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No. 5 | October 2014

WORKING PAPER SERIES IN PRODUCTION AND ENERGY

KIT – University of the State of Baden-Wuerttemberg and
National Research Center of the Helmholtz Association

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Potentials for Electric Vehicles in France, Germany, and India

A comparison of the three markets

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Abstract

As road transport is responsible for a major part of greenhouse gas emissions, broad diffusion of electric vehicles (EV), in combination with electricity generated from "clean" energy sources, can contribute to reducing overall CO_2 emissions significantly. EV include plug-in hybrid electric vehicles (PHEV) and range-extended electric vehicles (REEV) which still contain a combustion engine and, hence, do not restrict the user compared to conventional vehicles, as well as pure battery electric vehicles (BEV). BEV will be focused in this article, as the user behavior is affected considerably by a limited range and longer 'refueling' times. However, with a current market penetration below 1 %, the impact of BEV is marginal. Although the sales figures of BEV are low all over the world, it will be pointed out in this article that the potential for diffusion and take-off of this new technology varies in different countries depending on some framework conditions like infrastructure and energy generation as well as on individual factors measured by surveys in the different countries. Hence, this study tries to compare market potentials for BEV in different countries in order to improve the knowledge basis for decisions of policy makers. Two Western countries, France and Germany, and one rapidly growing developing country, India, have been chosen. In the first step of our analysis, framework conditions are analyzed and compared, which influence societies' strategies as regards future developments of national passenger transport systems determining the future role of BEV. This step focuses on economic differences, greenhouse gas emissions, national EV promotion programs, differences in the underlying electric power system, as well as passenger car stock and vehicle (including motorized two-wheeler) registrations. The second step concentrates on the differences in user acceptance of BEV in the three different nations. Therefore, consumers' responses to internet questionnaires relating to BEV acceptance which were distributed in France, Germany and India were compared. With the help of variance analysis statistical differences of consumers' statements in the three countries are determined. The main result of the two-step analysis is

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that France currently has the biggest market potential for BEV, since the economic conditions and acceptance patterns in society are more beneficial for BEV than they are in Germany and India. While the individuals' BEV acceptance level seems to be comparably lower in Germany, Indian framework conditions negatively influence the diffusion of BEV. Thus, it seems advantageous to start promoting BEV in France, to focus on REEV and PHEV in Germany, and to neglect promoting policies for (four-wheel) EV in India in the next years. However, it seems necessary to support long-term diffusion of EV in India, considering the increasing sales figures of new vehicles and the corresponding challenges in Indian megacities.

Keywords: Electric vehicle; market potential; market comparison; Germany; France; India

Highlights:

- Comparing market potentials for electric vehicles in France, Germany and India
- France seems to be most convenient for battery electric vehicles today
- India has a high market potential in the future if reliable charging is guaranteed

1 Introduction

According to governments' plans in countries like India, France, and Germany, mobility with battery electric vehicles (BEV) will become increasingly important. BEV in passenger transport are supposed to lower greenhouse gas (GHG) emissions (i.e. mainly CO_2 emissions) and other local air emissions, to reduce the dependency on fossil fuels and to improve the integration of fluctuating renewable energy sources (Jochem et al., 2012). Individual transportation with internal combustion engine vehicles (ICEV) developed continuously in the last century, whereas the development of BEV was reactivated just recently by decreasing battery prices, increasing battery performance, government support, and political willingness motivated by the global challenges of decreasing availability of fossil fuels and globally rising CO_2 emissions. The most probable increase in natural disasters due to climate change (IPCC, 2013) and the corresponding explosion of future costs can only be controlled, if major GHG-emitting countries cooperate in developing strategies to decrease their GHG emissions. As road transport is responsible for about 23 % of global GHG emissions (IEA, 2013), electrification of the car, in combination with electricity generation from "clean" energy sources, might contribute to reducing overall CO_2 emissions significantly. However, this will require a higher market penetration of BEV. The consumers' future car purchase decisions are crucial to the global diffusion process of BEV. So far, the new technology has not entered the mass market. In 2013 6,051 BEV were sold in Germany (KBA, 2014), 13,954 in France (AVERE France, 2013a; AVERE France, 2014), and at least 1,500 in India (Indian Ministry of Heavy Industries and Public Enterprises, 2012). These numbers are equal to market shares of 0.2 % in Germany, 0.7 % in France, and about 0.06 % in India. A significant effect on mitigating emissions certainly cannot be reached by those small numbers.

Currently, these small shares are mainly due to the comparatively high vehicle prices and little vehicle supply by most automotive manufacturers. Nevertheless, many new BEV have been launched recently (IEA, 2011b). From the current perspective, it is highly uncertain, whether demand will continue to increase and considerable market shares will be reached in the future automotive market. This is the result of a survey of different studies estimating the market potentials (cf. Figure 1). Therefore, the following analysis focuses on framework conditions supportive to BEV diffusion and on the survey participants' individual level of acceptance in two different Western countries, France and Germany, as well as in one fast growing developing country, namely India.

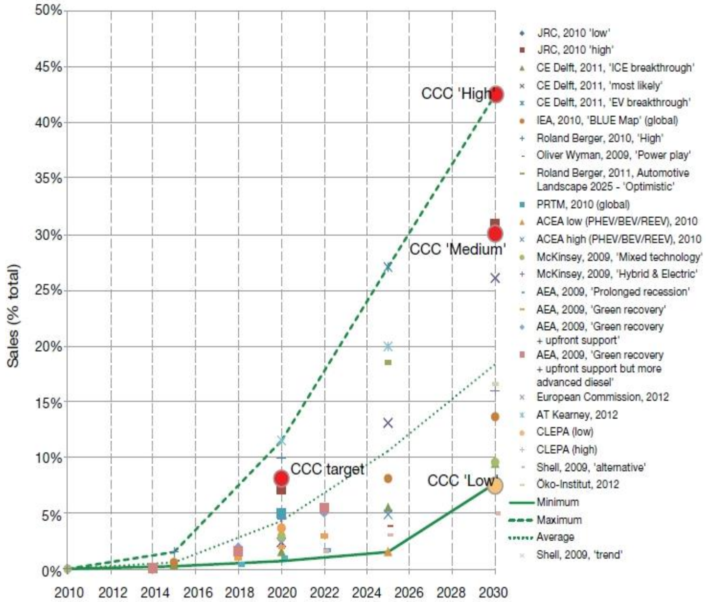

Figure 1: Overview of different scenarios of market penetration for advanced electric vehicles

Source: UKPIA and RAC, 2013

In a first step, framework conditions have been analyzed in order to roughly identify EV market potentials in each of the three countries. Particularly, the three countries' economic developments (which is measured by the GDP per capita here) have been focused, as it influences the mileage, car ownership, transport infrastructure, and modal split (IEA 2009 and 2013, WBCSD, 2004, IPCC, 2007) and, hence, directly affects the market potential of BEV. Furthermore, (1) the historic development of CO_2 emissions (and the resulting political pressure to reduce CO_2 emissions in road transport), (2) implemented political promotion programs for EV, (3) the national electrical power system, as well as (4) total car and motorized two-wheeler sales in each country have been analyzed, as these parameters seem to influence the EV market potentials, too.

In the second step, consumers' acceptance of BEV has been considered, as this issue represents a main cornerstone of successful EV market penetration. An acceptance analysis has been accomplished based on own surveys, and differences of consumers' perspectives and acceptance patterns in the three countries have been studied by an analysis of variances (MANOVA). Finally, both perspectives have been consolidated to obtain some first hints about main factors influencing the successful EV market diffusion in the three countries considered.

The paper is organized as follows: Section 2 gives an overview of recent research concerning the diffusion of EV on the three markets as well as first studies focusing on comparisons of consumer acceptance in different countries. Section 3 outlines framework conditions which might influence the market diffusion of EV. In section 4, the individual perspective (user acceptance) is studied and the responses obtained in the survey for the tree countries are compared by a MANOVA analysis. Section 5 presents potentials for electric mobility on the three markets derived on the basis of demand patterns and framework conditions in the countries. Section 6 gives a conclusion and highlights recommendations for policy makers as well as practitioners working in the field of electric passenger cars.

2 Literature Review

2.1 Factors Influencing BEV Acceptance

It is widely acknowledged that experience with BEV is an essential factor in the process of consumer acceptance (e.g. Dudenhöffer, 2013). Franke et al. (2011) suggested that range problems for example, can be solved by experience like information or training. However, a low diffusion rate makes the current share of EV users small. Nevertheless, many studies were made in recent years, indicating that the prices of EV are too high, their range is too short, and the charging infrastructure insufficient (e.g. Caulfield et al., 2010; Hidrue et al., 2011; Pierre et al., 2011; Windisch, 2012; Propfe et al., 2013). For these reasons, only small market potentials are estimated. However, not all studies were performed with EV users. Instead, a stated preference analysis was made. Deloitte (2011) for example, conducted a survey with more than 13,000 individuals in 17 countries. The study revealed that only a small group of today's consumers would find the current BEV technology acceptable and that mass use of BEV is unrealistic in the next decade. Alternatives to pure ICEV and BEV are assumed to be more successful in the future. The study suggests that the success of these new technologies depends on changing consumers' expectations and preferences coupled with effective government policies.

Despite that, Pierre et al. (2011) point out that the users of BEV found the vehicles pleasant to drive and also practical. Two groups of BEV users were identified by the authors: Innovators characterized by a pioneering ecological spirit who want to display and defend their values and people who purchased a BEV due to specific advantages almost by chance. Both groups agree on the fact that EV increase their sensitivity to transport issues, energy savings and environmental topics.

Egbue and Long's (2012) online survey indicated that attitudes, knowledge, and perceptions concerning BEV are statistically influenced by age, gender, and education. Furthermore, the study found that sustainability and environmental benefits of BEV have a major effect on BEV adoption, but they are still less important than costs or performance. According to the authors, socio-technical barriers exist, particularly with respect to battery technology and fuel source. Also, sustainability and environmental performance of BEV compared to ICEV were found to be crucial by some respondents with a high environmental awareness. These test persons did not consider the purchase of a BEV to be beneficial for the environment. Consequently, the authors conclude that incentives like tax credits and fuel taxes may have little effect on the diffusion dynamics of BEV, if consumers have only little confidence in BEV technology.

