a positive impact also from an economic standpoint. However, the incentives are not utilizable, in fact, have been suspended with effect from 1 January 2014. The Decree Unlock Italy (Decree-Law of 12 September 2014, n. 133) has introduced some changes in the incentives for the purchase of EVs. Also with applicable law, the incentive mechanism is not particularly attractive: for example, for those buying an electric car which cost is 30,000 EUR, are addressed about 5,000 EUR of contributions, paid half by the State and half as a discount of the seller. For green car endothermic 120 gCO_2/km about 15,000 EUR price, incentives belong about 2,000 EUR. Therefore, the incentives for hybrid cars are more profitable, which is why Italians are increasingly choosing car LPG and CNG (+ 117% in 10 years).

The current incentives in Italy are:

- There is no need to scrap another car, as long as the vehicle purchased does not exceed a total of emissions of 95 g/km;
- There is no contribution of a fixed incentive, but a ceiling calculated on the car's price before tax;
- Contributions can be broken down as follows: more than 3,500 EUR for vehicles with emissions up to 50 g/km; 3,000 EUR for cars with emissions up to 95 g/km and 1,800 EUR with emissions up to 120 g/km.

In Italy in 2014 were sold 21,387 electric cars, + 25% compared to 2013 (since UNRAE) and almost all hybrid, out of a total of one million and 360 thousand cars sold. So about 1.6% of the total. To date, the registered electric cars in Italy is about 60 thousand units, but the space for growth is pro-very significant responsibility. Compared to 2014, in the first 5 months of 2015 the electric car registrations experienced an 87.7% increase (units recorded increased from 416 to 791).

From the point of view of Italy infrastructures has 351 charging points, mainly scattered in the north-central area. According to some research and interviews, the problems that are currently still present regarding the scarcity of recharging infrastructure and battery charge. In Figure 3 shows the spread of electric vehicles.

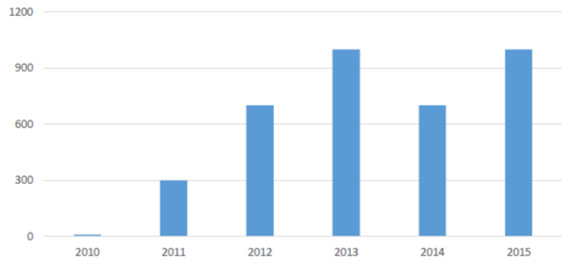


Fig. 3. Outlines the correlation between the incentives and the relative diffusion EVs and charging stations [16].

Table 2 reports all the incentives and legislation active in the Italy.

Table 2. Incentives ad Legislation

Purchase subsidies	☑
Registration Tax Benefits	☐
Ownership Tax Benefits	☑
Company Tax Benefits	☐
VAT Benefits	☐
Other Financial Benefits	☐
Local Incentives	☐
Infrastructure Incentives	☑

In Italy e-mobility is still something unusual. The infrastructure is still reduced and except in a few cities, charging stations are hard to find [17]. Figure 4 shows the spread of charging, respectively, for the CHAdeMO charging and Tesla Supercharger stations.

4. Forecasts Charging Stations

This part is addressed to forecast the upcoming trends for EV deployment and for the number of installations with different charging stations in Norway and Italy to set a correct future planning of the electric system based on the use of EVs [18]. This study is based on the current data collected from a literature survey and updated with the most recent data provided by the corporate websites of the manufacturers of EVs and charging systems. Therefore, this work wants to consider on the middle-term forecast. However, 2020 is the year that the objectives of the Kyoto protocol are to be met. The first analysis is on the trend of installations for normal (22 kW) charging stations from the beginning through today, a polynomial curve was found to provide a good fit to this trend.

(a)

(b)

Fig. 4. Diffusion of charging station, in particular a) CHAdeMO and b) Tesla [14, 15].

Figure 5 shown the trend of number of normal charging stations for two countries, in particular Italy and Norway.

Considering the diffusion charging station installations in the Norway for different years starting of 2010, this curve can be represented by the second-order function represented in (1):

$$CS_{\leq 22kW} = 54y2 - 224y + 2524 \quad (1)$$

where $CS_{\leq 22kW}$ represents the number of installed traditional stations in the Norway, and y is the corresponding year starting from 2010. The related correlation coefficient R2 value is equal to 0.96 (very close to 1), i.e., a good correlation exists between the polynomial curve and the actual trend. The Confidence Interval (CI) chosen in this analysis is equal to 95%.

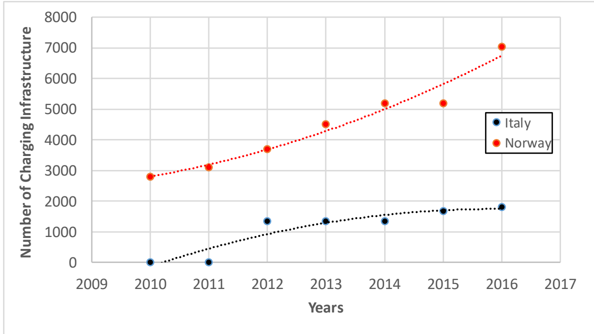


Fig. 5. Trend of the number of normal (<= 22 kW) charging stations in Norway and Italy.

The same procedure was applied to the Italian country, obtaining the following result expressed in (2):

$$CS_{\leq 22kW} = -53y2 + 742y - 820, \quad (2)$$

where $CS_{\leq 22kW}$ represents the number of installed traditional stations in Italy, and y is the time variable. For this case, the related correlation coefficient R^2 is also equal to 0.87.

It is important to observe that in these Countries particular attention is on other charging station, CHAdeMo and Tesla as shown in Fig. 6.

