Automatically Charged Vehicles in the Prosumer's Ecosystem

Robert Eriksson
Volvo Car Group
Vehicle Propulsion – Strategy and Innovation
Gothenburg, Sweden

Stefan Pettersson, Urban Kristiansson,
RISE Viktoria
Electromobility
Gothenburg Sweden

Abstract — since more than 40 years [1], electrification has been on the car manufacturers' observation list. Research, development, production and sales of electrified vehicles proves that they are the alternative for future mobility. Improvements in battery technologies have finally matured and viable products with electric propulsion are now on a broad scale entering key markets. However, it does not stop here. Transitioning to electric mobility means so much more as it opens up a world of new opportunities with foreseen changes in user behavior enabling new offers to users of future electrified mobility. Just seeing the change as a different fuel is just not enough. For example, there is a need to control charging during peak power hours to save money for the customers. Furthermore, some customers also want to use their remotely produced electricity when charging their vehicle, preferable by using new convenient inductive charging.

How will the electromobility solutions for next generation customers of vehicles look like? Volvo Cars and RISE Viktoria are undertaking a pre-study with the main task to address additional research needs covering a situation where vehicles are finding charge spots, optimizes automatic charge control and enabling prosumers to utilize electricity they have produced themselves as fuel.

This paper will explore some of the needs and possibilities opened up when transferring to new generations of electromobility while taking power production, and remote distribution of energy into consideration.

I. Introduction

Electrification of vehicles is in many ways a new development area for the automotive industry. In the past, development was focusing on implementation of technologies around designing combustion engines driven by liquid fuels coming from mature distribution networks. Over a short time period there is a need to switch technology base where energy production, storage systems, power transformation and energy conversion components will change radically and in combination with the fact that passenger vehicles are made for consumer markets where the expectations are extremely competitive. Vehicles of today comes with connectivity services for navigation and entertainment where electrification will introduce further expansion with connection to the infrastructure for charging meaning potential touchpoints with electricity production and power grid distribution. In addition, intelligence for finding the charging stations while driving for topping up on energy will become important as well as getting information on available charging stations etc.

From an automotive OEM point of view, there is a tight focus to develop electrical architectures [2] that fits the needs of the vehicle users, and with electrification the distribution of electrical energy will be part of a new user interface for energy fueling which could cause frustration and complication. For this reason, efforts in user experience research is a top priority while beginning to understand electrification and its effects to the users.

More and more customers with electrified vehicles requests simplified home charging, and preferably if they own solar cells, they would like to use the electricity they produce themselves. They become prosumers, meaning both consumers and producers of electrical energy [3].

Storing surplus electrical energy for later use could be done with a stationary battery system connected with solar cell system but investing in an electrified vehicle makes an investment in a stationary battery questionable. The battery in an electric vehicle more or less serves the same need and often has a higher storage capacity. However, it is movable and hence not always available for energy storage.

Electric vehicle storage, autonomous driving and automatic charging, together with privately owned electricity production and Internet-of-Things technologies is beginning to mature separately. By assembling these technologies into a System-of-Systems the motivation of the prosumers to invest in electrified vehicles will therefore increase.

The work presented in this pre-study is partly financed by FFI "Fordonsstrategisk Forskning och Innovation" [4] with the goal to maximize benefits for users that act as both producers and consumers of electricity where battery electric vehicles may play an important role in expanding the benefits of future electrification.

II. Background

An expert panel within EU [5] has identified important aspects electrifying the transport sector. Joint studies in the field of automotive and electricity production/charging infrastructure will lead to improved values for the users of electric vehicles.

A. Cost efficient and simple to use infrastructure is necessary to support electrification of vehicles.

Simplicity is key for the users. Vehicles and infrastructure for charging should be highly integrated using equipment that improves the user experience. As examples, this means that supporting features such as wireless charging and automatic parking are valuable contributors.

B. The synergies between electric vehicles, connectivity and electrical distribution infrastructure is important

Since electrical storage in vehicles is limited and charging infrastructure should be handled with sound investments, it is important to incorporate new ownership models and provide good consumer advice in order to dimension the equipment mix between quick and slow charging capabilities. Synergies with connected electric vehicles together with well-managed energy distribution will be important.

III. Goals for the study

Below is listed the targets for the pre-study.

A. Scenarios for prosumer and automotive OEM economy
B. Use cases and their verification
C. Interfaces between different involved subsystems
D. High level Control algorithms
E. Potential changes in the connectivity infrastructure
F. Dialogue with electrical distribution company
G. Create a number of project proposals for continuing the buildup of knowledge.

One of the more important work efforts is item E in order to define the most essential architectural needs for the connectivity infrastructure.

IV. User scenarios for prosumers

In order to define the eco-system for a prosumer-oriented charging infrastructure a use case study took place. Some of the use cases are listed below. It is notable that most of the user scenarios described are available already, but not well integrated or offered to customers in Sweden.

A. Charging the electric vehicle with energy produced at home while parked at home as well as remotely at other locations.

Access to real time electric energy production at the prosumer's site is made accessible at any charging point regardless of charging operator. An eco-system connecting prosumer and charging infrastructure together will be set up via contracts for handling the business transactions.

