Anna ZIELIŃSKA

AGH University of Science and Technology,
Faculty of Electrical Engineering, Automatics, Computer Science and Biomedical Engineering

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Model for settlement electric vehicles charging and financing infrastructure for charging them with the support of blockchain environment

Abstract: *The paper presents a model of potential application of technology and blockchain environment for the implementation of the electric car charging process. The described model gives the possibility of establishing direct relations between the energy market parties, and most importantly, thanks to its users and relationships between them, it allows creating new charging points, thus developing a network of chargers. The model describes relationships, flows, gives the opportunity to model market behaviour. It uses blockchain technology to account for the charging process of electric cars.*

Streszczenie: *W pracy prezentowany jest model potencjalnego zastosowaniem technologii i środowiska blockchain do realizacji procesu ładowania samochodu elektrycznego. Opisywany model daje możliwość bezpośredniego nawiązywania relacji pomiędzy stronami rynku energii, oraz co najważniejsze, za sprawą swoich użytkowników i zależności między nimi pozwala na tworzeniu nowych punków ładowania, rozwijając tym samym sieć ładowarek. Model opisuje relacje, przepływy, daje możliwość modelowania zachować rynkowych. Wykorzystuje technologię bloków (blockchain) do rozliczania procesu ładowania samochodów elektrycznych. (**Model rozliczania ładowania pojazdów elektrycznych i finansowania [ICO] infrastruktury do ich ładowania przy wsparciu środowiska blockchain.**)*

Keywords: electric vehicle, model, blockchain, algorithm, charging, charging infrastructure.
Słowa kluczowe: samochód elektryczny, model, blockchain, algorytm, ładowanie, infrastruktura ładowania.

Introduction

Electromobility is one of the mega economic trends of developing countries. For Poland and other European countries, the development of electric transport is a great challenge, but also a great opportunity. Responding to the challenges facing the development of electromobility requires achieving an adequate level of market saturation with electric vehicles (EV), but also providing them with charging infrastructure, which, for example, forces the modernization and expansion of transmission and distribution grid [1]. This is a chain reaction, because the construction of infrastructure for charging cars will contribute to technological development, and the service of the charging process will give the opportunity to develop new concepts such as the use of technology and the blockchain environment. Such synergy creates the possibility of real integration of vehicles with the power system, financial market, IT industry and new technologies and is able to stimulate the development of this branch of industry [2].

Poland is not the first country who seriously think about electric motorization. The Netherlands and Norway have already started internal discussions on the ban on the sale of diesel cars after 2025. Sales of electric cars are still growing, talking about Norway in the first half of 2019, about 40% of newly purchased cars were electrically powered and electrified (Fig. 1) [3].

However, in order for electromobility to become a real alternative to conventional means of transport, its implementation must be preceded by modeling of technological processes and comprehensive economic analysis, and most importantly by the development of the infrastructure of chargers.

The paper presents the description and assumptions for the potential application of technology and blockchain environment to the process of charging an electric vehicle, which gives the possibility of establishing direct relations between the parties of the energy market, and most importantly, thanks to its users it actively participates in creating new charging points, developing same charger network. The model describes relationships, flows, gives the opportunity to model market behavior. The use of block technology to account for the process of charging electric cars is possible, but requires a lot of support not only from the ideological side, but also from the development of infrastructure, charging points and the popularization of electric cars.

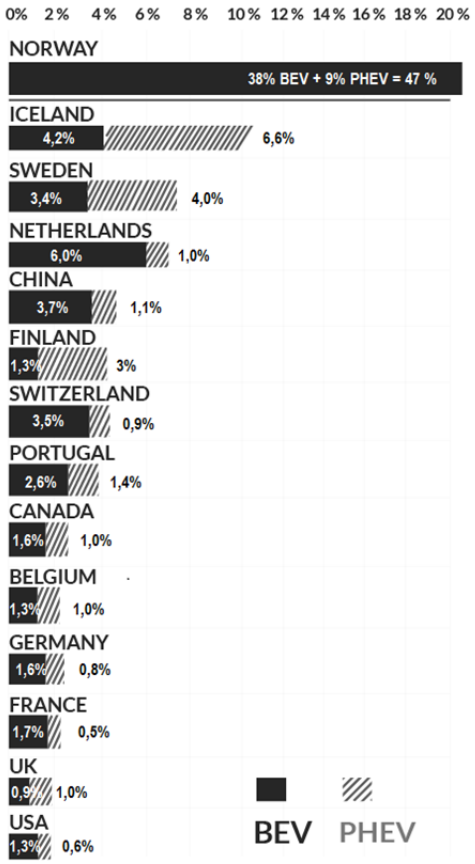

Fig.1. Share of electric vehicle sales in the car market [3]

