THE ROLE OF CONSUMER INVOLVEMENT IN OPTIMIZING THE ELECTRICITY SUPPLY CHAIN - SMART GRIDS, SMART CARS, SMART CONSUMERS?

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Abstract

The electrification of personal, public and commercial transportation is considered as one of the possible solutions to challenges such as global warming, sustainability, and the limited availability of fossil fuels. The integration of electric vehicles into the electricity portfolio present many challenges, but also opportunities to the operation and planning of the electricity supply chain. The supply chain of electricity is a unique one of its kind; not only because of the fixed distribution routes and strictly pull strategy, but because the end consumer has the option to directly contribute to the chain as a producer/wholesaler/system influencer as well. This study investigates consumer attitude towards incentives supporting electric car usage, and towards the promotion of active consumer involvement for electric car owners as contributors in supply chain optimization. Research was conducted in central Hungary (N=211), and results indicate that given the sufficient amount of state support and concrete consumer benefits, consumers have the willingness to cooperate with smart grids whilst creating a more balanced, more stable and more efficient electricity supply chain.

Keywords: consumer involvement, electric cars, smart grid, supply chain optimization

1. INTRODUCTION

Local and global businesses, as well as consumer energy systems getting more dependent on electric networks is a tendency worldwide (Veres, 2014). Besides classical, fossil-fuel power stations and nuclear power plants, renewable energy sources also feed the electric networks in order to satisfy constantly growing consumer needs. Increasing energy efficiency is one of the top priorities of the European Danube Region Strategy (European Commission, 2010) and the Paris Agreement, while the improvement of energy networks on a national level is of key importance for countries; not only to increase the security of energy supply but also to support macroeconomic competitiveness. As consumers are getting more dependent on electric networks as never before, they have certain expectations towards electric power services. They want electricity to be affordable, clean, reliable and capable of supporting both the evolving economy and society (Sioshansi, 2011). Energy efficiency aims to reduce the amount of energy required to provide products and services (ISO 17743:2016), while worldwide energy demand is predicted to grow with an average annual growth rate of 1.6% until 2035 (International Energy Outlook, 2016). While the number of energy consumers and the amount of consumed energy is constantly growing, the electricity supply chain struggles with the lack of storage and balancing opportunities within the system. This paper focuses on the role of consumer involvement in optimizing the supply chain using the storage capacity of electric car batteries, and on the willingness of consumers to cooperate with system operators. We investigate if, and if so, how and to what extent individual users are ready for cooperation and whether or not they are willing to sacrifice their freedom to some degree in order to have a trustworthily operating and sustainable national electric supply system. Therefore, our research questions are the following:

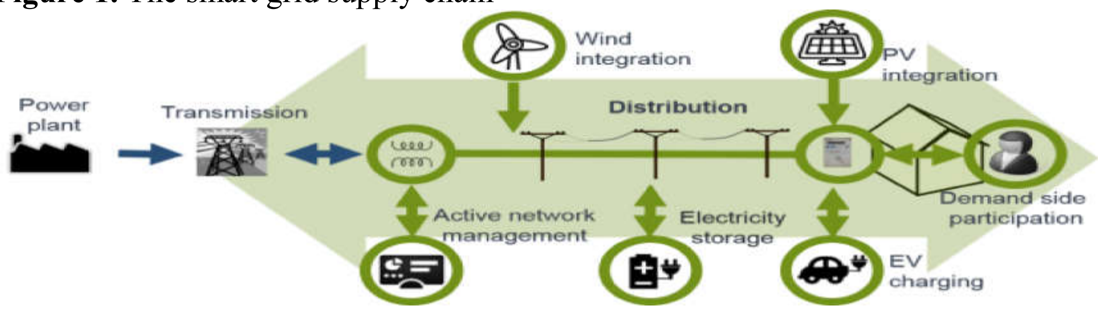
1. What is the individual users' opinion and approach if their freedom of driving range and charging access becomes limited?
   Are they ready to give up on their freedom for figurative or indirect advantages? If so, what do they expect in return?
2. Where and how do they require state support? What kind of support or offset could they accept?
3. What do people think of electric cars as energy storage facilities? Are customers aware of their role as potential system influencers? Are they open and able to fulfill this new role and expectation?

2. ELECTRICITY IN THE 21ST CENTURY: THE SMART GRIDS

As electricity demands increased through the late twentieth century, system operators and power generators have searched for ways of managing peak loads. The costs of building and maintaining capacity to handle peaks — capacity which would not be used during long periods of non-peak load — led system operators to study their demand periods, price them accordingly, and to encourage customers to switch consumption from peak to non-peak periods. The goal was to match consumption to generation, and it required meters, which could measure the time of day of the consumption in addition to the cumulative consumption. Automatic meter reading devices introduced in the 1970's were the beginning of meters, which provided information back to the utility, a basic requirement of any smart grid system. Smart grids are "automated, widely distributed energy delivery networks characterized by a two-way flow of electricity and information, capable of monitoring and responding to changes in everything from power plants to customer preferences to individual appliances" (IEEE, 2011).

