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## Editorial of the 2015 special issue about Electromobility

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## **Editorial**

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## **1 Introduction**

Electric vehicles (EVs) are not a 21st century innovation. They first surfaced during the early days of the automotive industry, and continued evolving until the rise of Fordism. During that period, EVs dominated the market but, within a matter of years, they disappeared in favour of internal combustion vehicles (ICV). Throughout the 20th century, researchers, engineers, experts and consultants encouraged manufacturers to launch new EVs, but each attempt led to failure.

Today, EVs (full electric, hybrids, plug-in hybrids, as well as hydrogen fuel cell vehicles) are resurfacing through a wide range of projects and in a number of different ways. First, EVs are no longer considered to be experimental concept cars, but rather are incorporated into the production plans of mainstream manufacturers (e.g., Zoé by Renault, Leaf by Nissan, Prius by Toyota, DS by PSA, BMW i by BMW). Second, new entrants to the marketplace like Tesla Motors or BYD are bypassing the barriers that traditionally controlled entry into the automotive industry and are instead positioning themselves within the elite circle of car manufacturers (Donada, 2013). Third, the EVs resurgence does not focus solely on the vehicles themselves but also on a set of associated services such as car-sharing, battery rental, charging infrastructures, and vehicle-to-grid (V2G) systems. Operating these services are many non-automotive companies such as energy and service providers, battery producers, telecoms, and internet companies; all of which are motivated stakeholders in the new 'electromobility' industry.

Electromobility has much more to offer than simply EVs sold to individuals or fleets. It also refers to the use of electric powertrain technologies, in-vehicle information, vehicle-to-vehicle communication systems and dedicated infrastructures that enable the use of personal or collective EVs. Therefore, the electromobility industry in fact corresponds to the ecosystem of stakeholders contributing to electromobility products and services.

Numerous researchers in the fields of management and economics, in engineering sciences, or in political and social sciences, have analysed the development of electromobility in terms of its 'raison d'être' and principle consequences. Their studies have been disseminated through books (Ehsani et al., 2009; Calabrese, 2012) and in academic papers published in general or specialised reviews (Aggeri et al., 2009; Sioshansi and Denholm, 2009; San Roman et al., 2011). The authors generally consider electromobility to be a solution to various mobility issues due to its compliance with fuel efficiency and emission requirements, as well as market demands for lower mobility costs and constraints. Additionally, electromobility can be considered a contributing factor in protecting collective public goods like local public health (via reduced urban air and noise pollution), stabilising the effects of global warming by reducing sulphur dioxide (SO<sub>2</sub>), nitrogen dioxide (NO<sub>x</sub>) and carbon dioxide (CO<sub>2</sub>) emissions, and increasing energy security by creating conditions for energy independence that also serve to reduce the impact of oil price fluctuations.

## **2 Electromobility generates challenging issues**

The emergence of electromobility generates challenging issues for the markets, the industrial processes and the business models of the traditional automotive industry. Among these issues are:

- 1 the innovation and service transition consequences
- 2 the grid integration and service aggregator actions
- 3 that public policy support is critical for the emergence and sustainability of this new industry.

### *2.1 Innovations and service transition issues*

Electromobility requires many innovations. Some of the key such innovations are: product innovations (EVs and self-driving cars), service innovations (car-sharing and connected cars), raw material and composite innovations (use of rare earth or chemical composites for batteries and bodies), business innovations (battery rental or after-sale activities), and marketing innovations (online sales). Most of these innovations result from incremental technological evolution. For example, building functional EVs requires major modular changes in terms of batteries and the design of new electrical devices, including new heating and cooling devices. It also requires the development of modules for in-vehicle information and vehicle-to-vehicle communication. However, as important as they are, the innovations behind these technological challenges are not sources of creative destruction in the sense suggested by Schumpeter (1942). The 'servitisation' of the automotive industry is, on the other hand, a more radical and disruptive concern

(Kessler and Stephan, 2013). Servitisation here refers to the innovative development of an organisation's capabilities and processes to better create mutual value through a shift from selling a unique product to selling product-service systems (PSS) that deliver value in use (Baines et al., 2009). This innovation paves the way for new forms of mobility and is perfectly in line with contemporary social standards, environmental concerns, and appetite for new forms of community sharing of goods and services. Nevertheless, servitisation is disruptive when it comes to the structure of the current automotive value chain and the overall industry dynamic. Indeed, servitisation requires car manufacturers to collaborate with new complementors such as electricity grid operators, IT solutions suppliers and mobility service providers. This presents quite a challenge for the industry because the organisational design of complementor relationships management is inherently different from that which prevailed in the traditional automotive industry value chain characterised by hierarchical power relations (Brandenburger and Nalebuff, 1997). It calls for new governance structures and contractual relations within business ecosystems driven by cooperative behaviours (Donada and Fournier, 2014). For example, EV batteries are potential sources of energy if the grid integration is effectively and efficiently managed by grid and fleet managers (i.e., if both actors cooperate for a secure and economically efficient management scheme). If the necessary cooperation does not materialise it will lead to deadlock with, on the one hand, a possible increase in electrical charging costs and a higher total cost of ownership (TCO) for EV owners and, on the other hand, a risk of local or regional electrical disruptions for the grid manager if all EVs are connected to the electrical network at the same time.