Blockchain technology is so new that the environment of investors, users and speculators began to look for investments through issuing tokens (Initial Coin Offer (ICO) [4]) in investments with hard assets. In the blockchain environment there are very few projects that can be supported by the Initial Coin Offer, and the investment will be secured and made, for example, by an electric vehicle charger. Such projects are already being implemented in the world and enjoy great interest in both the blockchain environment and the electrician industry. The model presented below describes the scenario where the charging infrastructure was 100% financed by the ICO, and the tokens from the issue were as bonds transferred to investors, and the built infrastructure gives the possibility of charging vehicles to ordinary users who charge the vehicle unconsciously using the benefits of blockchain environment.

Operation of the model

The economics of value management in the financing and accounting model in the infrastructure for charging electric vehicles can work in many ways, including the option of using a blockchain layer. The presented model assumes the combination of electrical engineering, economics and new technologies to manage the process of charging electric vehicles, which will directly build new charging points through its users [5]. The main assumptions are:

- developing a model which will result in maximizing potential profits for investors, proportional to the rapid increase in the value of the electric vehicles charging market,
- creating a model striving to reduce the number of tokens, and in the medium term burning / buying all tokens and ending the life of token economy in the system, while leaving the network active for charging electric vehicles,
- lack of visibility of token economy and blockchain technology for the "ordinary" electric vehicle user who uses a network of electric car charging stations,
- linking the value of the token to inflation and the value of electricity.

Currently, thinking about Poland, the infrastructure for charging electric vehicles is very early in the development, therefore the resulting model is based on a value and investment token (value / equity token (VET)) [6]. Such a token can be used to raise the right amount of funds for an investment in infrastructure for charging electric vehicles, but also to use the same system for accounting for charging cars and to activate the community of token owners to control the dynamics of investment. Thus, due to the tokenization of the process of building chargers, one of the objectives of the resulting model is a real participation in obtaining funds for the construction and development of the infrastructure of chargers, and handling the process of electricity flow in the charger.

To talk about token economy, you need to start from the beginning, it is necessary to understand how blockchain works, and more precisely what tokens are emitted on the blockchain platform. For example, consider the Ethereum [7, 8] platform founded, among others by Vitalik Buterin.

In the described model, an algorithm must be created that will represent the behavior of individual cells in a distributed database. These cells have a fixed part of the code, describing e.g. the only functions that a cell can perform and what data it can store, but they can also have variable elements in them, e.g. the status of a given value, or e.g. the effect of calling a function in given cell. This whole algorithm and a set of constant or variable number of database cells is called cryptocurrency (algorithm - cryptocurrency) [8].

The desire to participate in the market of chargers and the electricity market is closely related to Initial Coin Offering (ICO) [4], which is a kind of creation of an algorithm, cryptocurrency, which defines how tokens will be issued (created) by the system, or when will be transferred between owners (e.g. a record in the Ethereum database of a private key to which a token is assigned) or burned, colloquially speaking destroyed/deleted.

ICO is a very similar tool to the public issue of securities on the stock exchange, only in this case instead of shares or bonds, the investor receives tokens. ICO usually has a specified: minimum and maximum number of tokens that must be paid (real currency, i.e. fiat money or other cryptocurrency), it also has the entire algorithm of tokens economics and all the rules how they will perform their role: in the case of the described model - investment role (equity) as well as settlement role and value carrier (value).

So how do you apply this mechanism to an investment that can build thousands of electric vehicles charging stations? The given model gives an interesting option, using just the ICO to raise the appropriate capital needed for capital expenditure (CAPEX - capital expenditures) [9] building a charging station, which in addition to the investment token gives a lot more benefits to the potential investor and is consistent with the assumptions and objectives of the model.

Actors of the electric vehicle charging algorithm

To thoroughly understand the idea of the blockchain model, it is worth first getting acquainted with its participants - called *actors* performing their roles. There are four of them in the presented model:

- *Beneficiary* of the electric vehicle charging station network – he invokes the ICO algorithm and cryptocurrency and is both an IT and technical administrator over the technology of chargers. It is a real owner who will benefit from this model in the long run. It is also the party responsible legally and financially for the success or failure of the project.
- *Investors (Token Holders)* – is an international community with the intention of investing in cryptocurrency during ICO, which after passing the Know Your Client (KYC) [10] process sends money (fiat money) or other cryptocurrency that is accepted under ICO, and which the beneficiary can exchange for fiat money in cryptocurrency exchanges / exchanges and use for investment.
- *Customers (User)* – i.e. users of electric car charging stations, de facto providers of the margin from the charging service, which will be transferred to the beneficiary and investors through the economy of tokens or simple settlement.
- *Blockchain algorithm (cryptocurrency*) – applied to the charger network. He also plays a very important role, because he settles the effect of the electricity charging service, activates the billing system of tokens and settles or initiates functions stored in the algorithm on the blockchain.

