institut français des relations internationales

Actuelles
October 2010

Electric Cars Charging Standards: Does it matter?

Analyst Contact

Maïté de BONCOURT
0032 2 238 51 11
deboncourt@ifri.org

Key Words

Electric Cars
Infrastructure
Charging
Standards
Non tariff barriers
Internal Market

Main Points

There is currently no standard for infrastructure charging in Europe.

Standards are being developed in Japan, China and the US.

Standards are key for

At the *Paris Motor Show* every car manufacturer presented its own electric car version: full electric or plug-in, urban or familial, private or utilitarian. One could have a look at these cars, but not open their "reservoir" as most of the vehicles plugs were actually sealed. Surprising as consumers may want to know where and how to charge EVs before buying any. This is due to the fact that in Europe, vehicles plugs, socket sand charging stations are still not standardized. As Electric vehicles are already being produced and will soon be on the market, why has Europe still not define its own infrastructure standards? Does it matter? Should Europe not hurry?

The electric vehicle charging puzzle: different plugs for different charging modes and different charging types

In a rather frightening tone for consumers and for the future of the French electric car sector in general, a polemic article recently written in the French Journal *Les Echos*[1], criticized the two biggest French manufacturers Renault and PSA for their lack of cooperation.

A shame, when the French government is heavily subsidizing the sector to create French leadership; A risk when one knows that Europe would gain competitive edge by agreeing at home in developing its own market; an aberration for French consumers who would have to carry around multiple adapters.

Renault, in particular, is said in this article to develop specific and incompatible charging modes and plugs, while other manufacturers have agreed on a common system; and in addition forcing EV drivers to change

consumers and emerging markets. Charging infrastructures are crucial for the market penetration of electric vehicles.

The lack of standardisation also concerns EVs' communication systems with the grid, allowing the smart charge of vehicles and therefore decreased CO2 emissions.

Related Research

CO2 & Transport
European Energy Policy

their home electricity system to increase the load capacity. Well, actually the debate is not as simple as it is presented and the article is not always accurate. There is indeed no good and bad boy here, just different business and marketing strategies.

The following section reviews technicalities of vehicle charging, and tries to clarify the dividing lines between manufacturers. The charging equipment required by an electric car includes the outlet socket, the vehicle plug, the cable and the power converter. All these elements may take different shapes around the world, across EU member states and among car manufacturers. The type of current and mode of charging can also vary from one vehicle to the other. For public stations, these would need to be harmonised. The following section will review the electric vehicle charging systems.

Slow, semi fast and fast charging

Different charging systems exist for the electric vehicle. Slow charging, can be done at home, at a parking plug or at work by plugging the car into the local electricity grid. It can take more than 8 hours depending on the battery size and the capacity of your home network. In this case the more powerful the home electricity network, the faster the battery will be charged. Domestic electricity capacity usually starts at 3KW and goes up to 12kW.
Semi fast and fast charging implies a higher voltage provided either by a tri-phased alternative current or direct current.
Finally, fast charging, relies on very strong electric power (from 30 to more than 60KW depending on the country). Under this mode, the battery is usually charged up to 80% in half an hour or less. To date, the most rapid charging system has been invented by the Tokyo Electric Power Company, whose station can recharge a small electric car up to 50% in less than 3 minutes. This type of fast charging will definitively play a role in the competition between pure battery electric vehicles models and plug-in-hybrids.

The latter currently benefit from a longer driving range thanks to the addition of a small motor to its battery. Yet fast charging is not yet an optimal solution. It indeed requires a special and expensive station for safety reasons. It also puts much more pressure on the electricity grid and is not optimal in terms of CO2.

Last but not least, a battery swap infrastructure, invented by a Californian company Better Place, permits a "charge" in about 3 minutes just by switching a depleted for a fully charged battery. In the latter case, not only the voltage and the type of current (AC/DC) would need to be standardised but at a minimum the battery location and format.

These divergent charging systems also determine the equipment required for current up to 22 KW (slow and semi fast charge), the cable and the charger can be embarked and charging made from home; for a 43KW charge, cables need to be on the charging station, and thus stations sockets need to be harmonised. This is why the debate on charging is very much focused on fast charging stations[2].

Alternative and Direct Current

Technically the charging of a battery is done by Direct Current (DC) while in Europe electric current is distributed in an alternating form (AC). A power converter -combined with a cooling system- is therefore needed to change that AC current into DC. Electric vehicles therefore require an external convertor (like mobiles phone do) unless the charger is on-board the vehicle.