While several other studies also indicate that tax incentives do not improve the acceptance of BEV, other researchers think that governmental incentives have beneficial effects and insist on demanding more political support (e.g. Pierre et al., 2011; Windisch, 2012; Achtnicht et al., 2012; Propfe et al., 2013). The result of a study conducted by Chandra et al. (2010) was that only 26 % of the final purchasing decisions in favor of hybrid electric vehicles (HEV) in six Canadian provinces between 2000 and 2005 were caused by tax reductions. It was found that the majority of buyers would have bought the car even without incentives. Additionally, the replaced cars were comparatively CO_2-efficient. In this funding program, the cost per ton of CO_2 saved was US$ 214. Saldarriaga-Isaza and Vergara (2009) analyzed the influence of incentives for compressed natural gas (CNG) driven ICEV. According to their survey, 57 % of car owners would have opted for CNG without incentives. The main purchase motive was identified to be the low price. Gallagher und Muehlegger's study (2011) comes to the conclusion that mainly personal preferences and increasing gasoline prices influence purchasing decisions in favor of HEV. Since purchase incentives extrinsically motivate an action, this might not be a sustainable solution. Another disadvantage of purchase incentives is the rebound effect (Frondel et al, 2008). However, considering fast decreasing battery prices, it seems reasonable to support the EV market in the beginning in order to boost the economies of scale and to reach a faster decrease of EV prices. This would lead to a balancing of vehicle prices (EV vs. ICEV) by 2020 in most vehicle segments (Pfahl et al., 2013).

Due to the high uncertainty of the future market share of EV, policy instruments, such as tax and purchase incentives, but also government funding of technology development, research, and infrastructure seem to be highly risky.

2.2 Comparisons of Countries

As CO_2 emissions are a global problem and the specific emissions per kWh highly differ in different countries, the CO_2 mitigation potential of EV differs, too. In most countries, it is an efficient instrument to reduce CO_2 emissions, more efficient than other technological changes within the car (Pfahl et al., 2013). Several studies try to estimate market potentials of EV in different countries taking into account cultural differences. In the field of green technologies however, only few studies have been based on a comparative analysis so far.

Oliver and Lee (2010) studied the intention of American and Korean consumers to buy a HEV. As a basis, they used the cultural model of Hofstede (2001), according to which Korea is a rather collectivistic and the USA a rather individualistic country. The researchers wanted to find out, whether the decision to buy an environment-friendly product is dependent on culture. For this purpose, 1,073 American and 783 Korean car drivers were interviewed. The result was that the cultural background influences the social importance to drive an HEV. The Korean users' intention was more influenced by the perceived social importance of using an HEV than in the USA. In the USA, the correlation between social importance of ecological products in general and purchase decision was significantly negative. This connection was not significant in Korea. This means that in individualistic societies, there is an influence of psychological response to social importance of the technology on the purchase decision (Oliver and Lee, 2010).

A comparison of acceptance of EV in twelve different countries was made by TÜV Rheinland (2010, 2011a-d). After clustering, India, together with China and Italy, ranks among the promoters of electric mobility. By contrast, Germany belongs to the group of 'waverers'. Japan and Denmark rank among the neglectors (TÜV Rheinland, 2011d). In France, the researchers found that even with limited knowledge levels nearly half of the test persons would consider buying an EV within the next five years. The biggest drivers are potential cost savings with regard to fuel, whereas the biggest barrier is the short range (TÜV Rheinland, 2011b). According to the study, even the majority would consider buying an EV within the next five years in India. TÜV Rheinland concludes that pure BEV will be the future for India, whereas hybrid cars are expected to succeed in France. Due to high self-reported knowledge levels and fitting driving behaviors, the study finds that India is more suitable for further introducing EV than France (TÜV Rheinland, 2011c).

Dudenhöffer et al. (2012) compare the acceptance of EV in Germany and India. The theoretical framework is based on the Technology Acceptance Model (TAM) by Davis et al. (1989) and a literature-based extension. The data were obtained from an online survey in India and an online survey in Germany. The result was that the acceptance is higher in India indeed, whereas the level of knowledge is lower. In all objectivity, India seems to have less potential for electric mobility. Again, this leads to the assumption that theoretical surveys bias the persons' statements towards acceptance if the product is not known very well.

Ensslen et al. (2013a) compare the experience gained by French and German BEV users. The BEV considered in their analyses are predominantly part of company fleets. On average, the users have experienced EV for about a year. According to their analyses, the French respondents show a higher affinity to innovations and they are worried more about climate change impacts. The German respondents, on the other hand, point out more often that BEV are favorable for their companies' corporate image. Hence, prestige is more likely a reason to purchase a BEV in Germany than in France.

Furthermore, results indicate that people living in communities with more than 20,000 citizens show a higher degree of satisfaction with the following characteristics of BEV: Absence of local emissions and reduced range. Additionally, they are more worried about future impacts of climate change. Accordingly, on the one hand, potential for widespread diffusion of BEV currently might be a little higher in France. On the other hand, the comparably positive perceived corporate public image of BEV in Germany might at least be a decisive factor for including BEV in commercial or public authorities' fleets.

3 Framework Conditions

3.1 GDP per Capita

It is common to use the GDP per capita as a simple approximation of economic development of a country. It is highly correlated with mileage and car ownership as well as with the transport infrastructure of a country (IPCC, 2007) and, hence, one of the main indicators in national comparisons. In 2012, the GDP per capita was US$ 39,772 in France, US$ 41,514 in Germany, and US$ 1,489 in India (World Bank, 2013). Similarly, car ownership per 1,000 persons differed considerably (cf. Figure 2). In France and Germany, about every second person owned a car statistically, whereas in India only about 1.3% of the population did so (Kumar, 2012). According to a report by McKinsey (2007), India will develop to the fifth largest consumer market in the world by 2025. Increasing Indian purchasing power is reflected by high per capita GDP (considering purchase power parities, PPP) growth rates (between 2000 and 2011, about three times higerh as in France and Germany on average) at a very low level (only about 10 % of the French and German per capita GDP PPP in 2011). Moreover, India is non-saturated concerning the diffusion of automobiles.

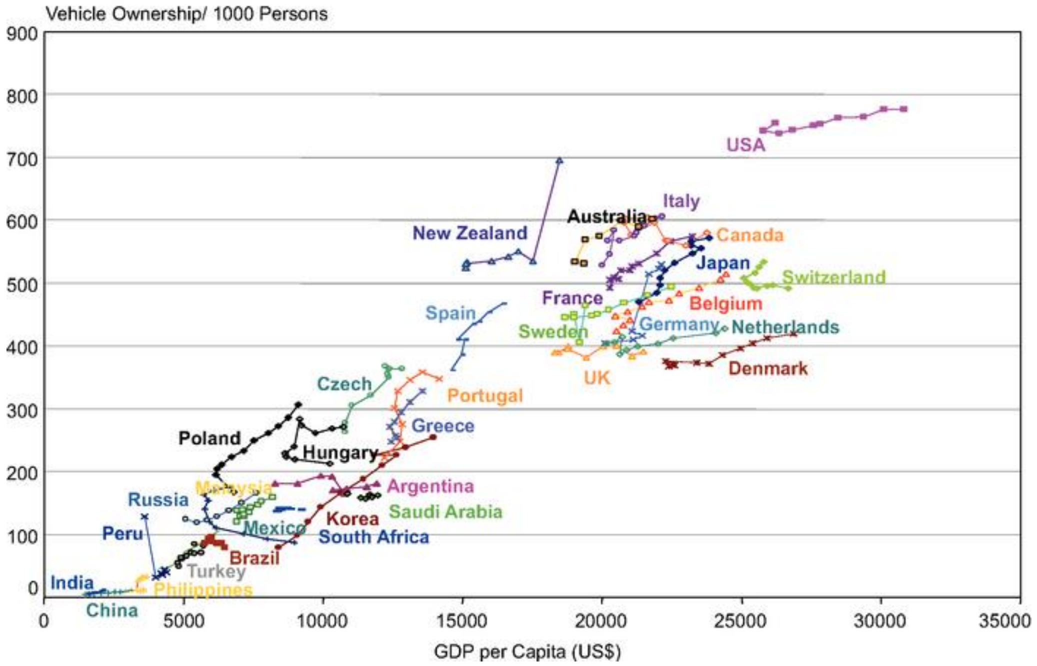

Figure 2: Vehicle ownership as a function of GDP per capita over the last few years

(Source: IPCC, 2007)

The results of representative mobility surveys during the last decades in France and Germany reveal that the share of motorized individual mobility has reached a level of saturation and even exposes the trend to decrease in both countries. Whereas the share in Indian cities is only half as high (29 %), it has been increasing continuously for the last two decades. The annual growth rate is about 12 %, which is especially due to the increasing share of two-wheeler trips, resulting in an increase of congestion and a decrease of average speed on major traffic routes (Indian Ministry of Urban Development, 2008; Indian Ministry of Urban Development, 1998). Surprisingly, the most significant difference in mobility usage patterns between Germany and France is the usage of bicycles. In Germany, more than 20 % of the trips were made by bicycle in 2008, whereas the French used their bicycle for less than 5 % of the trips. In 1994, the share of bicycle trips was highest in Indian cities (30 %, Indian Ministry of Urban Development, 1998), but it decreased rapidly to 11 % in 2008 (Indian Ministry of Urban Development, 2008). Major reasons are an increase of individual purchase power, resulting in affordability of motorized individual mobility and the totally inadequate cycling infrastructure in Indian cities. The observable trend towards individual motorized mobility in Indian cities did not only result in a decrease of the cycling mode share, but also in a decrease of walking trips (28 %). Nevertheless, urban Indian citizens are still walking more than the Germans (9 %) and French (22 %) (cf. Figure 3).