## *2.2 Grid integration vehicles and service aggregator issues*

The above discussion connects with the second group of disruptive issues, those concerning grid integration and service aggregator actions. For full battery and plug-in hybrid EVs, the energy stored in the batteries comes (totally or partially) from the electric grid. The grid-to-vehicle (G2V) systems require specific charging devices and infrastructures, the development of which is the key for the sustainable growth of electromobility but is not radically innovative. In contrast, having systems that allow for the grid to be charged from the vehicles (V2G) is quite challenging for economic, organisational, and psychological reasons. The idea of grid integration is simple to understand and attractive: one grid integrated vehicle alone cannot contribute much to the grid but a fleet of vehicles plugged in at the same time constitutes a source of energy that can be exploited during times of high demand. Hence, EVs could be positive contributors to energy policies, load levelling or frequency regulation (Kempton and Letendre, 1997). This role could even become strategic as intermittent renewable energy sources, such as solar and wind, are added to the grid (Weiller and Sioshansi, 2014).

There are several possible grid integration vehicle scenarios according to the characteristics of the particular fleet (size, ownership, and organisation) and the grid services provided (Kempton and Tomić, 2005). These services are as varied as ensuring building energy security, providing transmission system operator (TSO) services (reserves and frequency management), providing distribution system operator (DSO) services (local congestion and voltage control provision), and some kind of smart-charging that requires aggregation and communication between different economic agents.

- The home-to-vehicle and vehicle-to-home scenarios deal with an EV that is privately owned and plugged-in at home, and so has no market intermediary.
- The building-to-vehicle and vehicle-to-building scenarios deal with EVs either owned by a company or belonging to a group of people living or working in the same building. The fleet size is rather small (from a few vehicles in a private parking garage to a thousand of them in a company fleet).
- The G2V and V2G scenarios deal with thousands to hundreds of thousands of privately owned EVs.

The second and third configurations require the involvement of a new complementor: the EV aggregator. The notion of an aggregator is commonly addressed and employed in market and firm theories (Spulberg, 1999). Aggregators reduce transaction costs by fulfilling four main economic roles:

- 1 they aggregate products and services to facilitate the functioning of the market
- 2 they manage information to provide the market with data regarding products, prices and quantities when needed by market users
- 3 they help match buyers and sellers in the market
- 4 they guarantee the liability for all transactions.

Moreover, as they have a vested interest in maintaining a good reputation, they avert opportunistic behaviours and guarantee that an agent's promises and transfer of property rights will be fulfilled.

EV aggregators can gather a fleet of EVs into a single entity to provide electrical power to the grid (in most electricity markets a minimum size in megawatts is required in order to be eligible). They can help fleet managers to optimise their revenues and to facilitate the complicated and time consuming administrative processes that are compulsory to be eligible for participation in the grid (Codani et al., 2014). Due to their central position and their capability to deal with large quantities of data concerning vehicles, usages and driver behaviours, EV aggregators can provide valuable information to many electromobility stakeholders. Considering the market potential, aggregator organisations look on the electromobility industry as offering an opportunity to enlarge their businesses. Their entrance into the market is still quite disruptive for the incumbents of the traditional automotive industry who are not used to dealing with market intermediaries, except for their dealerships.

### *2.3 Public policy issues*

Kempton et al. (2014) have tried to define a 'smart public policy' regarding electromobility. Their results show that a perfect public policy has yet to be worked out. Welfare economics suggest that an environmental tax, reflecting the value of any marginal damage caused by pollution, provides incentives to achieve optimal levels of technological substitution and the development of clean power transport equipment. However, adopting such a tax is difficult for three main reasons. First, no firm consensus has yet been reached regarding the marginal damage of pollution or the health costs of car pollution, while the economic impacts of various greenhouse gas emissions are diffuse and site specific. The difficulty lies in the fact that the amount of the proposed tax

would have to be based on a judgement call regarding a range of damage estimates with no clear economic evaluation or methodology (Owen, 2004). Second, a high level of tax is likely to be problematic in terms of public, political and social acceptance during times of budget constraint and economic crisis. Third, as with any new technology, EV technologies meet numerous classical entry barriers and eco-taxation may not be sufficient to overcome these barriers.

Part of the solution to the above involves a public action whereby the TCO of an EV is less than its thermal equivalent. While that logical goal is easy to define, the cost evaluation and the national differences in all the components of the TCO render a single policy inefficient. Another part of the solution is related to a joint action toward the direct subsidy of the vehicle at buying time and actions toward the later running costs of the car including repairmen and its residual value (Leurent and Windisch, 2011). A more innovative means by which to reduce the TCO of an EV would be to use the grid integration systems in order to provide additional revenues and to compensate for the limited willingness to pay for actual EV services (Hidrue et al., 2011). In Table 1, we have compared the actual information that consumers may use to choose between ICVs and EVs.