What makes a grid smart? According to Amin and Giacomoni (2015), smart grids are self-healing systems that empower and incorporate the consumers, tolerant of attack, provide power quality needed by 21st-century users, accommodate a wide variety of supply and demand, and are fully enabled and supported by competitive markets. As seen on Figure 1, smart grids are complex networks, and usually include a wide variety of operational and energy measures including smart appliances, renewable energy resources, and energy efficient resources (Saleh et al., 2015).

Figure 1. The smart grid supply chain



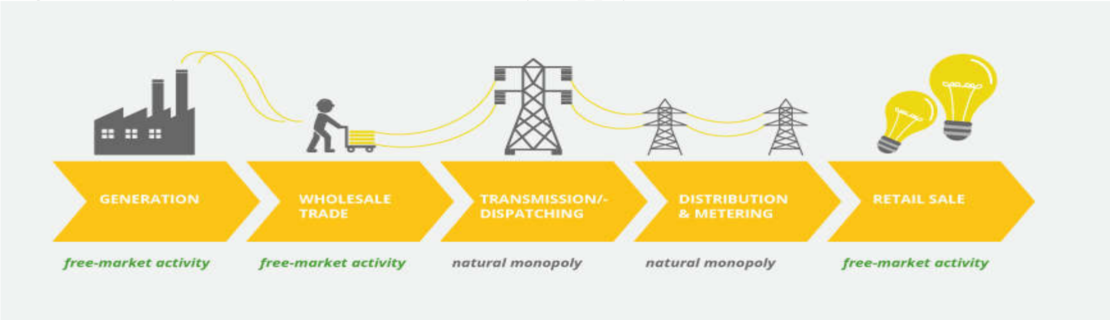
Source: http://www.edsoforsmartgrids.eu/home/why-smart-grids/

When thinking about electricity, it may seem that the product of a power station is the alternating current power that travels from the power plants straight to the consumer's home. However, the real product provided by this supply network is not simply electrical energy, but the availability of electrical energy - whenever and wherever consumers need it. The main function of the electricity supply is to serve the consumer demand with solidly available (security of supply) and satisfactory (quality of supply) electrical energy (with adequate frequency and voltage), on as low full costs as possible (Bajor, 2008).

National and worldwide energy networks bear every trait of a traditional supply chain: they are integrated networks between various producers with different transmission stages until the product reaches the final consumer (Hofbauer, Wenninger, 2011). In order to reach the right customer at the right time with a right amount and right quality of energy, system operators perform supply chain management tasks like network design, production planning, order management, sales and operations planning, collaboration with suppliers and customers and many other processes to successfully plan, operate and manage this worldwide supply chain.

Compared to traditional supply chains, the electricity chain has many unique features. The chains usually operate under strong state influence, are often vulnerable to changes in national politics, and - despite being interconnected - mostly operate on national markets. Moreover –as demonsrated on Figure 2-, the supply chain of electricity is partly or fully a natural monopoly, where giant power generators, transmission or distribution companies dominate the markets.

Figure 2. Layout of the Italian electricity supply chain



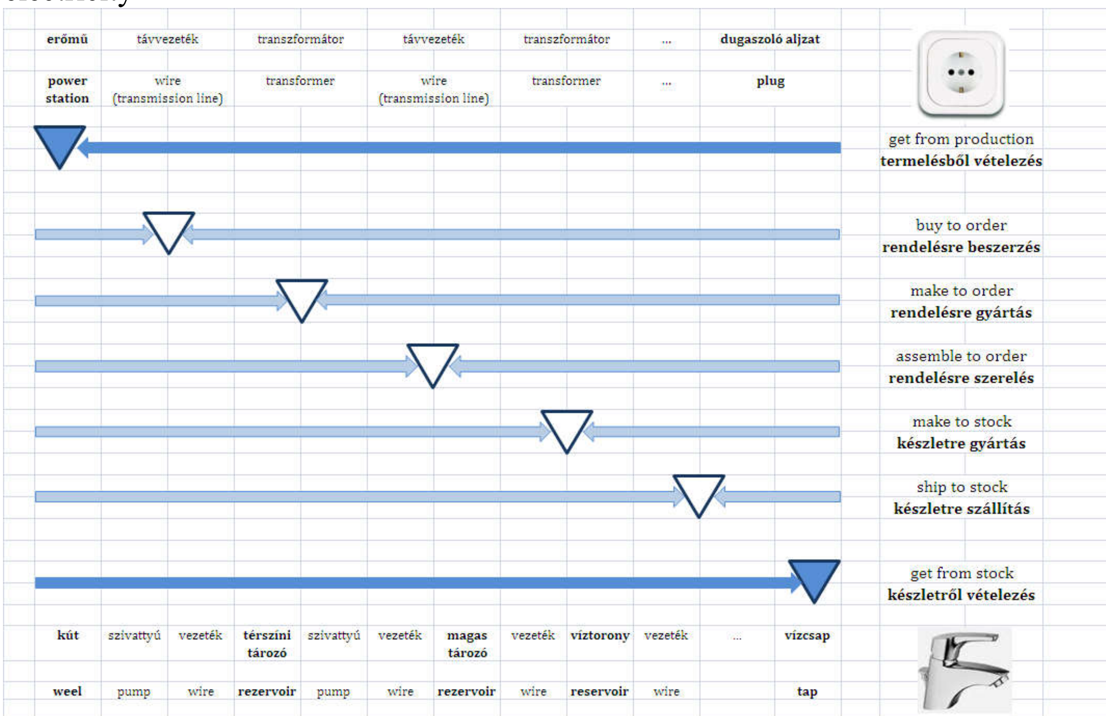
Source: http://eng.gruppohera.it/group/business_activities/business_energy/electricity/