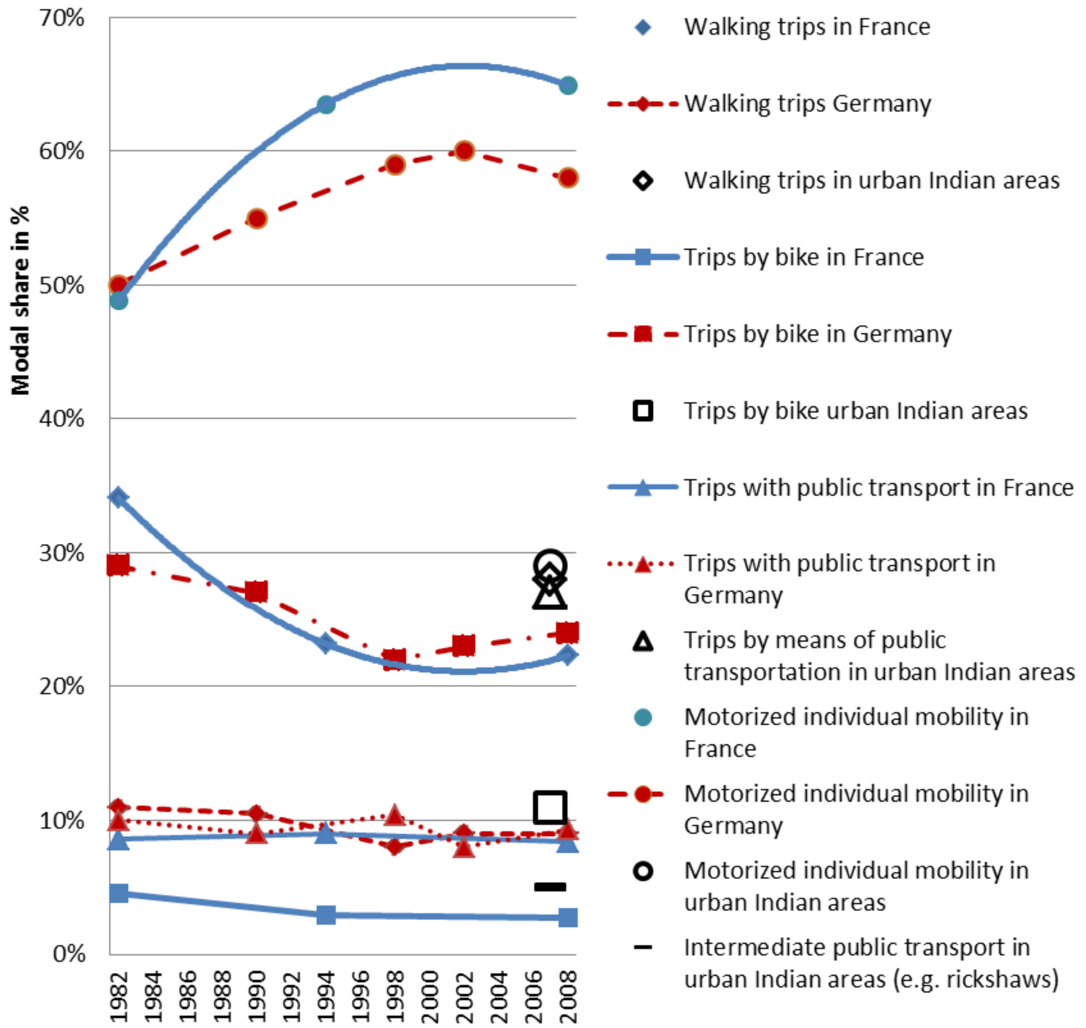

Figure 3: Development of modal shares in France, Germany, and urban Indian areas

Sources: Lenz, 2013; Le Jeannic et al., 2010; Indian Ministry of Urban Development, 2008

3.2 GHG Emissions

During the last years, it was proved scientifically that anthropogenic GHG emissions most probably result in climate change (i.e. increase of extreme weather conditions) (cf. IPCC, 2013) and that adaptation strategies (e.g. building higher levees, improving the stability of roofs) will be more expensive than mitigation (i.e. limiting global GHG emissions) (Stern, 2006). As CO_2 emissions have the highest share in GHG, they are responsible for some 63 % of anthropogenic global warming, and represent the major contributor to climate change, European countries have decided to cut GHG emissions by implementing mechanisms like CO_2 trading schemes, targets to reduce CO_2 emissions, and supporting renewable energies (EC, 2012).

European legislation has committed to reducing GHG emissions to 20 % below the 1990 levels by 2020 and implementing a roadmap for moving to a competitive low-carbon economy in 2050

(EC, 2012). By 2050, the total emission is to be reduced by 80%. While the power generation sector is to cut emissions by 93 % to 99 %, plans for the whole transport sector foresee emission cuts between 54 % and 67 % (EC, 2011b). According to the European Commission (EC, 2011a), electrification of passenger cars will permit to cut emissions from cars strongly after 2025. In summer 2011, German legislation adopted a package of six bills, called "Energiepaket", as a basis of a fundamental reorganization of energy supply in Germany. Germany plans to stop nuclear power generation by 2022 and aims at an energy supply, consisting of 80 % renewable and 20 % fossil energy sources by 2050 (BMWi, 2012).

India had the highest growth rates of CO_2 emissions in the last two decades. In 1990, India's CO_2 emissions from fuel combustion (582 Mt CO_2) were lower than the German level (950 Mt CO_2), but higher than the French one (352 Mt CO_2) (cf. Figure 4). Between 1990 and 2010, per capita total CO_2 emissions increased by 101 % in India. During the same period, they decreased in France (-8.9 %) and Germany (-22 %) (cf. Figure 4). In 2010, total CO_2 emissions were more than twice as high in Germany than in France while Indian CO_2 emissions were more than twice as high as in Germany.

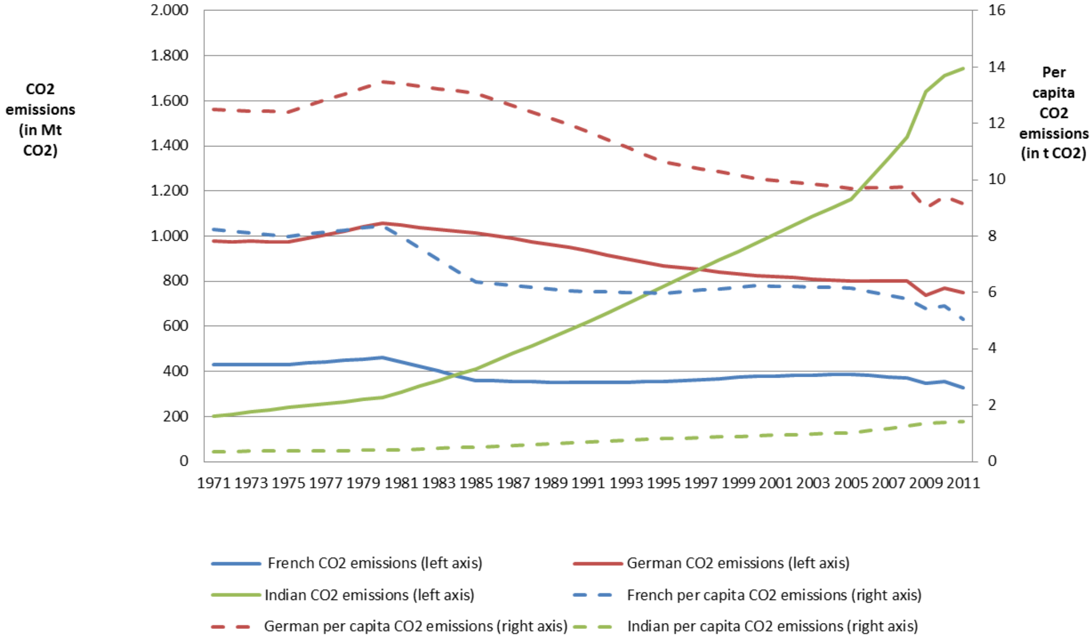

Figure 4: CO_2 emissions in France, Germany, and India

Sources: IEA, 2013

Today, due to a high share of nuclear electricity generation (76 % in 2009), France is very efficient concerning GHG emissions already (especially in CO_2 emissions per unit of GDP, cf. Figure 5). Whereas emission intensities decreased continuously in France and Germany between 1971 and 2010, they increased in India until 1995 before they started to decrease, too. In 1990, the year of the German reunification, emission intensities (i.e. CO_2 emission per unit GDP PPP) in Germany and India were at about the same level and about twice as high as emission intensity in France. Between 1990 and 2010, France decreased its emission intensity by 24 %, Germany by 39 %, and India by 22 % (IEA 2013).

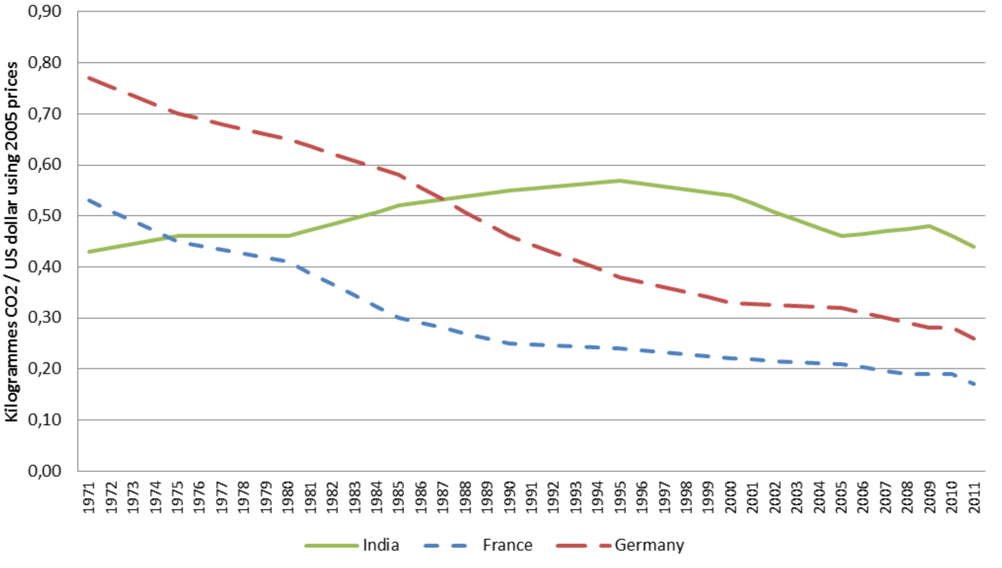

Figure 5: CO_2 emissions per unit GDP using purchasing power parities

Source: IEA, 2013

In 2008, road transport was responsible for 8.4 % of the total CO_2 emissions in India, for 16.8 % of the total CO_2 emissions in Germany, and for 30.1 % of the total CO_2 emissions in France (ITF, 2013). Between 2000 and 2008, CO_2 road transport emissions decreased by 5 % in France and by 16 % in Germany, whereas they increased by 41 % in India (cf. Figure 6). Moreover, India is six to ten years behind the emission standards for both light and heavy duty vehicles in Germany and France (Mohan et al. 2012).

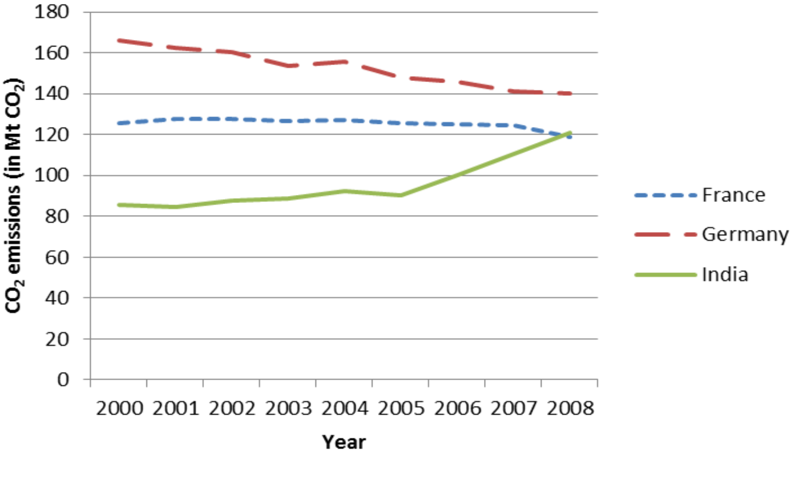

Figure 6: CO_2 emissions from road transport

Sources: International Transport Forum, 2013

As the transportation sector in Europe makes up for about one quarter of European CO_2 emissions and road transport is responsible for more than two thirds of the transportation sector's emissions (Germany: 78 %; France: 79 %; India 83 %, taken from ITF, 2013), measures to lower CO_2 emission intensities can contribute significantly to reaching European CO_2 emission targets (European Union, 2011; EC, 2011a, and 2011b). Light duty vehicles, cars, and vans are responsible for about 15 % of the total emissions in Europe (EC, 2012).