Currently, the PSA and Renault models both benefit of on-board chargers for up to 3KW. Yet for higher tensions, and thus fast charging, manufacturers opted for different models as stated in *Les Echos*. PSA Peugeot Citroën Ion and C-Zero will be charged faster on DC (direct current) contrary to Renault models adapted to AC. The differences regarding the type of charge are explained by their industrial strategies. With its EV models Renault offers an on-board charger, and can therefore be plugged directly into the alternating current provided by the European network. It means that the car could be directly charged in any European standard plug at a slow or semi fast speed. In this case a special plug with higher amperage

than a normal plug can be used, such as the one used for ovens in domestic houses. PSA electric cars can also be plugged into alternating current up to 3KW (a standard house plug) as they benefit from a small on-board charger. However for a higher level of charge they must be plugged into a direct current source by means of an external charger. This is explained by the fact that PSA has drawn for their EV models on Japanese cars such as the i-Miev, designed for the Japanese electricity grid which contrary to the European grid delivers direct current. Japanese car charging modes were adapted to the Japanese grid. Finally, it should also be acknowledged that an AC charging station is less expensive than a DC charging point because the latter requires expensive cables and a power converter integrated into each terminal. So far differences in term of charging methods would mean that public charging points in France will need to be adaptable to different car models.

Europe is fighting internally on standardisation

Despite some deficiencies, the article in *Les Echos* still had a point. It raises the question of standardisation of infrastructure which is actually crucial and that indeed French manufacturers do not so far even agree at home. A quick look at the following blog will give you a greater sense for the problem: http://www.casteyanqui.com/ev/evplugs.html. If in France, a country said to be a test bed for the electric vehicle, we can not cope with standardisation, how will Europe manage?

In the European Union today, there is a worrying patchwork of public financed projects and joint ventures in EVs. Additionally, Manufacturers have started developing projects on the basis of their national norms and contexts. Confronted to this lack of standardisation, electricity equipment suppliers and specialised infrastructure companies have ended up creating alliances nationally to promote their own plug standards. In Germany, electric equipment companies developed a special AC plug for electric vehicles called the "Mennekes plug"[3], more powerful than the Japanese and US common standard. This coalition is already successful. It has managed to impose its standards for the socket on the vehicle, leaving competition still open for the home or public charging station socket and the cable. This is due to the fact that the plug was amongst the only one complete and available when car manufacturers started conceptualising their vehicles. The consortium is also developing a

fast charging DC standard. On the French side, Schneider Electric, Legrand and Scame created the EV plug alliance in mid march 2010, in order to propose norms for charging stations. The Mennekes plug seems to have won the standard for the vehicle socket, as it was the first available on the European market. The competition for wall sockets is still open. The EV plug alliance proposed that the plug benefit from an additional safety protection (a small plastic cover), fitted for the French and about 12 other member states regulation on plugs. Norms are used to gain competitive advantages.

Opinions also diverge on the charge. In Germany, a large number of houses are already equipped with tri-phased alternative current. Semi fast charge, taking about 30 minutes for an 80% charge with 22-24KW, is therefore seen as the standard. On the contrary French households usually have mono-phased plugs (up to 3KW). This also influences car manufacturers and utilities position in the debate.

These standards have been proposed while a Franco-German group on electro-mobility set up in March 2009 has been given the objective of studying normalisation and to develop pilot projects. The group includes BMW, Daimler, Volkswagen, Renault, Eon, RWE, EDF, Bosch, Evonik, Schneider Electric, Valeo, Din, and the *bureau de normalisation cento*.

Why is standardisation important?

Global competition: the clock is ticking

If Europeans keep fighting one with another, they risk that standards, and hence property rights fees, may be imposed by others: China, Japan or the US. Japan has clearly established a direct current as the norm. It has already defined a standard type of slow charging, based on Yazaki protocol[4]. The US aligned with its SAE JI772 standard. A US level 3 charging (fast charging) standard has not been defined yet. This model is compatible with the Chevrolet Volt, the Nissan Leaf, the I-Miev and the Toyota Prius Plug-in Hybrid. In Japan, a new consortium, the so-called CHAdeMO association, now promotes a higher performance standard. Named after a quick charging method, this partnership including Toyota, Nissan,

Mitsubishi, Fuji Heavy and Tokyo Electric power and foresees quick charging DC of 62.5 KW via a special electric connector. Even Korea has released its own. Indeed, the Hyundai group KOPCO announced the creation of a charging interface with Korea Electric Power Corporation. Finally, China has announced the roll out of three standards to cover the technical requirements for EVs charging facilities by October 2010, in particular the use of fast DC charging stations. The Chinese government allocated a budget of 15 billion Euros, more than 5 times the EU budget (and available immediately), to establish the electric vehicle as a new pillar of the Chinese industry. The plan pools manufacturers, OEMs and utilities into a single group to set up common standards.
The lack of standards appears therefore costly, the lack of a European defined standard risky.