Prices are influenced by many factors: geological, political and economic environments, the proportion of renewables in the portfolio, and vary significantly - from 0,308 Euro/Kilo Watt hours (KWh) in Denmark to 0,065 Euro/KWh in Serbia (Eurostat, 2017) - from country to country within Europe.

From the viewpoint of conventional logistics, the electricity supply is a typical pull system, without significant storage possibilities at the final product level. Power plants and other generators produce the required electrical energy from moment to moment, otherwise the system loses its balance, and the service breaks off – generating high balancing costs and enormous costs of restarting (Bajor, 2007).

Comparing the supply chain of electricity to the supply of water (see Figure 3.) highlights the main differences between a push (water) and a pull (electricity) system.

Figure 3. Comparison of the supply chain of water and the supply chain of electricity



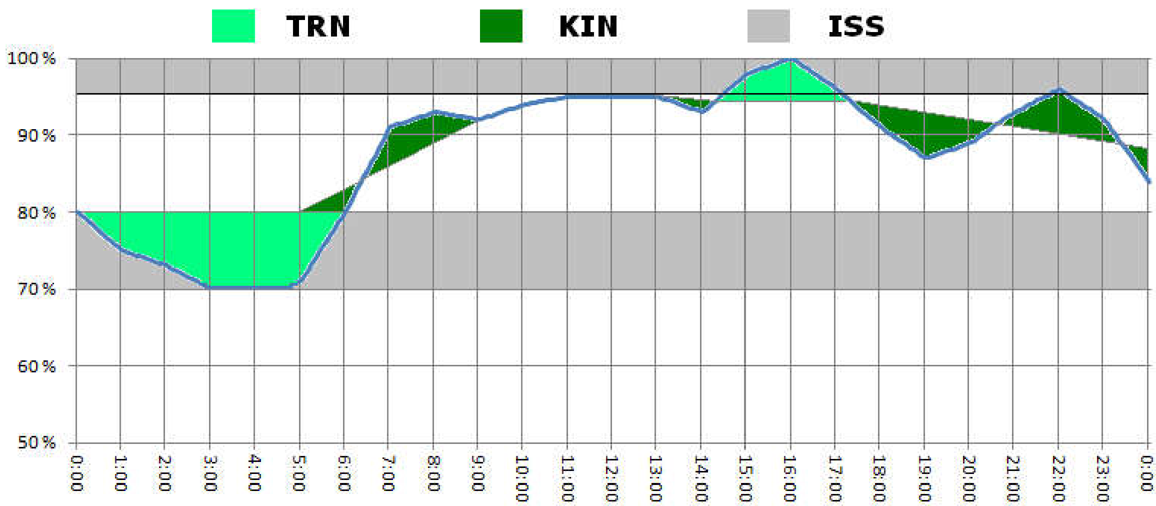
Source: Bajor, 2014

While the supply chain of water incorporates several storage facilities (reservoirs, water towers, etc.) and pushes – in this case, pumps- the product directly to the customers who get their water from already available stock, the electricity chain works differently. Due to the very limited options for storing electricity, the chain operates with a variety of protective capacities – power plants with different physical abilities and different price-regulations –to ensure the availability of compensating backup-resources. In the case of water, the product is waiting in the place of use for the consumer who only needs to open a faucet, while in the case of electricity, the consumer gets electricity straight from production by switching on the light.