3.3 National EV Promotion Programs

Automotive industry is a mature industry with more than one hundred years of tradition. From the business perspective, the risk of investing in EV is high. From the political perspective however, it might be reasonable to invest in this technology in order to decrease the obstacles to widespread use and to accelerate the economies of scale for the battery. This might result in comparable costs of EV and ICEV, a corresponding increase in the EV share (e.g. Pfahl, 2013), and, hence, a decarbonization of road transport. Besides CO_2 emissions, local emissions and national oil demand are reduced and energy efficiency in road transport is increased. It might be argued that the EV's current situation is comparable with the situation in Germany before funding of electricity generation from renewable energy sources to support their market entry. To support accelerated commercialization of EV, governmental support does not necessarily need to be a direct financial support, but may consist in other policy instruments, such as regulatory requirements (e.g. after a certain period of time, only EV will be allowed to drive in large cities; EC, 2011b).

In Germany as well as in France, electric mobility is considered a strategy to reduce CO_2 emissions in road transport and dependency on crude oil (German Federal Government, 2009, MEEDDAT, 2012a). Therefore, the German government launched its national initiative for electric mobility in 2008 and was followed by France in 2009 (IEA, 2011a and 2011b). The Indian Ministry of Heavy Industries and Public Enterprises announced India's National Electric Mobility Mission Plan in August 2012, with the major objective to help India emerge as a leader in the BEV two-wheeler and four-wheeler market by 2020, with total BEV sales of 6-7 million units in order to achieve global BEV manufacturing leadership and to contribute to national fuel security (Indian Ministry of Heavy Industries and Public Enterprises, 2012). An overview of the different policies is given in Table 1.

The French government's declared objective is "Facteur 4", i.e. to reduce CO_2 emission by 75 % compared to the year of 1990. This idea was initially communicated in 2003 and was approved in 2007 by the Grenelle Environnement, a group of representatives of national and local governments and organizations trying to find a common position on key points of public policy and on ecological and sustainable development issues (Tuot, 2007). The Grenelle Environnement's round table on mobility and transport aims at reducing the transport sector's CO_2 emissions by 20 % until 2020. Measures to reach this goal are, amongst others, the bonus-malus system to encourage CO_2 saving technologies of new passenger cars sold as well as special measures to encourage the development of BEV (Le Grenelle Environnement, 2007).

India ratified the Kyoto protocol in 2002 in order to benefit from transfer of technology and additional investments without being required to reduce greenhouse gases ("leapfrogging") (Indian Ministry of Environment and Forest, 2002). In 2009, with the UNFCC (United Nations Framework Convention on Climate Change), India registered its voluntary endeavor to reduce the emission intensity by 20-25 % by 2020 in comparison to the 2005 level. As the battle against poverty and for social and economic development is more important to developing countries than reaching CO_2 emission reduction targets, deriving conclusions from comparing overall CO_2 emissions is inadequate. Emission intensity (i.e. CO_2 emission per unit GDP PPP) is used to compare CO_2 emissions across countries instead (cf. Figure 5).

Governments in the three countries defined different objectives concerning sales numbers of EV until 2020. Germany plans to have one million electric cars (BEV, plug-in hybrid electric vehicles (PHEV), and electric vehicles with range extenders (REEV)) on the streets by 2020 (NPE, 2011; IEA, 2011a and 2011b) and six million in 2030 (German Federal Government, 2011). 1.6-1.7 million electric cars and 4.8 million electric two-wheelers are envisaged to be sold in India by 2020 (Indian Ministry of Heavy Industries and Public Enterprises, 2012) and two million BEV, PHEV, and REEV are planned to be sold in France by 2020 (4.5 million by 2025) (IEA, 2011; Grenelle Environnement, 2010; MEEDDAT, 2010). According to Leurent and Windisch (2011), the market share of newly sold electric vehicles in France shall have reached 7 % by 2015 and 450,000 electric vehicles shall have been deployed. From today's perspective, this seems unrealistic. In order to support EV diffusion, total cost of ownership of BEV needs to be reduced and equalized with the costs of conventional cars (Dütschke et al., 2011; Pfahl et al., 2013). Each of the three countries has its own perspective on BEV market development. France pursues a rather proactive policy, as can be seen in the French program *Investissements d'avenir, véhicule du futur* with a volume of US$ 1,304 million. According to a convention signed by the French prime minister and the president of ADEME (Agence de l'environnement et de la maîtrise de l'énergie) (cf. French Republic, 2010), US$ 978 million are planned to be invested in automobile construction. Until August 2013, ADEME accepted EV pilot projects with a total volume of US$ 385 million. US$ 148 million of *véhicule du futur's* volume have already been spent (cf. Table 4 in the Appendix). The bonus-malus system for motor vehicles as part of the program *Investissements d'avenir, véhicule du future* was introduced to encourage consumers to invest in CO_2 saving technologies and to penalize consumers who buy vehicles emitting more than 140g CO_2/km with up to US$ 4,700. Up to US$ 9,130 are granted by public authorities if electric cars are purchased (MEEDDAT, 2012b). Some regions grant additional incentives between US$ 6,520 and US$ 10,430 for individuals, small businesses, and local authorities (La Région Alsace, 2012; Région Poitou Charentes, 2013). In order to guarantee competitiveness of Germany's automotive industry with at least 730,000 workers at car manufacturers and suppliers, the four federal ministries of the environment, transport, industry, and research presented their goal in a joint press statement on November 25, 2008: "Germany is to become the leading market for electric vehicles." Compared to competing countries like China, France, Japan or the United States, this is a very ambitious target. In a "National Strategy Conference on Electric Mobility", it was decided: "Electric vehicles are the future. They soon will become part of everyday life, especially in city traffic. By the year 2020, over one million rechargeable EV are to drive on German roads". To implement these goals, the 'National Development Plan for Electric Mobility of the Federal Government' was presented in August 2009. The first major project was the promotion of eight model regions with 190 projects that are supported with a budget of US$ 153 million under the auspices of the Ministry of Transport. This results in an average project funding sum of US$ 806,000. The National Platform for Electric Mobility criticized the vague and hardly focused actions. Consequently, a more specific set of measures was taken in May 2011 in another 'Government Program, Electric Mobility'. One aim is the popularization of electric mobility by demonstration effects instead of purchase incentives for EV. The federal government has approved of a budget of about US$ 240 million for "showcase" projects over a period of three years (BMVBS, 2013). No purchase subsidies have been granted on the federal level. The situation is different on the local level. E.g. lately, the community of Heidelberg has announced to incentivize the purchase of EV with US$ 1,000 (Heidelberg, 2013).

In New Delhi, India, BEV were promoted with an overall purchase price reduction by subsidies and exemptions (not recovered value added tax, registration fee, and provided subsidy) of about 25 % (Mahindra REVA Authorised Dealer Sri Durga Automobiles, 2011) until March 2012 (Economic Times, 2012). According to the National Electric Mobility Mission Plan 2020, incentives for electric two-wheelers varying between US$ 83 and US$ 250 are proposed to be granted for the first million units sold on an annual basis starting in 2012 (Indian Ministry of Heavy Industries and Public Enterprises, 2012). For three-wheelers, incentives of up to US$ 167 are supposed to be provided for 20,000 units every year between 2012 and 2017. Four-wheeled BEV shall be supported with bonuses between $1,666 and $2,500 depending on the type of BEV (cf. Indian Ministry of Heavy Industries and Public Enterprises, 2012).

Table 1: Overview of programs in Germany, France, and India

	Germany	France	India
National EV target numbers	1 million BEV/REEV/PHEV by 2020 and 6 million by 2030	2 million BEV/REV/PHEV by 2020 and 4.5 million by 2025	1.6 million EV, 4.8 million electric two-wheelers by 2020
National targets for electric vehicle supply equipment (EVSE)	150,000 public, 800,000 private, and 7,000 fast charging stations by 2020	400,000 public and four million private charging stations	Targets have not been announced so far
Subsidies	No subsidies on federal level	Bonus-malus system	Purchase incentives planned
Pilot regions	Yes, funding: US$ 153 million	Yes, funding: US$ 148 million	No pilot projects have been announced so far

According to Achtnicht et al. (2012) and Dütschke et al. (2011), not only purchase prices or total costs of ownership are crucial to user acceptance of BEV, but also the availability of fuel infrastructure. As private investors have not been able and willing to set up public electric vehicle supply equipment (EVSE) on their own (due to their poor profitability), charging infrastructure development has been included in national electric mobility strategies. In France, four million private and 400,000 public EVSE facilities are to be installed by 2020 (Grenelle Environnement, 2010). In Germany, 950,000 EVSE facilities tailored to suit the market need are planned to be installed by 2020. 800,000 of these are supposed to be set up by private investors and 150,000 are supposed to be public EVSE systems (NPE, 2012). The European Commission released a proposal for a directive of the European parliament and of the council on the deployment of alternative fuel infrastructure, defining minimum numbers of EVSE systems in each member state (cf. EC, 2013). According to this proposal, France (Germany) has to set up 970,000 (1,503,000) EVSE systems by 2020. 10 % of these EVSE facilities need to be publicly accessible. India's National Mobility Mission Plan identified the development of EVSE to be crucial. Besides installing EVSE systems during pilot projects, the Mission Plan envisages the private sector to set up EVSE facilities, as profitable business models might become viable for some regions (Indian Ministry of Heavy Industries and Public Enterprises, 2012). Publicly accessible EVSE systems reserved for BEV in residential areas of agglomerations like Mumbai or Delhi, where public parking space for cars is very limited, could be a major incentive for people to buy EV instead of conventional vehicles, especially if a reservation of these parking lots would be possible.

