Contribution to the

European strategy on clean and energy efficient vehicles

We, the German renewable energy organizations

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in the context of the following question, which was raised by the Commission

6. *What actions should be best taken at regional/ national /European or international level to promote technology development and market uptake of alternative powertrains (electric and hydrogen)?*

would like to focus on one core structural aspect for the policy regarding electric mobility:

Every Electric Vehicle should have its own legally binding Smart Electricity Meter

There are a number of reason, why the place where energy is "logically" transferred into the domain of an electric vehicle should be seen as lying inside the car and not outside the car. The core benefits are, that it…

1. Simplifies the billing process
2. Ensures transparency for the customer
3. Simplifies the infrastructure
4. Simplifies taxation
5. Enhances data security
6. Enables public infrastructure
7. Leads to a reduction of cost
8. Allows a more rapid development and innovation process
9. Allows more competition
10. Allows more flexible business models
11. Enables better integration of renewable energies

Many of these issues are interlocking with one another and the argument that can be made is not a straight line. The benefits of putting the legally binding energy meter into the vehicle are of a structural nature which sometimes would even require very detailed discussions of technical issues.

The following is a short description of the involved aspects.

Simplifies the billing process

Recharging an electric vehicle only takes small amounts of energy, especially with small or efficient vehicles. Sometimes a partial recharge of a vehicle can be below 1 kWh of energy, which translates to around 0,20 Euro. At this range the transaction overhead of billing this small amount of money exceeds the real value of the energy. Besides that, all these micro payments and micro measurements must be monitored, processed, archived and validated at multiple levels and then merged to present one unified bill to the customer (vehicle owner). This is a complex issue, where all involved parties must agree on one system throughout the entire system, before the first Euro can be billed … if the system should be customer friendly.

It is technically far easier to have one meter designated to one customer (vehicle) where all charging operations are being measured. There will be one well defined place with one well defined value that defines

the consumed energy. During every technical inspection of the vehicle the involved authorities could validate that the metering system has not been tempered and they could report (validate) the measurement value.

Ensures transparency for the customer

Since electricity is invisible there is no way a customer can "see" how much energy a charge spot delivered to his vehicle. To solve this issue the charge spot would need to provide a display, where this value could be seen, and/or a printed receipt. But since the car will stop at many different charge spots it will be very hard for the car owner to track all those small transfers of energy, sum them up and double check with the bill that he might get later during the month or year. He might even get multiple bills from multiple grid operators because he might have to be a member of all of the recharge providers in order to get from A to B.

With the meter inside the vehicle this task would become trivial, since naturally the meter does the "summing up". Only with a meter inside the vehicle will the EV owner be able to validate if the energy that he is being billed for actually matches the energy that his vehicle did consume.

Simplifies infrastructure

One of the strategic benefits of electric vehicles is, that every power outlet in a private home or garage is a potential recharge infrastructure. Recharging at this type of already existing infrastructure will be a dominating use case because it is so extremely convenient. Since this is a structural benefit, it will most likely remain this way forever, even when other ways of recharging will become technically available.

For the purpose of "heating the engines in cold climate", the Scandinavian countries already have a major electricity infrastructure in place. In Sweden alone there are more than 500.000 existing "charge spots" available. They are simple outdoor power sockets.

In order to measure and bill for the energy being consumed by just one single electric car and still be able to use that existing infrastructure, every single power socket would have to be upgraded with a smart meter. The alternative would be to put one meter into that one vehicle.

The number of power outlets will always (by far) out number the fleet of existing electric vehicles (EV). This is one of the areas where the EV world has the totally opposite characteristic of the combustion engine fleet (and there are even more structural difference along these lines). From the economic point of view it will always be more expensive to put meters into the power outlets than to put them into the vehicles.

Simplifies taxation

It is natural to tax the "usage" of vehicles. If somebody is driving a heavy vehicle a lot he will consume more energy than somebody how drives a light vehicle or drives his vehicle only occasionally. The energy consumption also nicely correlates with the damage inflicted upon public infrastructure (like roads, bridges, etc.). Taxing energy consumption in mobility makes a lot of sense when it comes to refinancing public road infrastructure. Gasoline taxes are common in many countries and are a large part of the their "income". It is obvious that drivers of electric vehicles will also have to pay their share.

But how should taxation be implemented for electricity that is being used for mobility purposes in the future? While this initially might look like an unimportant topic, it seems crucial to have a working solution in place right from the start … even if the initial taxation rate might be zero.

If an electric vehicle can recharge at virtually ever power outlet that already exists, then there is no way to tax that energy consumption specifically. Putting an energy meter into the vehicle would solve that problem.

If an energy or mobility provider, that is responsible for a certain customer or vehicle, can prove which type of energy source (mix) he is using, it would also be very simple to implement a taxation/reporting schema that is linked to the CO2-intensity of the power plants. This process would be very transparent to the customers and would make it very easy to correctly monitor the CO2-intensity of the mobility sector.