3. THE IMPORTANCE OF STORAGE IN OPTIMIZING THE ELECTRICITY SUPPLY CHAIN

In a pull supply chain, procurement, production and distribution are demand-driven rather than to forecast. Toyota Motors is frequently used as an example of pull production, yet the company follows the "supermarket model" where limited inventory is kept on hand and is replenished as it is consumed (Ohno, 1988). In the electricity supply chain, the availability of these safety inventories is highly limited, thus making the supply chain vulnerable to unforeseen events or sudden changes in demand. While options like hydroelectric pumps, batteries, flywheels, compressed air, thermal energy and hydrogen are all used in storing electricity, their production and operation is expensive and their availability is limited (Energy Storage Association, 2012). The United States, the world's second largest energy consumer has around 0,023 TW of storage capacity (of which 96% is generated by hydroelectric energy), while the average daily consumption is more than 11,35 TWh (Electric Power Annual, 2015). Storage in the electricity supply chain has many important functions, like providing resource transfer (TRN), networks savings (ISS) and kinetic advantage (KIN) (see on Fig. 4).

Figure 4. The role of storage in electricity supply



Source: Bajor (2014). pp. 91.

While energy storage is a great possibility by itself, the electricity of electrical energy cannot be stored, or just in limited ways and amount. Electricity must be used as it is being generated, or transformed to another form immediately. This means that the system has losses in the process of transformations, but these losses are mostly inferior to the losses of other processes, which operators apply to regulate the system (Papp, 2015). Due to this condition, we believe that the behavior of all actors – including consumers- in a smart grid may become vital.

4. THE ROLE OF ELECTRIC CARS AND ELECTRIC CAR OWNERS IN STORING AND BALANCING ELECTRICITY

According to several researchers, with the emergence of technologies like plug-in hybrid (PHEV), fully electric (EV), vehicle-to-grid (V2G) and grid-to-vehicle (G2V) vehicles, the storage and management of electricity could better be secured (Hannan et al, 2017; Putrus et al, 2015; Gennaro et al, 2014). One of the biggest obstacles in electric car penetration has always been the price of the battery, which takes up a significant amount of 30-40% of the total retail price. In 2010, 1 KWh of electric car battery cost $1000, with predictions that by 2020, it can decrease to around $225. In 2017, 1 KWh of electric car battery costs $195, and predictions believe it may drop a further 40% in the upcoming year (Institute for Energy Research, 2016).

EV batteries have considerable energy storage capacity (from 20 up to 100 kWh) that can be used in various ways to balance high and low demand periods, or even to upload electricity to the grid when it is needed. Controlled charging allows a schedule whereby EVs can be charged at a time when the grid has surplus capacity (e.g. surplus renewable energy) and discharged when the grid has a shortfall in capacity (Putrus et al, 2015). Smart chargers allow consumers and system operators to control the output (charging rate and time) based on grid state (available power) and EV user requirements, while EV aggregators are able to aggregate supply and demand for electricity in EV batteries and to intermediate transactions between the different consumers of V2G and G2V services (Niesten et al 2016). Vehicle-to-grid (V2G) electric vehicles can return power stored in their battery back to the power grid and be programmed to do so at times when the grid needs to reserve power. Since providing this service can lead to payments to owners, it effectively reduces the life-cycle cost of owning an electric vehicle (Parsons et al, 2014) (Hannan et al, 2017).

According to a research conducted by Pwc Hungary in 2015, the number of electric cars is predicted between 53,000 (realistic scenario) and 140,000 (optimistic scenario) by 2023. Calculating with an average battery capacity of 50 kWh, the storage capacity controlled by electric car owners will be around 2,65-7 GWh, which represents 2-5% of the predicted average daily electricity consumption in Hungary (Pwc, 2015).

While an overall proportion of 2-5 % is not high, and does not require the integration of additional generators or power plants into the system, considered as a storage capacity and system-balancing tool, 2-5% of additional storage could be a significant factor in the Hungarian electricity supply chain. Due to its geographical location and characteristics, hydroelectric pumps can not be installed and cannot be operated effectively in Hungary, therefore, 2-5% of storage could eliminate many risks and - with appropriate consumer involvement - could be an effective tool in managing the peaks and valleys caused by the fluctuation of daily energy demand.

According to Lo Schiavo et al (2013), 80 % of the EV recharging activity will take place at home, out of convenience. This requires relevant technological and infrastructural developments and improvements in both households and in energy networks, and a certain amount of orderliness and discipline from the consumers. There are several options of cooperation for EV drivers, such as smart batteries and chargers operated by system operators, scheduled charging, uploading electricity to the grid when needed, and others (Yu et al, 2014). Co-operations with the supply chain are regulated by contracts between the parties, and usually provide benefits for cooperating consumers. Consumer benefits vary from country to country, and may include tax credits, exempt of VAT or registration tax, free or discounted parking, the possibility to use carpool lanes or public transport with a discounted price, reduced electricity prices and other state funds. The purpose of incentives is to persuade electric car owners to take part in the optimization of the electricity supply chain by deliberate and scheduled charging or energy uploading.