In order to convince the automotive industry to adjust the supply side for cars by further developing vehicle portfolios towards less polluting cars, measures like mandatory emission targets for manufacturers of cars and light duty vehicles have been introduced in Europe (EC, 2012a and 2012b). For example, the European Regulation 443/2009 considers BEV to be zero-emission vehicles which are weighted twice when calculating the manufacturer-specific CO_2 emission target of 95 gr. per km in 2020. This increases the interest of car manufacturers in selling EV considerably– at least until the point where the upper limit for zero-emission vehicles is reached.

3.4 Electric Power Systems

Considering the forecasted rising shares of fluctuating renewable energies in all three countries and nuclear power at least in India (U.S. EIA, 2011a and 2011b), electricity generation is going to be gradually decarbonized. Accordingly, the potential for CO_2 emission mitigation by increasing the market share of BEV is remarkable. Concerns of the additional load of the BEV destabilizing the power grids need to be taken seriously, but can be refuted for all three countries in the short term, as the little number of vehicles introduced until 2020 will not have any severe impact on the grids (Kumar, 2012, Pregger et al., 2012). However, especially the lower voltage grid levels are heterogeneous and an EV charging at 22 kW (or even more) will certainly increase the electricity load of private households. As we assume a heterogeneous distribution of EV, the impact on the grid might be considerably higher in streets with a higher share of EV. This will also refer to the charging and mobility behavior of users (Heinrichs, 2013). The impact on the power plant fleet portfolio seems to be marginal however, as for example the target of one million EV in 2020 for Germany will lead to an increase of the energy demand by about 1 % (Jochem et al., 2013). When the charging process could be scheduled (automatically) in time, BEV are an option to better integrate fluctuating renewable energy sources in Germany in the future (Linssen et al., 2012) or to increase the full-load hours of base-load power plants (Jochem et al., 2013), such as nuclear power plants in France.

Due to a fast growing economy and a rising standard of living, India suffers from a severe shortage of electricity generation capacity. Blackouts are a common occurrence throughout the country's main cities (U.S. EIA, 2011a). In this context, BEV could be a solution for power shortage problems for households in the future. In case of power cuts, BEV could be used to provide electricity to the households by the so-called vehicle-to-grid (v2g) approach (Kempton and Tomić, 2005; Jochem et al., 2012). Additionally, it would make sense to integrate BEV in a smart way in the Indian power grid. This would prevent challenging the local grid components when high simultaneous charging takes place in a neighborhood (Linssen et al., 2012), especially during summers when electricity consumption reaches its peak due to the continuous use of air conditioners. Power peaks can be reduced by postponing the charging process and shifting load from peak to off-peak hours (Jochem et al., 2012).

The corresponding electricity generation mixes in the three different countries differ strongly. Whereas in France, nuclear energy carriers are dominating, India is mainly coal-dominated (cf. Figure 7). Assuming an average electricity consumption of 0.2 kWh per EV, the corresponding CO_2 emissions range from 18 gr. per km (France) to 192 gr. CO_2 per km (India). Compared to current vehicles and the targets for 2020 (e.g. the 130 gr. target by the European Commission), at least the values for India are comparatively high and therefore, the CO_2 mitigation potential seems to be questionable if no other local renewable energy resources are used to recharge the vehicle.

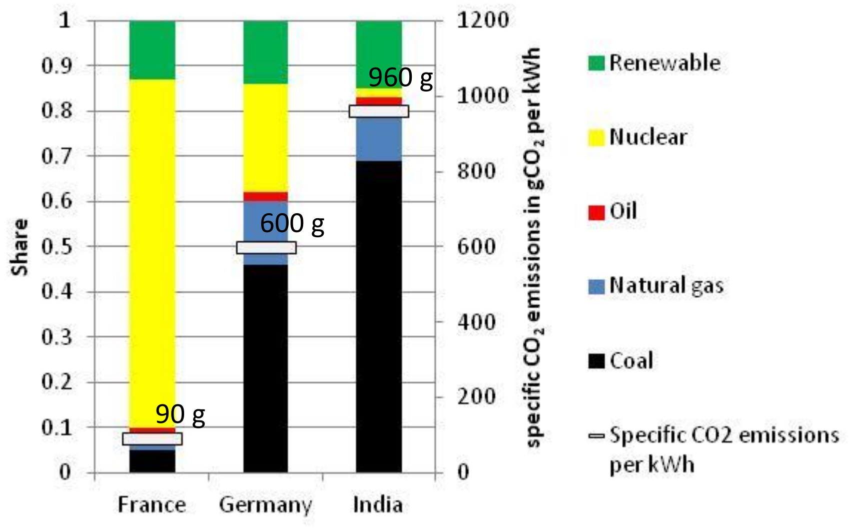

Figure 7: Energy carriers for electricity generation, resulting CO_2 emissions, and fuel prices for France, Germany, and India in 2010

Source: World Bank 2013, IEA 2012b, and EC, 2012c

Another crucial parameter is the fuel price. Obviously, all energy carriers are least expensive in India. However, the relative advantage of electricity over conventional fuels is highest in France (17.9, gasoline fuel divided by electricity price for industrial customers) and lowest in Germany (5.7, diesel fuel divided by electricity price for private households) (cf. Figure 8).

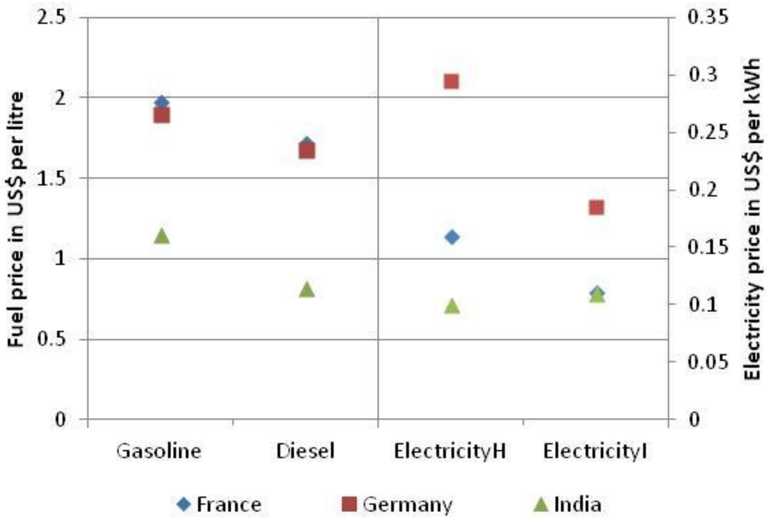

Figure 8: Fuel and electricity prices in the countries considered

World Bank 2013, IEA, 2012b, and EC, 2012c

3.5 Passenger Car Stock and Registrations

During the past seven years, India doubled its stock of passenger cars, whereas it only increased by about 10 % in France and Germany (ITF, 2006; World Bank, 2013). This is similarly true for new car registrations: Between 2005 and 2011, new car sales increased by almost 200 % in India, whereas registrations in Germany and France dropped by about 10 % until 2012 (cf. Figure 9).

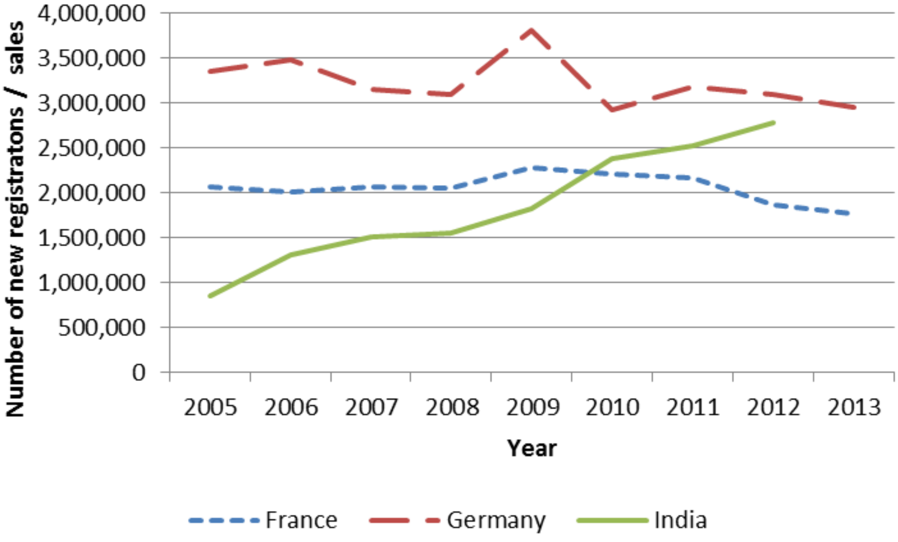

Figure 9: Development of new car sales (registrations of new vehicles) since 2005

Sources: MEEDDAT, 2014; Kraftfahrtbundesamt, 2013; Korea Automobile Manufacturing Association, 2013

At first glance, the starting points for diffusion of BEV seem to be similar for the saturated European markets of France and Germany, whereas the non-saturated Indian market appears to be completely different (cf. section 3.1). This high dynamic of sales numbers of new passenger cars seems to make the Indian market attractive. However, as the Indian income level is comparably low, two-wheeled motor vehicles play a vital role in Indian urban transport (Iyer and Badami, 2007, cf. Figure 10) and provide millions of people with affordable mobility.

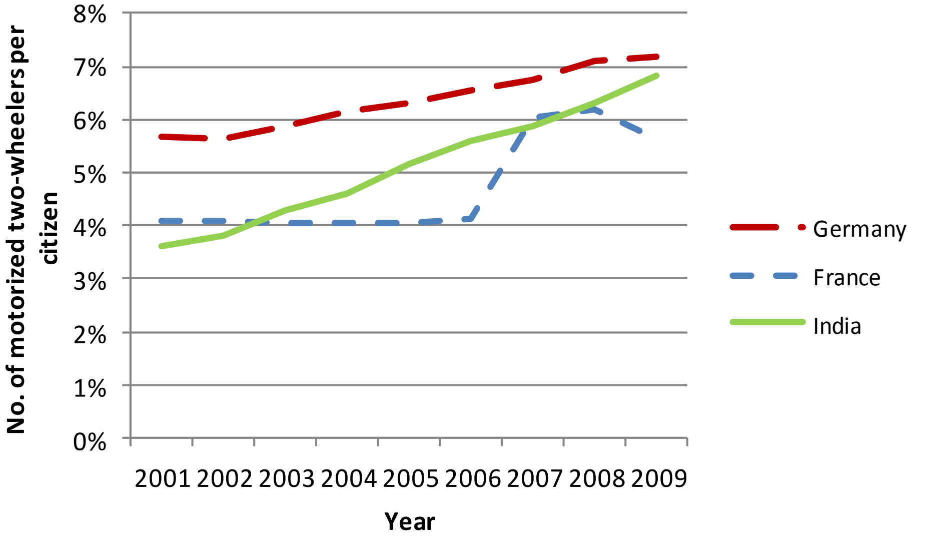

Figure 10: Number of motorized two-wheelers per citizen

Sources: INSEE, 2013; Destatis, 2013; Indian Ministry of Road and Transport, 2012

Furthermore, agglomerations like Delhi with more than 16 million citizens already have problems to cope with the individuals' mobility needs, as is demonstrated by the restrictive parking situation and higher flexibility on crowded roads (Dudenhöffer et al., 2012). The extensive usage of motorized two-wheelers is associated with the drawback of insecure traffic with a high death rate (Hinrichs, 2012). Furthermore, safety standards do not comply with European standards. It is not compulsory for a car to have airbags, anti-lock braking systems or electronic stability control. Cars sold in India are predominantly low-budget cars due to the comparably low income level of Indian households (cf. Figure 2).