Model operating principle

The operation of the algorithm is largely based on flows (electricity, cash, tokens). It is not linear, we can say that it acts on three levels and its actors interact with each other.

The easiest way to understand its operation is by example. Let's assume an example scenario based on one charger (off – board) [10] and make the following assumptions:

- The investor invests EUR 5000 and transfers them to the Beneficiary.
- The Algorithm automatically generates 25000 tokens to the Investor.
- The beneficiary for the received money buys and installs 1 charger for an electric car and sets the price 0,40 EUR/kWh for users.

If you want to charge an 100 kWh electric car, you have the following options:
a) Purchase of 100% energy for fiat money at EUR 0,40, which gives EUR 40 for charging
b) purchase of 50% energy for fiat money, i.e. EUR 20 and 50% energy using vouchers (see item 5.E), seen at the auction for 80% of the current price, i.e. EUR 16

What will happen in this model in scenario a):
The beneficiary will accept EUR 40, pay for OPEX[1] (operating expenditures) including the cost of purchasing electricity, will collect the remaining profit.
The algorithm will generate "100 (in relation to energy) x Degradation Factor (e.g. 0.5)" which gives 50 new tokens and assigns them proportionally to Token Holders (in this case to one already having 25000 tokens) another 50 tokens with the current value of "50 x EUR 0.40 ", i.e. the value of one charge of EUR 20. The algorithm will increase the number of tokens on the blockchain by 50 pieces.

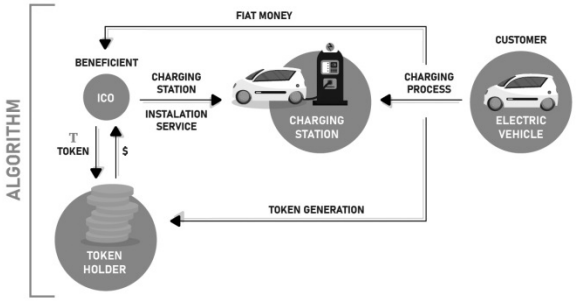

Fig. 2. Scenario a).

What will happen in this model in scenario b):
The beneficiary will accept EUR 20, of which OPEX will pay, including the cost of energy, most likely he will not be able to make an operating profit from this transaction.
The algorithm of the remaining EUR 16 will be given to the Investor and his 50 tokens, which he sold as a voucher, will burn, i.e. will be deleted from the total pool of tokens on blockchain. There will be a degradation of the number of tokens in the system, and the other token owners will benefit from this by increasing the capitalization of the entire number of tokens to the total investment.

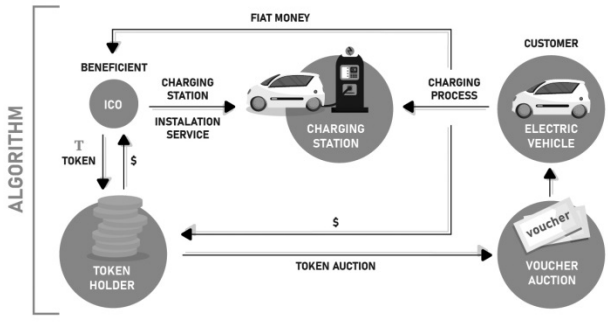

Fig. 3. Scenes b).

[1] OPEX - the sum of operational expenditure, i.e. related to maintaining the product or system [9]

Relationships between model users
Due to the fact that there are several actors in the algorithm and they perform very different, peculiar roles for themselves, the relationships between them must be strongly ordered. The easiest way is to use the diagram (Fig. 4) and additionally a description of the interaction between the actors, i.e.

A. Beneficiary vs. Algorithm
The Beneficiary is the creator of the Algorithm. He chooses the environment (a type of blockchain platform), he chooses the token economy model, he must also be credible for investors to participate in ICO, but he also carries out credibility of investors through the KYC process, which identifies and selects investors. He is also legally responsible for the final use of investment capital and is accountable to promises by the blockchain community. Legal regulations functioning in Europe already allow legal liability to be real and the ICO procedure itself takes place in the culture of traditional capital investment. The bridge of these two actors is the blockchain platform, e.g. Ethereum. Moreover, even in Poland, from 2010 it will be possible to establish a Simple Joint Stock Company whose issue of shares may take place through the ICO process [12].