Hungary currently has approximately 15,000 electric cars, but the regulation and incentive system is still in the developmental phase (Central Statistics Agency, 2016), therefore future owners are not fully aware of all incentives or of the possible ways of cooperation. The next chapter investigates the attitude of potential electric car buyers towards the existing incentive system, the expected benefits and the willingness of electricity consumers to cooperate with the chain as electric car owners.

5. RESEARCH METHODOLOGY

As a research methodology, respondent-driven, or snowball sampling was applied in the preliminary phase. First, a group of respondents (correspondence students at Dunaújváros University of Applied Sciences, Hungary) were chosen then respondents recruited further subjects from among their acquaintances who fulfilled the questionnaire online (N=211). The other group of chosen respondents have a residence in a 40 km radius of the city of Paks, which is the flag-bearer city of Hungarian e-mobility. Hungary's only nuclear power plant is located just outside the city, and both local and national governments are working on transforming Paks into the first Hungarian city equipped with a complete electric transportation infrastructure. Because of the proximity of the nuclear power plant, perceived income and general knowledge on vehicle-to-grid (V2G) and grid-to vehicle (G2V) technologies were expected to be higher than the Hungarian average. Generally, we can say that our respondents originate from middle Hungary.

As snowball sampling is usually applied to locate and identify specific or hidden groups in population, this research method enabled to study a group of people, who - based on their geographical location and perceived high income - might be interested in purchasing electric cars and in contributing to the optimization of the national electricity network. Applying snowball sampling, however, also limited the research, as with this sampling technique, it is impossible to determine the sampling error or make inferences about populations based on the obtained sample. Another limitation is that most respondents were located in central Hungary, and results might be different if sampling was made throughout the country.

6. RESEARCH RESULTS

Based on the theory of Diffusion of innovations by Everett Rogers, electric cars with their complex infrastructure belong to the group of innovative products, therefore their current Hungarian buyers are so called early adopters who "are typically younger in age, have a higher social status, have more financial lucidity, advanced education, and are more socially forward than late adopters" (Rogers, 2003). The results of this research confirm Rogers' theory, as the 70% of the respondents are between 25-45 years old, and 73,8% of them have at least a Bachelors' degree.

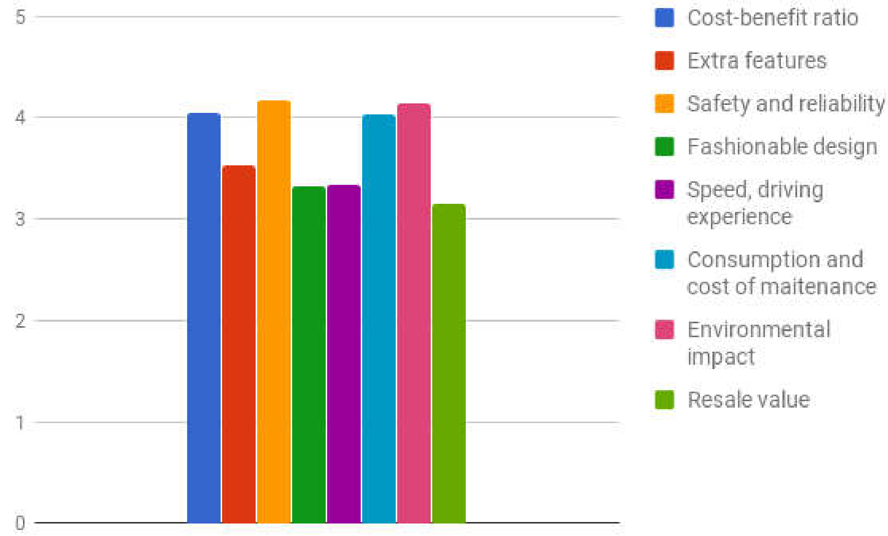
As expected initially, the financial conditions of the respondents are above the Hungarian average, as Paks region has the 9th highest income in Hungary. While the average net salary in the Hungarian administrative sector in 2016 was around EUR 500 and around EUR 580 in the private sector (Hungarian Central Statistical Office, 2017) the respondents' net income is mostly either between EUR 645-1000 or above EUR 1000. This is an important factor regarding e-mobility, as electric cars are still relatively expensive vehicles.