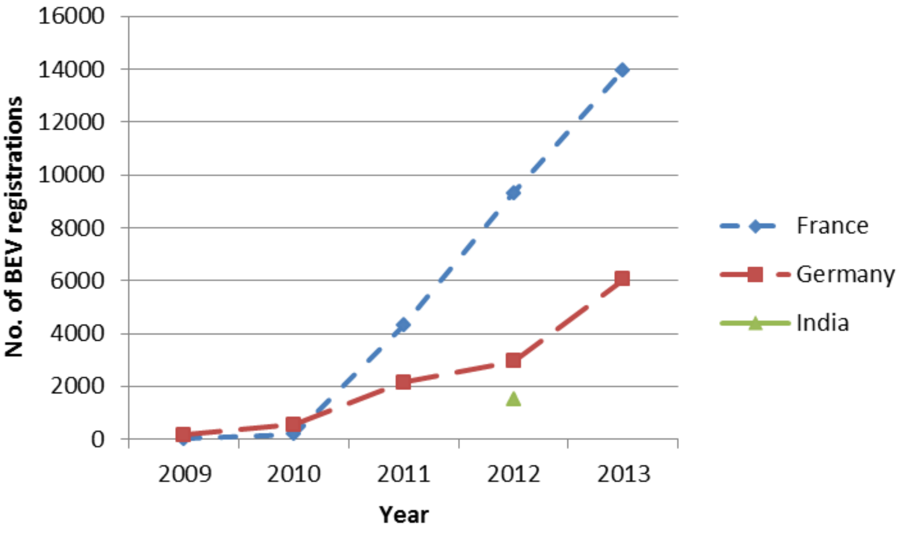

Figure 11: BEV sales without Renault Twizy and PHEV (2009-2013)

Sources: KBA, 2014; Indian Ministry of Heavy Industries and Public Enterprises, 2012; AVERE France, 2013a; AVERE France 2014

BEV sales have started to develop on a low level, but with high growth rates in all three countries. Currently, the French market is the most dynamic one, as between 2011 and 2013, 27,581 BEV were registered (AVERE France, 2013a; AVERE France, 2014; cf. Figure 11). BEV sales increased continuously during the last five years in Germany, reaching 2,154 units in 2011, 2,956 units in 2012 and 6051 in 2013 (KBA, 2014). In India, 1,500 electric cars of the Reva Electric Car Company (RECC) were sold until 2012, most of them in Bangalore City (Indian Ministry of Heavy Industries and Public Enterprises, 2012). Thus, the market share of BEV in 2013 reached only 0.2 % in Germany, 0.7 % in France, and 0.06 % in India in 2012.

4 BEV Acceptance Patterns in France, Germany, and India

4.1 Analysis Methodology

The empirical part of this analysis is based on three online surveys made in Germany (respondents n = 255), India (n = 296), and France (n = 238). The period analyzed extended from March to April 2011 in Germany, from June to September 2011 in India, and from August to November 2012 in France. The three online surveys are not representative, since snowball sampling via personal networks was used to distribute the questionnaires. Additional biasing factors are necessary, such as internet affinity as well as self-selection. For that, the mostly male, young, and highly educated samples are not surprising (cf. Table 2). 68 % (France) to 79 % (India) of the samples are male. The French participants are significantly older than the German and Indian ones. The French sample has the highest education and most children per household. In the Indian group, significantly more people are living in one household. These aspects have to be kept in mind when interpreting the results.

Table 2: Online samples in Germany, France, and India

	Germany	France	India
Age (mean value, range, in years)	32.6 (17-72)	38.2 (21-67)	31.2 (18-72)
Gender (male persons)	72 %	68 %	79 %
Without degree	0 %	0 %	2 %
Below A level	9 %	3 %	51 %
A level	35 %	17 %	42 %
University degree	56 %	79 %	6 %
Number of persons per household (mean value)	2.4	2.4	4.0
Number of children per household (mean value)	1.6	3.9	1.8

The samples are compared by means of multivariate analysis of variance (MANOVA) with SPSS software. For significance tests, two post-hoc tests were used, the Tukey HSD test and the Scheffé test. The ANOVA is considered a robust test against normality assumption. Since the number of observations is large enough within each group, the non-normal distribution of the data is considered unproblematic.

4.2 Comparison Analysis

The acceptance of a test drive with an EV is high in all three countries without significant differences (cf. Figure 12). But the countries differ concerning the actual intention of purchasing a BEV. The French sample has the highest purchase intention for a BEV as first car. The acceptance of a BEV as second car is also highest in France as well as in India (even though a second car is very seldom here). This indicates the importance of test drives to support the acceptance of EV.

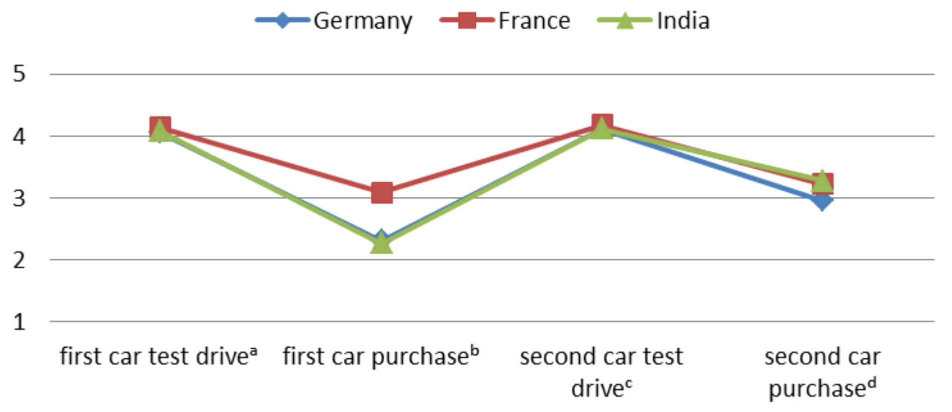

Figure 12: Intentions of usage of electric vehicles

With: 1 –' I don't agree at all' to 5 – 'I agree totally'
Significance of national differences:
a) G-I: ns, G-F: ns, I-F: ns, total: ns
*b) G-I: ***, G-F: ***, I-F: **, total: ****
c) G-I: ns, G-F: ns, I-F: ns, total: ns
*d) G-I: **, G-F: *, I-F: ns, total: ****
*With *** – significance at 1 % level, ** – significance at 5 % level*
** – significance at 10 % level, ns – not significant*

The possibility to experience the new technology personally becomes especially important when considering the knowledge and experience levels so far (cf. Figure 13). In total, the knowledge levels are medium to low. In Germany, media use and self-reported knowledge level are highest. The Indian participants have less experience with electric cars, but highest experience with electric bikes (i.e. in India mainly electric two-wheelers and in Germany mainly bicycles with electrical assistance – Pedal Electric Cycle). It is important to inform people about the general features of electric vehicles, since they are subject to several restrictions and not optimal for every driving pattern.

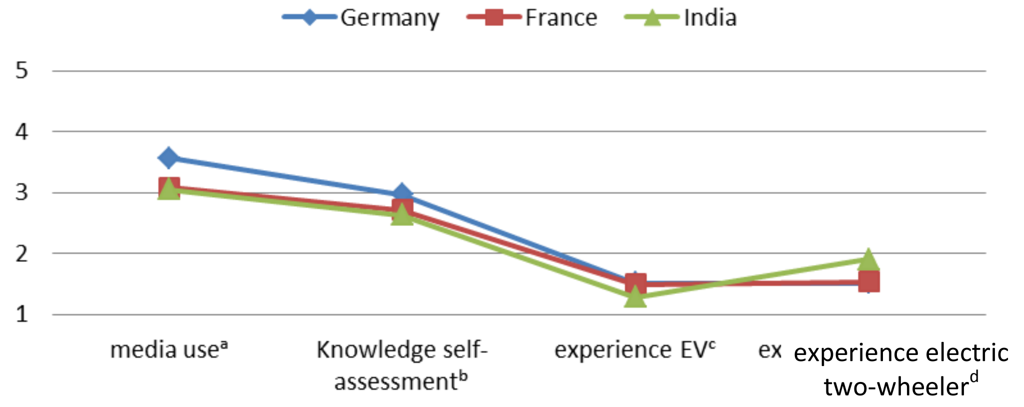

Figure 13: Experience and knowledge levels

With: 1 – 'I don't agree at all' to 5 – 'I agree totally'
Significance of national differences:
*a) G-I: ***, G-F: ***, I-F: ns, total: ****
*b) G-I: ***, G-F: **, I-F: ns, total: ****
*c) G-I: ***, G-F: **, I-F: ns, total: ***
*d) G-I: ***, G-F: ***, I-F: ns, total: ****
*With *** – significance at 1 % level, ** – significance at 5 % level*
** – significance at 10 % level, ns – not significant*

Figure 14 shows that the German interviewees have the lowest motivation to use BEV in general. The outstanding motive of the French and Germans is the prevention of local emissions. In India, the wish to contribute to environmental protection is the most important motive.