B. Control while charging

The user selects preferences for charging start. The feature considers where the vehicle is charging and if home produced energy is available. With an eco-system, connecting user, vehicle and electricity providers together an optimization of the power transmission is made

C. Balancing between amount of rate of charging and energy price.

Through user interfaces it will be possible to adjust charging preferece according to a cost-benefit scale where a user can optimise between urgent charging and delayed charging also inluding energy prodeced at home. Which options that should be available is still an open question needing more research.

D. Possible to prioritize between battery life and other prerequisites for the charging.

With the help of the eco-system the user can decide between protecting vehicle battery life and giving access for other actors to utilize vehicle battery as an energy buffer.

E. Possible to use the electric vehicle as an energy buffer while driving needs are low.

For instance, the vehicle can support a weak power grid and power shortage.

V. System-of-systems approach

The system of systems approach, as can be seen in Figure 1, involves the following systems:

- Automatic charging (consisting of parking, energy transmission and payment)
- Optimization of energy storage between stationary batteries and EV batteries
- Block chains and Internet-of-things
- Smart homes with vehicle integration

Figure 1. System of Systems

VI. PEEER TO PEER ENERGY

An interesting special case for the charging balance between mains and the vehicle's battery occurs when the home is equipped with solar cells, but the vehicle is charging at another remote location. The prosumer can then, despite the geographical distance, want to charge the vehicle with the same amount of energy that the solar cells generate at a given time while only paying for the usage of the power grid. By allowing the power grid to transfer electricity, a natural way forward to introduce storage capacity in the grid is created. This can then help reduce the negative effects of intermittent production that characterize renewable energy sources such as solar cells or wind power.

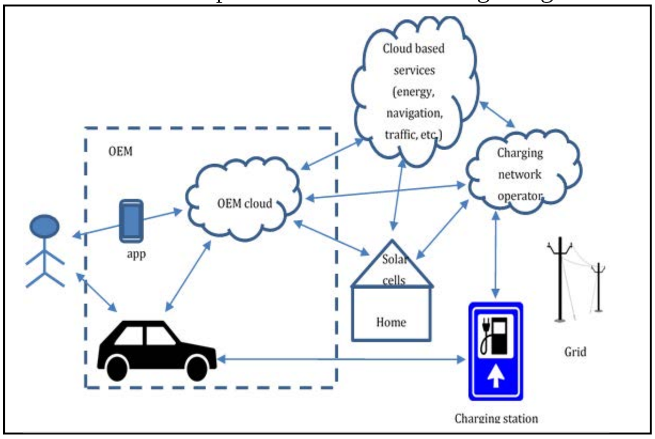
Earlier, electric vehicles have been assumed to connect to the mains when their driver gets home from work. This introduces a risk of locally overburdening the power grid without a competent regulator. Similarly, electricity produced from renewable sources could lead to a surplus of electricity, which, consequently, brings a low selling price or even needs to be dumped. However, with vehicles that automatically connect to the mains, this behavior can be partially rectified by using the solar cells to charge the battery or alternatively another stationary battery at home. The energy can also be stored thermally by, for example, using the energy surplus to heat or cool the house

This can, to the prosumer, lead to better economy and for the society a more efficient and robust electrical system.

VII. RESULTS

This study is an initiative aimed at understanding the upcoming possibilities and potentially new information exchange created when the automotive sector is transferring to electromobility. It is tightly focused on user experience and information exchange between entities forming a system of systems. Through a cross-industry cooperation between the power industry, automotive industry, universities and institutes, work has begun on defining user cases, information flows, interface, regulatory algorithms and verification plans for auto-charge of self-generated electrical energy even when the vehicle is parked elsewhere.

Continuation projects are in discussion and new applications are created, with parties from the automotive industry, power industry, institute and possibly university. Initial results points at significant benefits to both individual prosumers as well as the society as a whole. Prosumers can enjoy lower energy costs while the society receives a clear path towards installing large scale



distributed battery systems in the power grid enabling higher total grid efficiency and an ability to better handle the inherent power fluctuations from renewable energy sources.

VIII. MOTIVATION

Electrified light vehicles have great potential to change new car sales in a disruptive way - not only in Sweden but in large parts of the world. Many collaborative environmental factors point to a rapid technological jump towards more automated electrified transport. Once the pieces have fallen in place, the conversion can take place very quickly and risks drastically changing the sales pattern of traditional fossil fuel-driven vehicles that require an active driver. Historically, it has proved extremely important not to fall into the backwaters when this kind of technology is taking place. There are many dissuasive examples such as Facit's mechanical calculators and Nokia's mobile phones. But the other side of the coin is that if you are out on time you can achieve great success.

REFERENCES

[1] Experience from 40 years with Volvo Cars Electrification, Robert Eriksson, EEHE 2013, Bamberg, 23-24 April Expert Verlag ISBN 978-3-8169-3213-0

[2] Volvo Cars electrical architecture evolution into the next decade, Martin Hiller, Robert Eriksson, EEHE 2017, Bamberg

[3] Explanation of prosumers at Wikipedia. https://en.wikipedia.org/wiki/Prosumer

[4] FFI - Strategic Swedish vehicle research and innovation programme. www.vinnova.se/en/m/strategic-vehicle-research-and-innovation/about-ffi/

[5] Commission Staff Working Document, Towards clean, cempetetive and connected mobility: the contribution of Transport Research and Innovation to the Mobility Package, SWD(2017) 223 final