B. Investor vs. Beneficiary
The Algorithm combines these actors. Once saved, the rules as token economy remain until the end of the investment. The decentralized and automatic structure of the algorithm's functions means that investors, by reading the document describing the operation of the Algorithm and the ICO itself, are willing to entrust their money to the Beneficiary. Once saved, the algorithm should be immutable and ensure that the risk of fraud or extortion is limited, because we remember that the blockchain community is global and the only thing an investor can rely on is the blockchain platform and the well-designed algorithm itself.

C. Customers vs Beneficiary
This relationship is the simplest representation of a business relationship, the user and owner of the network, i.e. the bridge in this relationship is the charger itself, or rather a mobile application through which the user buys electricity, kilowatt hours (kWh) to his vehicle by paying cash (fiat money).

D. Investor vs. Algorithm
The relationship between these actors is described in points A and B.

E. Investor vs. Customers
This is the most interesting combination of relationships. Because the bridges in this relationship are both the Algorithm itself, the charging station and an additional function designed in the model, i.e. a system of vouchers and their auctions. As we know, the purpose of the model assumes the lack of visibility of the blockchain environment within the ICO by the charging station user. It is important because the operation of the charging system for the end user must be very simple and built with great trust in the charging station operator. Technology blockchain and cryptocurrencies in themselves are not yet a carrier of social trust, they create controversy, but they are the technology of the future. So the use of a trick in the form of an intermediary between the world of blockchain and cash can be just a classic voucher, which is why a voucher system has been introduced into the model. We can imagine it in such a way that the Customer wanting to buy a kilowatt hour, can simply buy it at the price of "X EUR" or in

his purchasing system (e.g. mobile application) will see the voucher purchase offer, which is, e.g. 98% of the value of one kilowatt hour. The voucher purchase option represents the token put up for sale by the Investor, who decided to close this part of his investment and wants to sell the token. On the one hand, we have a reverse auction list (who will give cheaper), and on the other hand the user sees vouchers for purchase with a given value - of course, only lower than the current value of 1 kWh.
This system means that when purchasing a voucher, it automatically changes to 1kWh, and the payment by the user is transferred via the Algorithm to the Investor, automatically burning the token (which represents 1kWh / each token). Thanks to this, the number of tokens in the Algorithm decreases and the user has "cheaper" charging of the electrician.

F. Algorithm vs. Customer
One of the assumptions of the model is the fact that the charging station user cannot see the algorithm. The Customer is the final source of income for the network in which Investors operate, and in the long run only the actual Beneficiary (the algorithm is designed so that the number of tokens tends to zero during the time striving for infinity). Therefore, the customer does not see all the ICO and blockchain effort, because it is only an investment stage. The same as if he did not see the bondholders who invested in the company that owns the station network in the classic business model.

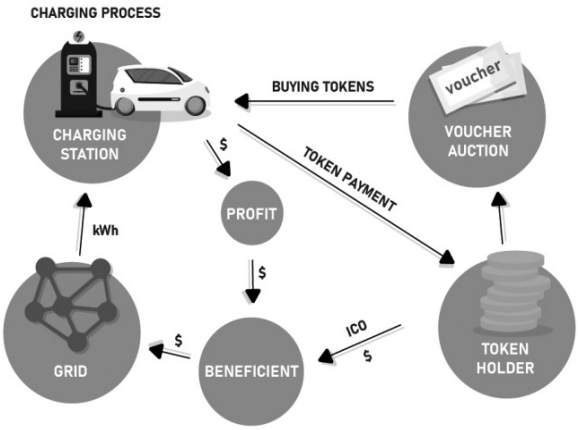

Fig. 4. Relations between model actors

Basic work of the model

When we talk about the functions of the model, we mean the principles of its operation, i.e. the work of the entire algorithm that supports the entire process of charging an electric vehicle. It's how the whole "body" works, how the number of tokens is regulated, what is the flow of electricity, how is the user treated, where are the flows of tokens and funds. By identifying the function of the model, it will be possible to simulate and infer about the impact of tokenization on the development of electromobility. Currently, blockchain gives a lot of opportunities, it is able to penetrate to many market mechanisms (including the electricity market) which gives the opportunity to develop and combine technologies. The simplest functions of the algorithm are to consider individual issues, to grade their diversity and interrelationships.