Enhances data security

In the real world a new market for "mobility service" or "energy service" provides will emerge. Every car only needs to talk with this, well known, service provider. Every customer will sign a contract with his service provider and thereby will agree to the terms of that provider.

Car company A will develop a communication system that service providers P or Q will be using. The number of involved parties that exchange data would be very limited and all parties will know each other and have contracts with each other. For this system to work there is not even a need to start with a unified communication standard. This is a benefit, because the requirements for such a standard are currently unknown since the underlying business models are yet to be developed.

Rapid technical development and competing communication protocols are a good thing, because security problems will be more isolated, and can be fixed more rapidly. If there is no need to communicated secure payment data between the car and an unknown operator of an infrastructure, then there is — by design — no potential security risk.

The complexity and vulnerability of a system increases as soon as a large number of unknown parties needs to be trusted. If the meter is in the car only a small number of trusted parties are involved in the communication.

Enables public infrastructure

The enforced unbundling in the energy sector (separation of production, distribution and sales) is a good approach, because it enables competition where it is possible (production, sales) and simplifies distribution by setting clear rules for all players that want to use the shared grid.

The infrastructure for electric vehicles can not be compared to regular gas stations, which are located in very few places. EV charge spots need to be place right where the vehicles are parked for extended periods of time. But from a structural and practical point of view it makes no economic sense that every potential energy provider will build his own charge spot a the same parking lot. A matching picture would be the chaotic collection of microphones at press conferences, where every TV and radio station has its own microphone in front of a single speaker. This would not be tolerated on the parking lots inside our cities.

In reality even refinancing a single charge spot is almost impossible, because the revenue at each parking lot is way too small to ever provide any reasonable return on investment.

Additionally, if cities provide public space to one service provider for EV infrastructure, then the cities are basically forced to charge a fee for the space they are providing. If they do not do so, they are basically providing an illegal subsidy to that one company which operates the infrastructure. But if they do charge a fee for the space, the payback of the infrastructure — which provided no return of investment in the first place — now becomes even more of a financial burden.

As of today there is no business case for operating only the EV charging infrastructure.

Once we move the electric meter into the vehicle we basically shift the "logical" location, where the energy service is provided, from the charge spot over to the vehicle. With this move the charging infrastructure would no longer be an installation of the sales branch of one particular company, but the charge spot would be a public and common grid connection point, that every energy and mobility provider can use to transfer his energy.

Moving the meter into the vehicle allows to maintain the unbundling idea in the domain of EV infrastructure and it allows the cities to provide the public space free of charge, since they would no longer provide subsidies to one company, but they would provide or enable public infrastructure for all market players.

Leads to a reduction of cost

Some aspects of the overall cost reduction have already been outline before. The meter inside the vehicle greatly simplifies the infrastructure (no meter required, no display required etc.) and it simplifies the technical implementation of the communication system.

One of the core arguments for cost reduction not mentioned so far, is the fact, that modern cars already provide all necessary hardware to perform the communication and measurement tasks which a smart meter inside the vehicle would require. The battery management needs to precisely measure energy flows in order to keep track of the state of charge. The power electronic will perform all sorts of measurements for protection and control purposes. GPS systems know the position of the vehicle and often come with online communication features. Many modern vehicles already provide wireless communication for remote fleet management, mobility or vehicle hot line support services or other advance features.

So basically there is (will be) no added cost if the metering is done inside the vehicle. However, currently all the energy metering inside a vehicle has no legal definition, legal protection or other legal status.

Allows a more rapid development and innovation process

With the meter inside the charge post the communication between the car and the infrastructure must exchange and provide all information that is necessary to enable every business model of every current and future service provider. Establishing such a standard is a very challenging and time consuming task. As long as this process is not finished no market player can start providing services that require the infrastructure.

Moreover the challenge lies in that fact, that the mobility business models of the future are currently more or less unknown, since the technology has just started to develop. For rapid development it is very important that all parts of the system can evolve independently and with their own "time scale". Some parts, like communications, security and computing change very rapidly (approx. every 5 years). Other parts like the electric infrastructure with the cables and substation change very slowly (every 20 to 50 years). Operating and upgrading legacy systems will become a major (cost) issue after the initial roll out.

Moving the meter into the vehicles changes the communication patterns and thereby the interdependencies between the systems. It would allow to greatly simplify the communication between the rapidly changing "car" domain and the long lasting infrastructure part. This enables more innovation on both sides.

Allows more competition

With less communication needing to be standardized, there is naturally more room for competition. The very likely domains of competition will be:

- how cars communicate to their mobility service providers
- how grid operator communicate to their charge spots

The most important point however will be, that energy or mobility providers will be competing for customers. With the meter inside the car there will be one contract between one energy provider and one car (customer). This gives security to both sides and it gives high convenience and higher customer satisfaction, because nobody will ever have to wonder what will happen or what he is require to do if he connects his car to a charge spot. The customer knows exactly "what he gets", because it is in his contract. But for every customer some mobility providers will offer better or more suitable terms then others.