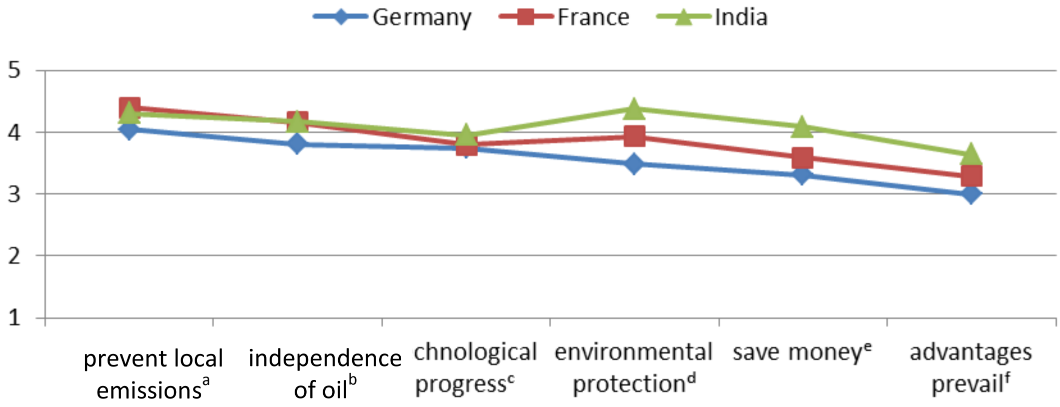

Figure 14: Motivations to use electric vehicles

With: 1 – 'I don't agree at all' to 5 – 'I agree totally'
Significance of national differences:
*a) G-I: ***, G-F: ***, I-F: ns, total: ****
*b) G-I: ***, G-F: ***, I-F: ns, total: ****
*c) G-I: *, G-F: ns, I-F: ns, total: **
*d) G-I: ***, G-F: ***, I-F: ***, total: ****
*e) G-I: ***, G-F: ***, I-F: ***, total: ****
*f) G-I: ***, G-F: ***, I-F: ***, total: ****
*With *** – significance at 1 % level, ** – significance at 5 % level*
** – significance at 10 % level, ns – not significant*

Maybe because the Germans have the highest knowledge level, they are most critical about EV. Both French and German participants think that the costs are too high (cf. Figure 15). Especially in India and also in Germany, the maximum speed of BEV is a problem: In Germany due to the lacking speed limit on some highways and in India due to the speed limit of 81 km per hour (50 mph) for the Mahindra REVAi/e2o. Other currently available vehicles have limited top speeds between 150 and 165 km per hour (about 95 mph) and, hence, suffice for usual driving patterns. The limited range is less problematic in India and France, as well as the long charging duration. This might be due to the fact that most users realize that even current charging times at household sockets (usually at a charging power of about 2 kW) suffice to satisfy the user needs due to long average parking times. Furthermore, most users know that in the medium term charging of EV could take place at a much higher charging power of up to 22 kW or even higher, which would allow to recharge the battery in less than a quarter of an hour (cf. IEC 61851).

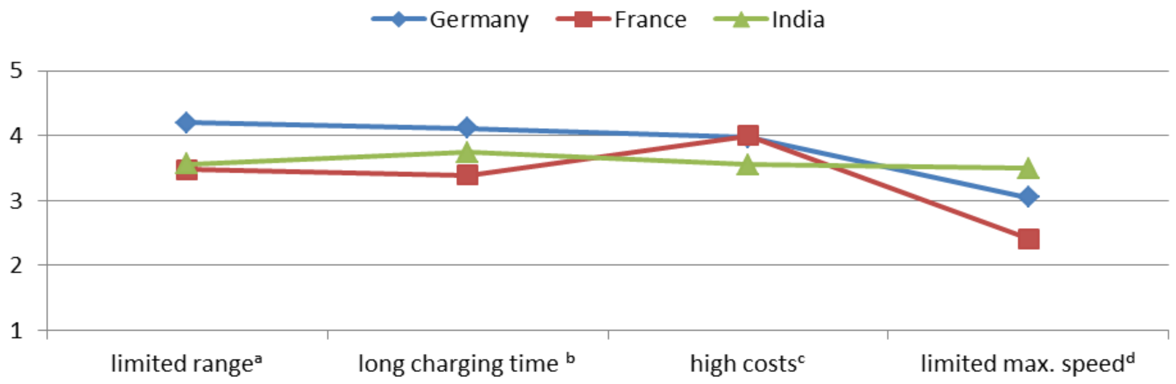

Figure 15: Obstacles to the acceptance of electric vehicles

With: 1 – 'I don't agree at all' to 5 – 'I agree totally'
Significance of national differences:
*a) G-I: ***, G-F: ***, I-F: ns, total: ****
*b) G-I: ***, G-F: ***, I-F: ***, total: ****
*c) G-I: ***, G-F: ***, I-F: ***, total: ****
*d) G-I: ***, G-F: ***, I-F: ***, total: ****
*With *** – significance at 1 % level, ** – significance at 5 % level*
** – significance at 10 % level, ns – not significant*

The French respondents are most optimistic about EV (cf. Figure 16). They expect driving a BEV to be much more fun, they have a clear conscience due to the use of green mobility, and they are most enthusiastic about BEV in general. But they are also, together with Indians, most worried about driving a BEV (mainly due to the limited range). The Indians do not trust the technology, too, which may be due to the low safety standards in India. Germans expect the lowest levels of fun and enthusiasm.

The analysis shows that the French interviewees are most open-minded towards the new technology. Their mobility patterns and acceptance structures fit both the restrictions and the advantages of BEV. In contrast to this, the German sample is more critical about the technology and shows a low motivation to use a BEV as well as a psychological resistance due to range, costs, and charging duration. The interviewed Indians have a high motivation to use a BEV, but they lack the knowledge and experience to evaluate, whether the car is appropriate for their mobility patterns or the infrastructure is available and safe.

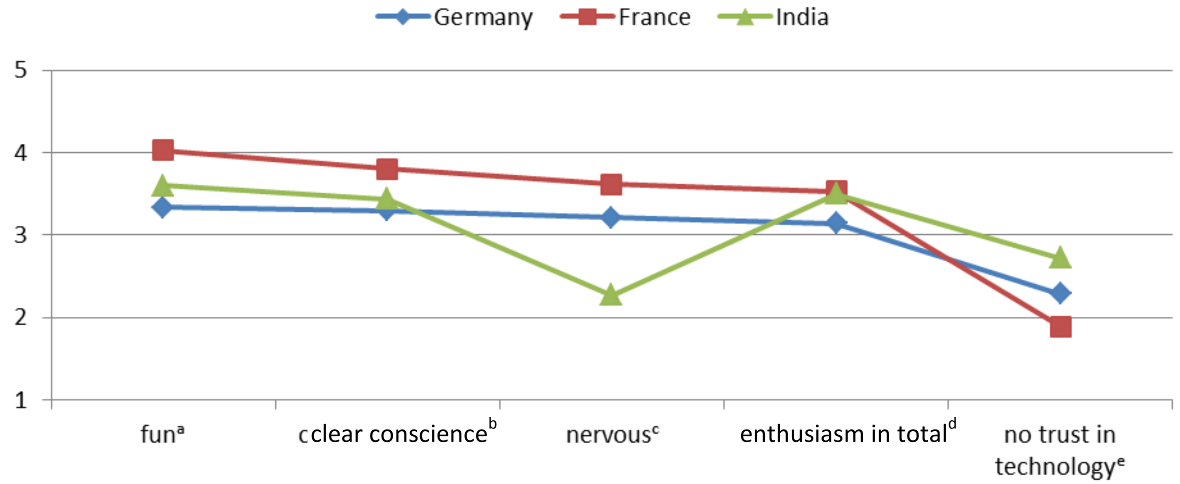

Figure 16: Levels of emotions concerning electric vehicles

With: 1 – 'I don't agree at all' to 5 – 'I agree totally'
Significance of national differences:
*a) G-I: **, G-F: ***, I-F: ***, total: ****
*b) G-I: ns, G-F: ***, I-F: ***, total: ****
*c) G-I: ***, G-F: ***, I-F: ***, total: ****
*d) G-I: ***, G-F: ***, I-F: ns, total: ****
*e) G-I: ***, G-F: ***, I-F: ***, total: ****
*With *** – significance at 1 % level, ** – significance at 5 % level*
** – significance at 10 % level, ns – not significant*

These findings are partly in line with findings of Ensslen et al. (2013a), according to which French EV users show a higher affinity to innovations, are more sensitive to CO_2 emissions, and show higher levels of satisfaction about climate protection due to low CO_2 emissions of BEV. On the other hand, Ensslen et al. (2013b) determined that French BEV users are less satisfied with the reliability of EV than German users. The differences observed between the two studies might be attributed to the respondents' different levels of experience with EV. As expectations (i.e. statements from non-users) concerning BEV technology were lower in the data sample for Germany, it is comparably easier for BEV characteristics to meet German EV users' expectations after they have experienced them.

Furthermore, these results do not completely seem to be in line with the results of Deloitte (2011). They observed that 5 % of the French respondents, 9 % of the Germans, and 59 % of the Indians might potentially be first movers of EV (at least the Indians seem to have a significant advantage). Figure 14 presents opposite results. According to the findings of the study at hand, EV usage intention is (significantly) highest in France and lowest in Germany. Our results concerning obstacles to using EV were partly confirmed by Deloitte (2011). According to both analyses, Germans are most critical about the EV characteristics of range and charging time (cf. Figure 15).The surveys did not reveal any difference between French and Indian respondents concerning range, whereas results of Deloitte (2011) show that 47 % (16 %) of the French (Indian) respondents accept a range of 160 km (about 100 miles). Concerning charging time, Deloitte (2011) shows that 51 % of the Indians would accept a four-hour charging time, whereas the values are considerably lower in developed countries (39 % of the French and 32 % of the German respondents). According to Figure 15, German respondents are most concerned about charging times, whereas the French are least concerned.

Similarly, the study conducted by TÜV Rheinland (2011c) reveals some contradictions to these findings. For example, India is found to be more suitable for further introducing EV than France due to high self-reported knowledge levels and appropriate driving behaviour. According to these findings, our survey indicates that the French respondents' level of experience with BEV is higher than the one of the Indians, whereas the Indians' level of experience with electric two-wheelers is significantly higher than the one of the German and French respondents (cf. Figure 13 and 14). We agree that average daily mileages are lower in India than in France and that therefore BEV might fit the Indian market better(according to this argument). But these findings are not supported by Indian and French respondents' evaluations of the limited range, as they do not differ significantly (cf. Figure 15).

These differences might be explained by the different times the surveys were made for this study. The lower degree of knowledge and individuals' levels of experience concerning test drives expressed by the German and Indian respondents in 2011 compared with the level of experience of French respondents in 2012 might cause this difference. Furthermore, none of the surveys are representative for the whole population and differences of the BEV models on the markets might additionally influence the respondents' evaluations.

5 Potentials for Electric Mobility in France, Germany, and India

This chapter presents an estimation of the market potentials for EV in the three countries France, Germany, and India, based on the analysis of framework conditions and BEV acceptance from above. Furthermore, we integrate the supply side and the sales number of EV in these three markets (cf. Table 3). The aim is to recommend the market which is better suited for electric mobility and to determine the period of time in which a diffusion of BEV is realistic.