The necessity to have a European norm has in this respect been recognised by everyone: politicians, utilities, equipment firms, car manufacturers. In May 2010 France, Germany, Portugal and Spain issued in May 2010 a joint declaration on electric mobility, pushing for an acceleration of the EV standardisation process. It is nevertheless difficult to find a consensus on who should define them. Standards are usually a playing card to segment and protect a market. The competition is understandable: the infrastructure market has been estimated at around 55 billion by 2014 for Europe, 60% of its world value[5].

Yet some believe that a transition period is necessary, and that the best technologies will be naturally selected. This was possibly the purpose of the European Commission 7th framework programme. This programme financed an entire patchwork of research projects for car charging that could be adapted to Europe needs and context. Meanwhile mixed solutions are being promoted. A project such as Elegie, lead by the French utility EDF, was clearly developed into that “transition vision”. It is developing a smart fast charge that recognises the type of car and offers two ranges of tensions, one fast and a slower one. This range approach allows the station to be compatible with different kind of models. There is considerable merit in this argument. In Japan, for instance, the new CHAdeMO option is already replacing the old defined standard. The technology is indeed not yet finalised, and fixing standards too early may not be adequate.

In this period of transition, the rate of EV penetration on the European market will be a decisive lever in imposing a standard. This explains why companies with announced larger production runs are less worried about finalising their standards than others. The same applies to companies not yet ready to roll out electric cars. Some companies targeting the development of plug in hybrids seem also less concerned by the development of standards for fast charging stations. The ambiguity allows them time to develop their own strategy.
But Europeans need to keep their eyes open. The Chinese company BYD which is planning to sale its massively produced EVs in Europe next year on, has signed an agreement with the German firm RWE to develop specific infrastructure[6].

The question is do we lead by being first or by finding the best solution? The best case scenario would be to find the best solution and to be the first to deploy it. Surely though, the risk of the European market being flooded with third parties products at the expense of European one is limited. In fact the European Commission has the regulatory powers to set up standards. It already mandated the standardisation bodies which should come out with standards by mid-2011 promoting safety, access everywhere and smart charging. One could hardly imagine the European Commission choosing a Chinese specific technology, if there is any, as European standard. Some also argue that China usually aligns on German standards and only starting to attend meeting on standardisation.

It is not the standardisation transition period that will make European car manufacturers loose or win on the European or global market, but rather what kind of EV they produce and at what price. As long as standards do not delay the roll out of EVs and the setting of infrastructure, they are of limited relevance for companies. Surely we should watch international developments closely, as it is true that standards can be imposed de facto by the dominant player on the market, as this has already been the case for EVs on board plugs. Yet standards are currently rather an issue for French companies competing with Germans rather than Europeans competing with the Chinese. Industrialists do not seem to worry, at least they pretend not to, about Chinese domination of the European car market. Still, a fast standardisation process is needed for other reasons.

Standards are key for consumers

The promotion of a single, integrated European market depends on eliminating non tariff barriers which have long hampered its good functioning. There is an economic rationale behind it. Just think of trains: French trains cannot run in Italy, as the rail width is different. The lack of standard will not only hurt competition, but as cars are concerned, this could hamper European freedom of movement. Some argue that BEVs have small driving range (100km to 150km, 300km in the case of the Chinese BYD) and that people will use them mainly in cities, not to go on holidays abroad. This is perhaps true for the first generation of pure electric vehicles, but not for electric plug-in benefiting from longer driving ranges up to 500km. Standardisation will be even more important in the future. Standards could be national or local, but what would be the consequences for a car manufacturer who sells cars in Germany and France? Not to mention the fact that in Europe some people (around 800 000[7]) also work across borders. And let us not be naïve, current automotive research in the field of pure electric vehicles targets longer driving range. The EU Commission electric cars strategy gave a mandate to European standardisation bodies CENELEC, CNE and ENTSI to define standards by 2011, according to three criteria, among which "access to all charging stations" by consumers. The consumer perspective, although not the loudest one at the moment, has also to be considered. Even if companies or governments continue to disagree, one thing is sure: the harmonisation of infrastructure at the European level will still be needed by the consumer.