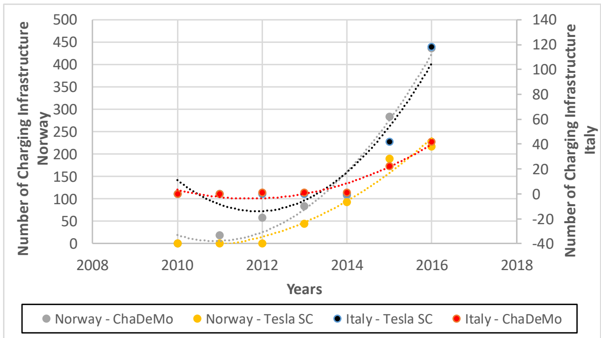


Fig. 6. Trend of the number of CHAdeMo and Tesla charging stations in Norway and Italy.

However, it is important considering other mode to recharge. Considering the diffusion charging station installations in the Italy in different years, this curve can be represented by the second-order function represented in (3) for the CHAdeMO charging stations and (4) for the Tesla charging stations:

$$CS_{CHAdeMO} = 2.4y2 - 13y + 14, \quad (3)$$

$$CS_{Tesla} = 7y2 - 40y + 44, \quad (4)$$

where $CS_{ChaDeMO}$ represents the number of installed Chademo stations and CS_{Tesla} represents the number of installed Tesla stations for the case of Italy, and y is the corresponding year starting from 2010. The related correlation coefficient R^2 value is for two case, respectively, equal to 0.94 and 0.91.

The same procedure was applied to Norway country, obtaining the following result:

$$CS_{CHAdeMO} = 16y2 -61y +64, \quad (5)$$

$$CS_{Tesla} = 8y2 -20y +8, \quad (6)$$

where $CS_{ChaDeMO}$ represents the number of installed CHAdeMO stations and CSTesla represents the number of installed Tesla stations for the case of Norway, and y is the corresponding year. For the both case, the correlation coefficient R2 value is equal to 0.97.

5. Discussion on Indirect CO_2 Emissions

The incentive policies aim to reduce global emissions of pollutants. In this context, we must compare the effort with desirable results. The use of EVs requires the production of electricity from the national power plants system, which also produces carbon dioxide emissions. Some Countries use nuclear power plants that will produce low values of emissions of carbon dioxide [19], for example, France has a coefficient of 80 gCO_2/kWh. Norway has a coefficient of 17 gCO_2/kWh [20], due to the employment of hydroelectric power plants. A small size EV, similar to Renault Zoe, can travel 100 km with a variation of State of Charge of 16kWh. In France, the indirect emissions reach a value of 12.8 gCO_2/km and in Norway 2.72 gCO_2/km: battery vehicle show very few carbon dioxide emissions.

In Italy the massive presence of a traditional thermal production system leads to a coefficient of emission of pollutants of about 400-500 gCO_2/kWh, depending on availability of energy in the international market. In the worst scenario, a Zoe can have indirect emissions about 80 gCO_2/km, very close to the one of a Renault Clio dCI EURO6, 85 gCO_2/km. It is understood how incentives to reduce emissions in such a scenario can be vain.

6. Future Plan for 2050

In order to give a robust forecasting tool for the development of EVs in the two considered Countries, some useful consideration can be made.

By following a U.K. study of 2010 reported in [23,24] it is possible to define four trajectories that represent different ‘ambition’ levels of change to 2050: T1, Conventional fossil fuelled cars and vans cover 80% of mileage; T2, road modal share is reduced by 50%, greater hybridization; T3, plug-in, electric and fuel cell cars/vans constitutes 80% of passenger mileage; T4, all car and van travel is electrified, 20% use of fuel-cell range extenders.

By considering the actual trend it can be easily assessed that Norway for 2050 can effortlessly reach the fourth trajectory. For the case of Italy, due to the lack in incentive policies, a middle level between the trajectories T2 and T3 can be addressed.

On the other hand, the aim to decarbonize the transport sector through electrification has to consider the energy efficiency of both the electricity production and the energy use. One of the main potentially of the Italy is due to high diffusion of solar energy, which can produce electric energy in the same charging stations [21,25-30]. In such a way the emissions reduction, primary aim of the employment of EVs, can be linked to the transport efficiency, expressed as the ratio of energy used per vehicle-km, that can be remodeled in low emission transport efficiency: a reduced number of EVs will employ decarbonized energy. Such idea can be confirmed by the positive trends in the increase of green plants in Italy, which in the 2050 will easily surpass thermal plants.

7. Conclusion

The aim of this work presents the current e-mobility scenario in Norway and Italy, in particular, many data regarding: EV technical and commercial features, EV market, focused related national realities and incentives, enterprises, technical and diffusion connector type and charging mode. In conclusion, on the basis of the existing history and analysis of the data available this work has shown a considered opinion on the probable development of this expanding niche market.

Firstly, EVs have a strong future diffusion. Many huge companies are investing in the EVs. In fact, many car manufacturers are creating and shaping new EV models. At the same time governments are encouraging EV sales and infrastructure planning, only in this mode will be possible to large diffusion of EVs also in Countries with a considerable delay in development such the case of Italy.

However, the EV market cannot be stimulated by subsidies and ecological ideology forever. People can be routed to a greener choice but in the future EVs have to be attractive in terms of comfort, performance. A network of rapid charging points will increase the EV fleet over the next few years. Knowing that charging is easy and convenient helps encourage residents and businesses to buy and drive EVs more than any national incentive. On the other hand, it is necessary to be able to guarantee a power plant production system that does not produce more emissions than an internal combustion vehicle, because it would only change the production of pollutants from one point to another.

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