Table 3: Potentials for electric mobility in France, Germany, and India

	France	Germany	India
Supply side	Developed: Several local OEM with at least one model on the market, all imports available	Medium: First local OEM with one model on the market, several other local OEM plan to launch their BEV in the next months, all imports available	Minor: One local supplier with three models, not all imports available
Demand side	9,314 BEV sold in 2012	2,610 BEV sold in 2012	1,500 BEV sold until 2012
Time frame for broad diffusion	Short term	Medium term	Long term
Product recommendation	BEV	First: REEV/PHEV, later: BEV	Low-cost BEV

Besides private users, BEV might be applied more easily in fleets and for commercial purposes. Especially in Germany, today's BEV are predominantly held by commercial customers. Only 22 % of the BEV were registered by private persons in 2012. In 2011, the share of private registrations was at a level of only 5 %, so the share of privately held BEV is growing. Considering that the share of all private new car registrations in Germany was at a level of about 40 % (cf. KBA, 2013) during the last years, the commercial sector is still overrepresented. This might be associated with the positive ecological image BEV can give to companies (cf. CAR, 2010a). According to BEV users of the CROME fleet test with more than 100 BEV in the French-German border region, the image factor of BEV of being environmentally friendly is more important to companies in the German part of the model region than in the French area, although the French respondents are more satisfied with BEV's characteristic of protecting the climate due to low CO_2 emissions (cf. Ensslen et al., 2013a).

According to interviews of 18 German fleet managers (cf. CAR, 2010a), there would be a market potential between one and two BEV to be used as pool cars in different average company fleets. Several different fleet tests with BEV have already taken place (cf. CAR, 2011 and Ensslen et al., 2013b). According to CAR (2010, 2011), fleet managers' car purchase decision is strongly influence by the total cost of ownership (TCO). 88 % of fleet managers had a better opinion about BEV after having experienced them in their company fleets (Carrol und Walsh, 2010). Ensslen et al. (2013b) point out that BEV in commercial fleets have the advantage of being used by several persons in a company, which increases the annual mileage of BEV and therefore improves their TCO. Furthermore, the BEV's limited range is of hardly any importance to the users, as they can use other pool cars for longer-distance trips.

As regards the supply side, the French government supported the French automotive industry in increasing their investments in BEV technology development (e.g. *Renault-Nissan* invested US$ 4 billion in BEV technology in 2010 (AFP, 2010)). This strategy might pay off when market shares of national manufacturers increase considerably at an early stage and economies of scale help to become the market leader for EV. French manufacturers have already taken over the lead on the French market (AVERE France, 2013a) and *Renault-Nissan* has already sold 100,000 BEV on the global scale (AVERE France, 2013b). Therefore, we assume that BEV acceptance patterns, consumers' favorable attitudes towards BEV, available BEV supply of different models from domestic brands, proactive regulatory measures by the government, and favorable framework conditions permit an accelerated short-term BEV diffusion process in France.

The German manufacturer *Daimler* was the first to produce a BEV for testing purposes: The *Smart Fortwo electric drive* has been tested in small series since 2009 and is available in its serial third generation since 2012. The OEM also developed the *Mercedes A-Class E-Cell* test fleet in 2011 and the *Mercedes Vito* in 2012. All other manufacturers are following and will launch several models in the following years. E.g. *Volkswagen* has been testing its *VW Golf electric* since 2011 and plans to launch the *VW E-Up* in 2013. In November 2013, *BMW i* will commercialize its *i3*. For 2014, the *Audi A3 PHEV* and *A1 e-tron* is planned. Since several importers' BEV are available in Germany, most of the 2,610 BEV sold in 2012 are of foreign brands. Due to psychological restrictions and the Germans' mobility patterns, the authors recommend entering and preparing the market with range-extended models, just like *Opel* has done with its *Ampera REEV*. The sales of the *Toyota Prius* PHEV (1,168 in 2012) show the high acceptance of range-extended electric and affordable cars. The diffusion of BEV is realistic in the second step only.

Currently, the *REVA e2o* is the only BEV available in India. The vehicle supersedes the *REVA NXR* and the *REVAi* which was the first BEV in India launched in 2011. In the first six months, *Mahindra* sold 4,000 *REVAi* worldwide (Sharma, 2011). The newly launched model *e2o* costs between US$ 13,000 and US$ 15,500 depending on the city. In Delhi, the government has granted a total of 29 % subsidy on BEV. *Mahindra* plans to sell about 400 to 500 units a month (Indian Express, 2013). Due to infrastructure problems, a broad diffusion of BEV will be achieved in the long term only. An affordable price of the vehicle is important for developing a mass market in India.

6 Conclusion and Implications

This paper focused on comparing market potentials for BEV in the three countries of Germany, France, and India by analyzing framework conditions and individuals' BEV acceptance patterns, which are supposed to influence the diffusion of the new technology.

The comparative analysis shows that total CO_2 emissions and emissions in road transport have been rising rapidly in India, whereas they stabilized in France and were even reduced in Germany. BEV can significantly contribute to further reducing country-specific CO_2 emissions from road transport: This is definitely true for France due to comparably low CO_2 emissions during electricity generation and potentially true for Germany if diffusion of BEV is accompanied by a further increasing in the share of renewable energies. India, on the other hand, might not be able to decrease greenhouse gas emissions in road transport in the short term. This is due to the lower market potential of BEV and the comparably high CO_2 share of electricity generation. This hypothesis is supported by the findings that currently, Indian consumers are less aware of CO_2 emissions, at least compared to the French and German consumers, and that their focus lies on the purchase price of the vehicle. For this reason, automotive manufacturers in India should be forced to display the CO_2 emissions per km for vehicles during the selling process, as is the case in European countries (according directive 1999/94/EC) in order to make the Indian customers more sensitive to CO_2.

If governments want to reach their self-set EV diffusion targets, strategies need to be developed for the commercialization of BEV. Comparisons of BEV diffusion rates in France and Germany allow the conclusion to be drawn that government incentives like bonus-malus systems support first-stage BEV diffusion, considering that BEV currently have major disadvantages compared to ICEV (i.e. high battery prices, long charging times, limited range). Furthermore, measures should be taken to compensate for BEV-specific disadvantages in order to emphasize the advantages of BEV: Lower variable costs and potentials of CO_2 emission reductions in particular. The comparatively high initial investment for BEV can only be compensated by their lower variable costs in case of high annual mileage. In cities, vehicle-specific annual mileage can be increased e.g. by using BEV for car sharing or in taxi fleets. Development of car sharing concepts with EV could be extended to cover motorized two-wheelers and rickshaws in Indian cities, too. Usage instead of possession would enable all social classes to use BEV. Additionally, the difficult parking situation for BEV in larger cities can be resolved, as parking space would be organized by the companies offering the sharing services. Low-threshold opportunities to test BEV would be provided by these sharing concepts. Particularly in India, this would increase the knowledge about BEV (when taking into account this paper's results that people in India are enthusiastic about new technologies), which increases the user acceptance. E-car sharing concepts would also support building of confidence in the technology, seeing that in France, where the biggest amount of BEV is on the market and visible to the highest degree, the level of trust in the new technology is the highest. In India, on the other hand, people do not trust the new technology yet.

Diffusion of BEV in France is more dynamic than diffusion of BEV in Germany and India. On the other hand, diffusion of PHEV and REEV is currently more dynamic in Germany than in France and India. In our opinion, diffusion dynamics of BEV is strongly linked to advantageous price-performance ratios, the BEV purchase bonus (US$ 9,130 per car), and the advantageous cost structure for electricity in France. According to Egbue and Long (2012), incentives to support market penetration of BEV are questionable if potential users are not convinced of their environmental benefits. Since the electricity mix in France is less CO_2-emitting than in Germany, individuals tend to think that BEV are environmentally friendly, which additionally supports diffusion dynamics in France. The comparably low knowledge level about BEV in India might explain their opinion concerning the environmental friendliness of BEV, which reaches the highest level of all countries. The German respondents are most critical about BEV. For them, BEV-specific barriers like long charging times and limited range are more important than for the French and the Indian respondents, whereas limited maximum speed is most crucial to Indian respondents. This result might be linked with the limited maximum speed of 81 km per hour (about 50 mph) of the model *Mahindra REVA*. In order to increase the knowledge level, we strongly recommend extending low-threshold possibilities to test BEV. Particularly Indian policy makers are encouraged to support fleet testing in urban areas, provided that EVSE components fulfill basic safety requirements so that physical integrity of individuals is ensured. The authors suggest integrating BEV in car sharing fleets in order to give all individuals, particularly in urban areas, the possibility to experience BEV.

Further research is needed to assess the impacts of different incentives on first-stage market diffusion dynamics of BEV. This should include private users as well as BEV in fleets and commercial use, where their application seems to be more convenient. A better understanding of user acceptance will allow for the development of effective and efficient policy instruments to achieve the policy targets in the countries analyzed by 2020.

7 Appendix

Table 4: Accepted EV pilot projects in France

Project names	**Funding by *INVESTISSEMENTS D'AVENIR PROGRAMME VÉHICULE DU FUTUR* (in million USD)**	**Funding total (in million USD)**
CROME	3.34	8.37
EGUISE	2.77	6.11
EVER	1.96	4.85
INFINI DRIVE	4.43	11.86
MOV'EO TREVE	5.03	12.77
TELEWATT	2.14	4.60
VERT	1.12	4.78
HYBRELEC	10.81	29.59
MODULO	6.63	13.46
TIGRE	N.A.	19.56
VELCRI	N.A.	N.A.
VELV	8.35	29.74
DHRT2	5.74	N.A.
ELLISUP	12.70	28.88
FOREWHEEL	9.13	28.43
HYDOLE	11.78	29.12
MELODYS	4.17	9.00
MHYGALE	4.30	11.22
QUAT'ODE	0.20	0.31
VEGA/THOP	7.56	18.39
VELECTA	2.27	N.A.
VELROUE	7.29	14.67
WATT	3.78	9.00
AMARE	2.74	6.13
LIM	1.96	3.91
S'PLR	0.58	0.93
SAVE	6.52	30.00
TILTER	1.84	5.42
VME	3.07	5.29
ZEN E-DRIVE	4.63	12.76
E-PARTAGE	4.89	11.92
AU-DACE	6.25	14.25
Funding total	147.98	385.32

Source: ADEME, 2013

Acknowledgements

This research was supported by the Karlsruhe House of Young Scientists (KHYS) providing a guest researcher grant for intercultural exchange of the French, Indian, and German authors.

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Working Paper Series in Production and Energy

recent issues

Impressum

Karlsruher Institut für Technologie

Institut für Industriebetriebslehre und Industrielle Produktion (IIP)
Deutsch-Französisches Institut für Umweltforschung (DFIU)

Hertzstr. 16
D-76187 Karlsruhe

KIT – Universität des Landes Baden-Württemberg und
nationales Forschungszentrum in der Helmholtz-Gemeinschaft

Working Paper Series in Production and Energy
No. 5, October 2014

ISSN 2196-7296