Energy providers will compete for the most attractive energy service. They will request the local grid owner to open up the charge spots on their customers behalf, take care of the billing and ensure that their customers will receive the (clean or cheap or …) energy that they ordered … no matter where the customer is.

Mobility providers can offer vehicles (like Better Place, …) or batteries (like Nissan, ese, …), offer kilometers driven or offer intermodal travel (like VLOTTE, Deutsche Bahn, …). There will be all sorts of ideas. But most of them only work if the mobility provider can ensure hassle free recharging and well defined conditions … in every in Europe, since customers want to be mobile with their electric vehicles.

Allows more flexible business models

There are two fundamentally different ways of looking at the function of the charge spots:

a.) it sells electricity (kWh)
b.) it provides access to the grid

We could phrase it differently. What is the focus of the business models?

a.) the infrastructure (the parking lot)
b.) the car (the consumer)

The first case is the traditional approach. But as was already mentioned, selling kWh of electricity might look like a simple task, but it actually is the only business model that will most likely never work with EVs. This is mainly because their energy consumption is very low and they can always get their energy from a "cheaper" source, since all they need is a simple power outlet.

The second case leaves all decisions about business models open, since the business models are now linked to the car. They can range from simple "kWh" energy services to highly sophisticated mobility services.

Enables better integration of renewable energies

Historically our energy system was based on stored energy. This allowed us to produce energy at the time, when we wanted to consume it. So supply followed demand. With renewables we have to turn this around: Demand must follow supply. With electricity it is very hard to move demand, as most demand is driven by human action and in those cases the cultural rhythm of a society is what defines consumption patterns.

Electric vehicles technically require an energy storage system and therefor naturally bring a capability, that is perfect to move demand. Technically it might be possible to move a huge percentage of the demand if electric vehicles would perform smart charging. However, there are a number of problems.

A car primarily has the serve the cars driver (owner). So from the energy management side a single car is not interesting, because its energy and power levels are way too small for the energy markets and the cars behavior is not really predictable. It can be unplugged at any time. Only large fleets have the necessary predictability because of the statistical distribution of events.

The second major problem is that smart charging and especially smart grid services (like providing power or energy back to the grid or stabilizing the frequency etc.) are not understood by the general public and they also have an impact on the lifetime of the battery system, which is an economic risk. Smart grid services will never happen, if the owner of the infrastructure has the economic benefit (a stable grid, less expenses for regulation power, etc) and the owner of the battery has the economic cost (reduced lifetime of the battery, reduced range of the vehicle, etc).

Only when the economic costs and risks are in the same hands as the potential economic gains or benefits it will become possible to develop business models, that will be able to tap into the technical potential of EVs and to stabilize the renewable grid.

Among the many linked aspects of this topic there is also the simple fact, that only vehicles that are connected to the grid are able to stabilize the grid. So if access to infrastructure is complicated or associated with additional (uncertain) cost or inconvenience … people will not connect their cars to the grid unless they really really need the energy. But in those situations there is no potential for shifting demand and the vehicles do not serve the renewable grid.

All of the above leads to the conclusion that in order to solve problems that the renewable grid will have, we need electric vehicles that are active “players” in the grid and that are managed by energy or mobility providers. Since these providers manage vehicles and provide energy services to and from these vehicles, it is only logical that they need an energy meter inside their "energy devices" (the vehicles).

Summary

As it was already mentioned, there are two fundamental approaches to view electric vehicles.

a.) They are cars that need to be filled up with energy. This approach:
- focuses on selling electricity (kWh) and building (owning) the infrastructure
- allows to stick with established business models
- wants the meter only in the infrastructure
- does not work economically, for all the reasons outlined above

b.) They are moving energy systems inside the (renewable) energy gird. This approach:
- focuses on mobility services and managing (owning) the energy storage
- requires new business models
- wants the meter in the vehicle
- could become an interesting economic domain

For many economic, structural and technical reasons — some outlined above — only case (b) has a high probability of actually establishing systems and business models that have the incentive to use electric vehicles to stabilize the renewable grid.

The potential of stabilizing the renewable grid of the future with electric vehicles is huge. But if the business models focus on the infrastructure there will be little incentive to really move demand. Only when the business models will focus on the vehicle it will become possible to link the fleets demand to the renewable production, because the vehicle is the place where all the decisions are being made, where all the risk and cost issues need to be considered.

In practice meters will most likely be everywhere. The distributed renewable electric grid requires measurement at all levels and in all places for many purposes. But for the future development of electric vehicles it is a crucial point to decide, where the legally binding energy meter will be placed. The overall structure becomes a lot more simple and thereby more flexible and open for innovation, if a required smart meter is placed inside the car.

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Notes

Some technical background is provided in these presentation slides:

<http://www.dgs.de/fileadmin/files/FASM/2009.11-DGS-FASM-IEA-Netzintegration.pdf>

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