**Table 1** Comparison of the relative performance of EVs and ICVs

	<i>EVs</i>	<i>ICVs</i>
Price per new vehicle	Minimum 23,000€	Minimum 7,500€
Driving range	150 km	400 km–600 km
Time to refuel	From 30 min to 6 hours	6 min
Lifetime	Unknown for the battery pack	Years
CO <sub>2</sub> emissions	0 emission while running; some according to the energy mix while charging	From 90 g to 250 g/km
Noise pollution inside and outside the vehicle	Very low	Function of the technology
Energy cost for 100 km	1€ to 3€/100 km	4–15 litres/100 km * price per litre
Ancillary services provided to the electric grids	Positive contribution if managed efficiently	None

*Source:* Kempton et al. (2014)

### 3 A special issue on electromobility

All of the challenges and issues presented above have been analysed by researchers from different and complementary fields: economics, management, engineering, political sciences, sociology, etc. Some of them presented their studies at The International Conference of the Armand Peugeot Research Chair on Electromobility, held in December 2013 in Paris. This conference provided an opportunity for a great deal of discussion among academics. With this special issue, we wish to share the results of some discussions with the rest of the research community involved in electromobility.

Carole Donada and Danielle Attias' opening paper asked the seminal question: 'Food for thought: which organisation and ecosystem governance to boost radical innovation in the electromobility 2.0 industry?' The aim of their paper was to explore how, at the beginning of the 21st century, the traditional automotive industry is entering a phase of disruptive changes (the disruption of markets and consumers, as well as the disruption of technologies and of business models) leading towards the development of the new electromobility 2.0 industry. The authors shed light on the multiple issues that have to be taken into account, and in particular whether the variety of stakeholders involved have the ability to create the necessary radical innovations. Following a systems approach, the paper explored how appropriate decentralised and open industrial ecosystems organisational structures can create the conditions necessary to foster the emergence of radical innovations for the electromobility 2.0 industry. It also highlighted the importance of having adequate inter-organisational governance modes to facilitate interaction between the numerous complementary stakeholders involved in the process.

Claire Weiller, Tianjiao Shang, Andy Neely and Yongjiang Shi's paper concerned 'Competing and co-existing business models for EV: lessons from international case studies'. It also dealt with the innovation issue and presented four innovative business models that are being developed in China, the USA, and France to support the commercialisation of EVs. Using an original business model framework and interviews with electromobility company founders and directors, the authors analysed the coexistence of competing business models and partnership strategies along the electromobility value chain. Their findings emphasised the importance of designing flexible business models, leveraging appropriate resources and establishing inter-industry partnerships to develop sustainable electromobility ecosystems.

The third paper was presented by Amandine Chevalier and Frédéric Lantz, who explored the modal choice of French households for their daily trips in order to predict the potential shifts from personal car to shared car. The main contribution of this research is methodological. The authors used a multinomial logit model to estimate and reveal the particular importance of car equipment on modal choices. They also used a conditional logit model to estimate and identify the lack of importance placed on costs in the modal choices. Their simulations showed that the personal car should remain the main mode of transportation up to 2020, except in households that have no car. In that case, public transport would become the main transport mode and the shift to shared car usage would be great.

The fourth paper was given by Gustavo A. Marrero, Yannick Perez, Marc Petit and Francisco Javier Ramos-Real. They considered the grid integration and the TCO issues. Their 'electric vehicle fleet contributions for isolated systems' paper aimed to measure the economic gains that EV fleets can provide to isolated electrical systems, taking as a case study the Canary Island model. The authors assumed that EVs can provide benefits to the power system by reducing both the need for backup thermal generation and the amount of spilled renewable energy (mainly wind). Moreover, EVs can introduce more electrical demand flexibility, which in turn reduces the intermittency costs that renewable technologies impose on electrical systems. Comparing scenarios and assuming the introduction of a maximum of 122,000 cars into the Canarias market by 2025, they found a reduction of almost 11% in average generating cost (about 80 million euros/year), 9% in risk (measured as the standard deviation) and almost 13% in emissions of CO<sub>2</sub>.

The closing paper by Petter Haugneland and Hans Håvard Kvisle concerned 'Norwegian electric car user experiences'. It explored a fascinating Norwegian

experiment involving real private EVs users' feedback about their cars. The authors claimed that lessons drawn from the experiences of members of the Norwegian Electric Vehicle Association can offer valuable input to decision-makers. The authors presented and analysed the results from the 2012 and 2013 Norwegian electric car user survey. They showed that the typical Norwegian EV user is a middle-aged family man with above average education and income, and that he owns a Nissan LEAF as one of two cars. He drives his electric car on a daily basis instead of a traditional petrol or diesel car. The EV saves him money and time thanks to incentives such as low fuel cost, free use of toll roads and access to bus lanes. The findings also highlighted that longer range and predictable EV policies are the two most important requirements necessary to encourage more people to buy EVs.

Of course, many key issues concerning electromobility are not addressed in this paper and a lot of additional work is expected in future papers, workshops and conferences. Our aim was to pave the way for diverse and timely scientific investigations to improve our understanding of the challenges involved in electromobility, and we intend to keep doing this in the future.

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