According to a representative survey of Robert Bosch Hungary conducted by Medián Public Opinion and Market Research Institute, 44 % of the Hungarian families had at least one car in 2016, and the average car owned by Hungarian households was 13,2 years old (Bosch Media Service Hungary, 2016). Average Hungarian buyers seek used petrol cars up to EUR 7,000, similarly, the respondents of this research mostly prefer used cars (72%), and 33% of them plan to buy - preferably used - cars in the next 2-5 years. Despite the financial limitations, respondents are open to and aware of new, environmental friendly ways of transportation, as 98% of them stated they are familiar with hybrid, 88,2% with electric, and 74,4% with plug-in hybrid cars.

Before investigating the respondents' attitude towards electric cars and offered incentives for electric car users, the most important factors influencing car-buying behaviors were reviewed – as a measurement tool, 5-point Likert-scales were used. As seen on Figure 5, respondents indicated 'safety and reliability' of the car as the most important. Despite the fact that respondents mostly seek relatively cheap and used cars, fulfillers indicated environmental impact as the second most influential factor considered before buying a car. While the number or conscious consumers has grown significantly, Hungarian individual buyers became more deliberate (the size of the market of electric cars has tripled in size between 2014-2016) (GfK Research, 2017), individuals participating in this research also consider the cost-benefit ratio and consumption and cost of maintenance as highly important.

While the amount of money respondents are planning to spend on their next car (around EUR 3225-12900) is relatively low, 14,8% of the respondents stated they would buy a hybrid or pure-electric car as their next vehicle, while 36,2% would consider buying an electric car given the sufficient amount of state support or additional benefits.

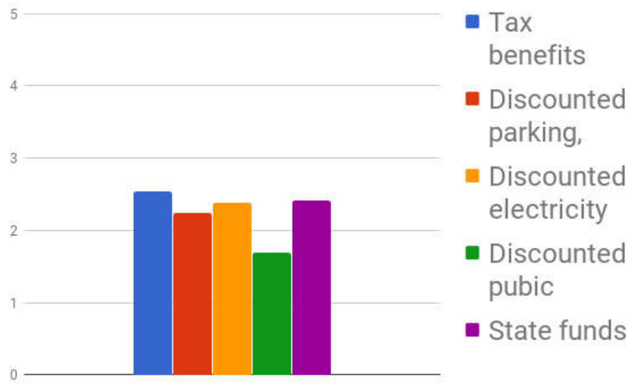
Figure 5. The most important factors considered before purchasing a car



Source: own study

According to respondents, the most favored state aids provided for electric car users are tax benefits, various state funds, and discounted electricity prices, while discounted parking and public transport are less appealing, but still attracti ve options (see Figure 6). Currently, the state funds provided by the Hungarian government cannot be higher than EUR 3,000 or 21% of the retail price of the vehicle.

Figure 6. Favored incentives and state-supplied benefits of electric car ownership

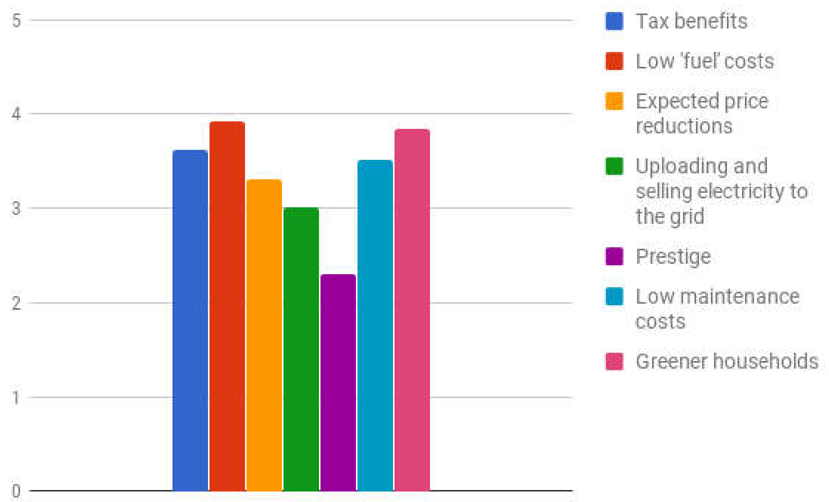


Source: own study

Regarding the main, perceived benefits of electric cars, respondents believe that the biggest benefits are the low fueling costs and the greener households, while tax benefits, low maintenance costs and expected price reductions are less at tractive options (see Figure 7). In Hungary electric fueling is free and currently this is the largest state support. Fortunately there more and more fueling points throughout the country therefore we can find more electric stations in Budapest and at leas t one in towns as well. So this benefit is quite natural and expected. Environmental consciousness has been developed in Hungary and this aspect may explain the found second important benefit. Respondents rated prestige as the least favored benefit of an electric car ownership.

As chosen respondents (and many of their acquaintances) originate from and around Paks (the city where the Hungarian Nuclear Power Plant is located), both income and knowledge of this field are above national average.