Standardisation is needed to promote the sustainable development of the electric vehicle industry

Because of the lack of electric vehicle infrastructure charging standard, the outside world might be hostile to an empty battery: consumers' office parking may not be equipped with the right plug, nor any other home than hours, nor even the nearest public charging point.
Yet, studies and real life testing of electric vehicle have revealed that new infrastructure is crucial for the market penetration of electric vehicles. A study done by the European

Commission Joint Research Centre (JRC) revealed that electric vehicles sales could increase by up to 50%[8] thanks to a dense network of charging points, including fast charging stations. In particular public charging points are needed to raise the acceptability of consumers, who suffer from range anxiety.

Standards are important in emerging markets. Accelerating the availability of infrastructure will therefore lower the risks of investments in EVs. The cost of infrastructure is also substantial. EDF, the French utility company, estimated that in France the cost of a domestic plug is around 500€, rising to 2000€ for a public point and jumping up to 16 000€ for a fast charging station[9]. If cars are not made compatible with all public charging points, this could significantly raise the cost, and this burden will likely be placed on the consumer or the citizen. Having mixed charging points could be an option up to two standards, not more. Standards could also improve economies of scale and decrease costs for companies.

Standardisation may also be needed for technology reasons. It is true that a battery able to receive a high power charge could be plugged into a lower tension, yet managing the charge properly increases the battery life (currently varying between 8 years and 15 years). Here also, a decreased battery capacity due to bad management, will impact the consumer and the industry in the long term.

Conclusion

Standardisation appears controversial as European industries are competing to promote their own version. Yet, the list of standards needed does not end with plugs. Other standards will concern software i.e. communication systems, needed for low cost and environmentally friendly charging. The success of technologies such as Vehicle to Grid will strongly depend on this software. With this technology, electricity can be stored in the vehicle and re-injected into the grid to relieve the network which in theory allows flattening the demand, and hence avoiding polluting electricity peak load. The interface of stations with the grid should be carefully studied given variations in voltage across countries. Transformers will also have to

be looked at, and related energy efficiency standards could be useful to enhance the environmental impact of EVs. Parking electricity load may need to be revised and new building facilities as well. Finally, for battery swapping, battery packaging should also be harmonised. This will probably an even greater challenge, as this concerns the heart of EV technology.

Electric Vehicles standards do matter. They impact competitiveness, consumers, budgets and the environment. Europe has to decide on adequate standards. Vehicles are already on the roads, and a standard for plugs is only one to be considered among others. Mid 2011 seems tight. The EU should not delay if it wants to sustain the birth of this heavily subsidized new technology.

Notes :

[1] Les Echos, PSA et Renault s'opposent sur les voitures électriques, 20 September 2009, available at: http://www.lesechos.fr/entreprises-secteurs/auto-transport/actu/020798103729-psa-et-renault-s-opposent-sur-les-voitures-electriques.htm

[2] The article also stated that the French companies disagreed on the charge amount: PSA opted for direct current up to 43KW and Renault for alternative current up to 22KW. Additionally, the article pointed out Renault was not standardising with other car manufacturers. Yet reality is more complex. Renault informs that their vehicles could be charged with 43KW as well.

[3] The Mennekes plug is based on the "VDE-AR E 2626-2-2" standard, based on International Electrotechnical Commission standard n°62196 (the International Electrotechnical Commission). It consists of a Mennekes plug design. The plug has 7 pins: 3 for the charge, 1 neutral, 1 and 2 for the communication and an external connector (this model can support from 240V 16A single phase – a home plug 3.7kW– to 63A three phase i.e. 43.5kW),

[4] This norm consists of a mono-phased charge of 16A, with a maximum charge of 3KW. This involves DC charging and stationary charger with connectors between (100-230V AC). Yazaki is the name of a japanese a battery manufacturer who promoted this charging type.

[5] http://www.ifandp.com/article/006629.html. This estimate includes everything except batteries manufacturing and recycling.

[6] It should be noted that RWE already signed partnerships with a lot of other car manufacturers, and that Chinese cars will still have to comply with safety standards.

[7] Eurostat, Statistical Pocketbook, 2008

[8] 50% of limited vehicles quantities: For the same type of vehicle, sale would increase from 0.8% to 1.2% by 2020 and from 2.3 to 8.7% by 2030.

[9] Aeroenvironment fast charging station providing 50KW and able to recharge a Nissan Leaf in 26 minutes cost around 30 to 40 000$.