Starting from the beginning, it is worth analyzing the functions of a single token, which in the model corresponds to the price of 1 kWh of electricity in the charger. The entire token economy system was based on the fact that the value of the token is speculatively limited, i.e. it will not reflect investor sentiment in the context of investment processing and development, but will reflect or oscillate around the value of 1 kWh in the charger corresponding to the market value of this kWh. It can be safely assumed that the demand for electricians will be inflexible and the price of electricity in Europe will rise, which will cause a sharp increase in electricity prices in chargers. Few chargers vs. a large number of cars, in addition, the growing price of electricity on the stock exchange, an increase in the value of charges per ton of CO_2 and we have an effect.

Another aspect of the functioning of the model is the possibility of exiting the investment for the Investor - the model provides for several solutions. The first option is the classic sale of equity token on the cryptocurrency exchange, and the second faster option, when there is sufficient demand for charging electric cars, will be the sale of the token as an electricity voucher to the end User of the charger (see section Relations between the Investor and the Customer above).
The algorithm assumes an irregular number of tokens. The number of tokens in the Algorithm will be different, there are no target ranges during the investment, but their number will degrade naturally by introducing the "degradation factor". The principle of the degradation factor in the Algorithm refers to the situation in which the User has no option (or deliberately resigns from it) during the investment period and buys kilowatt hours (kWh) in the charger for fiat money by resigning from vouchers (see section *Model operating principle a).*). notes the algorithm. Thus increasing the number of tokens saved in the blockchain, as a bonus for current token holders (Investors) in such a way that for each 1 kWh paid in the charger network Algorithm generates a new number of tokens equal to "paid kilowatt hours x degradation factor". This ratio is initially equal to 0,5, but over time it should decrease and go to zero. The model assumes that every two years it will decrease by 0,05 and in 10 years it will be equal to 0.

ICO will start digitized as 1 charger worth EUR 5000 in the investment (estimated value). For every EUR 5000 investment, 25 000 tokens will be issued, which is equal to EUR 0,20 / 1 token. In today's medium voltage chargers (e.g. 22kWp - for which there is demand in service areas: shopping malls, hotels or restaurants) 1kWh costs PLN 1,5-2,0, i.e. EUR 0,35-0,45 per kWh. Therefore, the discount that the Investor gets at the start of the investment is very interesting and even by immediately selling his tokens as vouchers to end users, the system generates above average profits for him.

The algorithm's work also provides for limiting the purchase of vouchers. When buying electricity in a charger, the customer can buy any number of vouchers that are available at reverse auction, but cannot use them alone. Each voucher for 1kWh must have a companion in the form of 1kWh purchased for fiat money (see section *Model operating principle b).*). This limitation has a deep systemic sense, because the Beneficiary pays for every kWh in the purchase cost (energy purchased from the network), which he sells to the User (during the charging process). If 100% of this stream of money would flow to investors, the Beneficiary would probably go bankrupt. Keeping the principle of balance, i.e. 50% of the cost of purchasing electricity is financed by live cash, it is able to cover 100% of the cost of electricity and operating costs of the so-called OPEX. The remaining part, i.e. the margin, can be transferred directly to Investors.

Summary

Observing the electromobility market, one can immediately notice the dependence of demand for electric cars with supply to charging stations and vice versa [13]. It is known that without electric cars there will be no stations, and without charging points there will be no electric vehicles. This is a classic casus of eggs and chickens. The presented model ideally meets both needs, giving the possibility of financing the charging station before there is sufficient demand for charging. By introducing dependencies between process users into the blockchain layer, the user (the owner of an electric car) has the chance to influence the development of the emerging infrastructure. The actors presented above in the medium term will jointly create business, billing and algorithmic relationships. They will mutually initiate events, which in their essence are in the blockchain environment called token economics or value economics, and in the real world will increase the share of electric cars in general wheeled transport.

The model gives the opportunity to conduct all simulations mapping social, economic and market behavior (related to electricity), the results of such simulations will be part of further research on the model. At the moment, it is a tool illustrating the impact of blockchain on the development of infrastructure for charging electric cars and on the development of electromobility itself. The model has unlimited possibilities of modification, adding new segments and actors, depending on the needs, it is modifiable and at the same time intuitive for the person handling the input data. The model itself can also be a separate segment when correlating the charger with renewable energy sources (OZE), e.g. photovoltaics, of course cooperation with the distribution grid is important here [14], however, with such an expansive development of renewable energy, this is an additional advantage of the model's functionality.

By connecting actors and the energy market, it becomes a kind of communication bridge, through which the interaction between the electrotechnical environments, closely related to the process of charging technology and the flow of electricity, is economical, and by locating new technologies in the blockchain area.

Author: *mgr inż. Anna Zielińska, AGH University of Science and Technology, Faculty of Electrical Engineering, Automatics, Computer Science and Biomedical Engineering, e-mail: azielinska@agh.edu.pl*

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