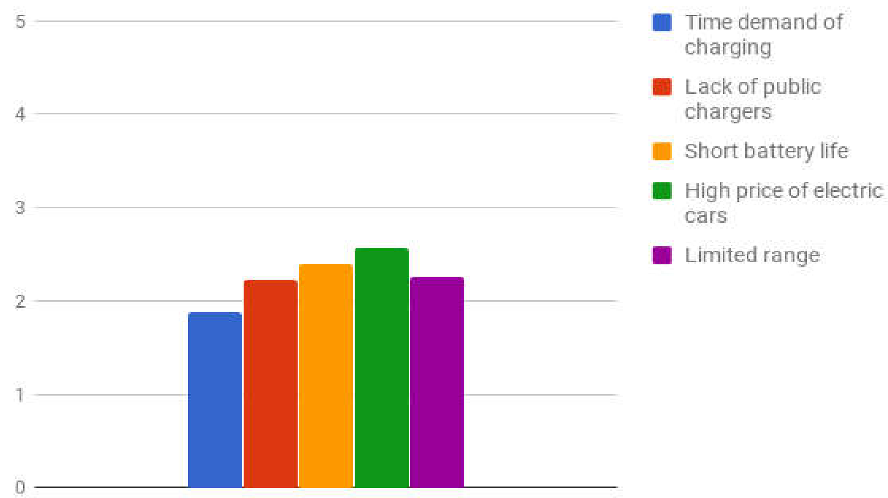
Figure 7. Perceived benefits of electric car ownership



Source: own study

When identifying the barriers of electric car penetration, there was no consensus among respondents. As seen on Figure 8, respondents had to prioritize what they considered as the most or least influential factors preventing electric car penetration – it has been confirmed that respondents consider all investigated factors as important barriers. These results indicate that further details and aspects should be investigated, possibly through qualitative methodologies.

Figure 8. The main barriers of electric car penetration (means)



Source: own study

When it comes to accepting the interference of system operators and smart solutions into charging and availability, 44,2% of the respondents believe they would be able to accept the limitations of the system (charging when electricity demand is low, and uploading energy when electricity demand is high) if the government or actors of the supply chain would offer concrete, measurable benefits in return. 17,5% of the respondents believe, that the supply chain can only be balanced with direct and centralized control over charging, and they state they would contribute to this effort if they owned an electric or plug-in-hybrid vehicle. Out of 211 respondents, only 38 (18,4%) stated that they would categorically not give up their freedom of constantly available, unlimited range (fossil-fuel vehicles), as their lifestyle or travelling habits require them to be available at any time, in any range. Based on the results of international researches (eg. Parsons et al, 2014) this level of consumer support is surprisingly high and needs further investigation and validation.

7. CONCLUSIONS

The emergence and penetration of electric cars and the related technological potential raise a number of questions – on both national and on a worldwide level. Will this technology be greener, smarter, more sustainable and effective in reaching goals like energy efficiency and conscious consumption of electricity? Based on our research, we can say that it strongly depends on the consumers: their behavior, attitude and perceived role in the electricity supply chain. Based on this research, we can say that in order to balance, operate and control the uncertainties of the electricity supply chain, the active and deliberate involvement and cooperation of electric car users is inevitable.

Preliminary results of this research are encouraging, as respondents claim they are open to the provided possibilities of this new technology, however, some results are contradictory and require further and deeper – possibly international-investigation. Contradictory results – like importance of environmental impact vs. money spent on cars, or the willingness of using electric cars vs. intended amount of money spent) may also be a result of direct or indirect social pressure or lack of information, and also need further investigation.

8. REFERENCES

Amin, S. M., & Giacomoni, A. M. (2012). Smart grid, safe grid. *IEEE Power and Energy Magazine*, 10(1), p. 33-40

Armstrong, M., El Hajj Moussa, C., Adnot, J., Galli, A., Riviere, P. (2013). Optimal recharging strategy for battery-switch stations for electric vehicles in France. *Energy Policy*; Volume 60, p. 569–582

Bajor, P. (2007). The bullwhip-effect in the electricity supply. In *Proceedings Papers of Business Sciences: Symposium for Young Researchers (FIKUSZ),* p. 19-25

Bajor, P. (2014). *Vezetékes ellátási hálózatok logisztikai rendszer-modellezése* (unpublished doctoral dissertation)

De Gennaro, M., Paffumi, E., Scholz, H., Martini, G. (2014). GIS-driven analysis of e-mobility in urban areas: An evaluation of the impact on the electric energy grid. *Applied Energy*. Volume 214, p. 94–116

Energy Storage Association (2015): Pumped Hydroelectric Storage [available at: http://energystorage.org/energy-storage/technologies/pumped-hydroelectric-storage, access April 3, 2017]

Euroepan Commission (2010). EU Strategy for the Danube Region [available at: http://ec.europa.eu/regional_policy/en/policy/cooperation/macro-regional-strategies/danube/ , access April 5, 2017]

Eurostat (2017) Electricity price statistics [available at: http://ec.europa.eu/eurostat/statistics-explained/index.php/Electricity_price_statistics , access May 22, 2017]

GfK Research (2017): The conscious consumer report [available at: http://www.gfk.com/hu/insightok/report/tudatos-vasarlo-riport/, access May 10, 2017]

Giordano, V., Gianluca, F. (2012). A business case for Smart Grid technologies: A systemic perspective. *Energy Policy*. Volume 40, p. 252–259

Han, W., Yang Xiao (2016). Privacy preservation for V2G networks in smart grid: A survey. *Computer Communications,* Volumes 91–92, p. 17–28

Hannan, M. A., Hoque, M. M., Mohamed, A., & Ayob, A. (2017). Review of energy storage systems for electric vehicle applications: Issues and challenges. *Renewable and Sustainable Energy Reviews*, Volume 69, p. 771-789.

IEEE (2011). Draft Guide for Smart Grid Interoperability of Energy Technology and Information Technology Operation with the Electric Power System (EPS), and End-use Applications and Loads [available at: http://ieeexplore.ieee.org/document/5975181, access May 4, 2017]

Kempton, W., Tomić, J. (2005). Vehicle-to-grid power implementation: from stabilizing the grid to supporting large-scale renewable energy. *Power Sources*; Issue 144, p. 280–294

Lo Schiavo, L., Delfanti, M., Fumagalli, E., Olivieri, V. (2013). Changing the regulation for regulating the change: Innovation-driven regulatory developments for smart grids, smart metering and e-mobility in Italy. *Energy Policy*. Volume 57, p. 506–517

Loisel R., Pasaoglu G., Thiel C. (2014). Large-scale deployment of electric vehicles in Germany by 2030: an analysis of grid-to-vehicle and vehicle-to-grid concepts. *Energy Policy*; Volume 65, p. 432–439.

Morte, M. (2016). E-mobility and multiagent systems in smart grid. In *Electric Power Engineering (EPE)*, p. 1-4

Niesten, E., Floortje A. (2016). How is value created and captured in smart grids? A review of the literature and an analysis of pilot projects, *Renewable and Sustainable Energy Reviews*, Volume 53, p. 629–638

Ohno, T. (1988). *Toyota production system: beyond large-scale production*. crc Press.

Papp, M. G. (2015). Economic modeling of energy storage plants in Hungary. In *Energy (IYCE)*, 2015 5th International Youth Conference on (pp. 1-7). IEEE.

Parsons, G. R., Hidrue, M. K., Kempton, W., & Gardner, M. P. (2014). Willingness to pay for vehicle-to-grid (V2G) electric vehicles and their contract terms. *Energy Economics*, Volume 42, p. 313-324

Putrus, G., Lacey, G., & Bentley, E. (2015). *Towards the Integration of Electric Vehicles into the Smart Grid*., Springer, p. 345-366

PwC (2015) Merre tart az elektromos autók piaca? [available at: https://www.pwc.com/hu/hu/kiadvanyok/assets/pdf/merre_tart_az_elektromos_autok_piaca-e-car_2014.pdf , access April 12, 2017]

Richardson D. (2013). Electric vehicles and the electric grid: a review of modeling approaches, impacts, and renewable energy integration. In *Renewable Sustainable Energy Review*; Volume 19, p. 247–254

Rogers, E. M. (2003). *Diffusion of innovations*. 5th Edition, Free Press, p. 183

Saleh, M. S., Althaibani, A., Esa, Y., Mhandi, Y., & Mohamed, A. A. (2015, October). Impact of clustering microgrids on their stability and resilience during blackouts. In *Smart Grid and Clean Energy Technologies (ICSGCE), 2015 International Conference on* (pp. 195-200). IEEE.

Sioshansi, F. P. (Ed.). (2011). *Smart grid: integrating renewable, distributed and efficient energy*. Academic Press, p. 118

Somogyi, L. T. (2016). *Az autóipar jövőjét meghatározó trendek elemzése*, BGE Budapest, (Unpublished master's thesis)

US Energy Information Administration (2016) Electric Power Annual 2015 [available at: https://www.eia.gov/outlooks/ieo/pdf/0484(2016).pdf, access April 3, 2017]

Veres, L. (2014). Logisztikai kihívások a villamos energia hálózatok hatékonyságának javításában. *Logisztikai Évkönyv*, p. 62-68

Yu, R., Ding, J., Zhong, W., Liu, Y., & Xie, S. (2014). PHEV charging and discharging cooperation in V2G networks: A coalition game approach. *IEEE Internet of Things Journal*, Volume 1(6), p. 578-589