A PEER-TO-PEER ENERGY TRADING MODEL FOR SMEs

MODEL DE TRANZACȚIONARE CU ENERGIE PEER-TO-PEER PENTRU IMM-URI

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Abstract: *Since the advent of smart grids and prosumers, new energy trading models have emerged and the energy industry faces the challenge of integrating digital technologies to accommodate these changes. This paper provides a review of Peer-to-Peer energy trading, where energy from small-scale distributed energy resources is traded among local energy prosumers and consumers. The main advantages and challenges of such platforms are discussed in the context of integrating a small-scale generation system. The paper also elaborates the architecture of a smart energy management system of a building having a solar generation system and storing the excess energy in crypto currency.*

Keywords: Peer-to-Peer energy trading, distributed energy resources, crypto-currency

Rezumat: *Introducerea din ce în ce mai accelerată a rețelelor inteligente și a prosumatorilor în sistemul energetic a condus către apariția unor noi modele de tranzacționare a energiei, iar industria energetică se confruntă cu provocarea integrării tehnologiilor digitale pentru a face față acestor schimbări. Această lucrare prezintă noi modele de tranzacționare cu energie tip peer-to-peer, unde energia provenită din resursele energetice distribuite și de mici dimensiuni este tranzacționată între consumatorii și prosumatorii locali, prin intermediul unor platforme ce utilizează noi modele și tehnologii digitale. Principalele avantaje și provocări ale acestor platforme sunt discutate în contextul integrării cu sistemele de generare distribuită de mici dimensiuni. Lucrarea elaborează, de asemenea, arhitectura unui sistem inteligent de management al energiei într-o clădire ce utilizează panouri fotovoltaice pentru a asigura consumul intern de energie, folosind excesul pentru generarea de criptomonede.*

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Cuvinte cheie: tranzacționare cu energie Peer-to-Peer, generare distribuită, criptomonede

1. Introduction

Electricity is one of the most demanded resources because it is used in homes, factories, shopping centers; all these are found mainly in cities. The most used process of buying and selling electricity involves the traditional wholesale and local markets. But in recent years, the need for optimization of the energy trading processes has risen the interests for the Peer-to-Peer (P2P) model. This model proposes a paradigm shift in which the energy exchange between consumers helps them obtain energy at a lower price. This paradigm shift can be easily adapted thanks to the fact that the number of sensors deployed in cities continues to increase, and therefore devices can connect even if the distance between them is large. However, the new model requires an architecture with data storage capacity and real-time response, features that industrial architectures already possess [1].

With the increasing connection of Distributed Energy Resources (DERs), traditional energy consumers are becoming prosumers, who can both consume and generate energy. Electricity generation of DERs is usually intermittent and difficult to predict. When prosumers have surplus electricity, they can curtail it, store it with energy storage devices, export it back to the power grid, or sell it to other energy consumers. The direct energy trading among consumers and prosumers is called Peer-to-Peer (P2P) energy trading, which is developed based on the “P2P economy” concept (also known as sharing economy), and is usually implemented within a local electricity distribution system [2].

Section 2 of the paper presents the related work, where Peer-to-Peer (P2P) energy trading platforms are described. Section 3 illustrates the smart power management of a SME’s office building consisting of the inverters to which the photovoltaic panels are connected and where the energy surplus is used for crypto currency. Section 4 presents the envisioned energy trading platform. Section 5 concludes the paper.

2. Related work

The energy industry has grown increasingly more aware of the importance of energy trading based on the "P2P economy", and many companies have developed trading platforms to enable a P2P exchange of energy between different stakeholders in the industry.

Piclo is a British Open Utility platform that performs peer-to-peer energy trading for generators and business consumers and which provides 30% benefits to its producers selling energy on the regulated market. It is a collaboration between an innovative technology company called "Open Utility" and a renewable energy supplier, "Good Energy," where business consumers could buy electricity directly from the local renewables. It uses a matching algorithm to match local generation and consumption. Data visualizations and analytics provided to customers. The meter data, generator pricing, and consumer preference information dates are to match electricity demand and supply every half hour. Generators have control and visibility over who buys electricity from them. Consumers can select and prioritize from which generators to purchase electricity. Good Energy provides contracts, meter data, billing, award-winning customer service, and balances the marketplace [3].

The Dutch company Vandebron has an online platform in Netherland where energy consumers can buy electricity directly from independent producers, such as farmers with wind turbines. Similar to Piclo, Vandebron acts as an energy supplier who provides incentive tariffs for consumers and generators to exchange energy. Prosumers who inject surplus energy to Vandebron are able to purchase energy from Vandebron at a lower price compared with other suppliers [4].

SonnenCommunity was created by SonnenBatterie, which is a battery storage manufacturer in Germany. It is a community of SonnenBatterie owners who share self-produced energy with others with a low-priced tariff provided by SonnenCommunity. With a SonnenBatterie system and photovoltaic panels, members can completely cover their own energy needs on sunny days and even have surplus energy. This surplus energy is not fed into the power grid, but into battery energy storage that serves the community when they cannot produce sufficient energy due to bad weather. The idea is very similar to those of Piclo and Vandebron, but SonnenCommunity highlights the importance of the storage system [5].

Smart Watts was also a German project. It proposed new approaches for optimizing energy supply through the use of modern information and communication technologies (ICT), and these ICTs were developed and tested. It has exploited the optimization potential of ICT in order to achieve greater cost-effectiveness and security of supply. [6]

Both Yeloha and Masaic were trails in the US. They allow interested consumers, such as apartment owners and others who do not own solar systems, to pay for a portion of the solar energy generated by the host's solar system. The subscribers get a reduction on their utility bills, so that in total, they save money, even if they move. They are similar to Piclo and Vandebron, but more interested in solar power than other renewables. [7][8]

Swarm Energy is a set of services provided by energy supplier Lichtblick. Swarm Conductor, which is one part of Swarm Energy services, is a unique IT platform in the energy market. On the platform, the processes of an increasingly complex world of energy to customer-friendly products and services for residential and business customers are combined. Customers' local power plants and storage are optimized. Swarm Energy allows a meaningful interaction of distributed and renewable energy sources.[9]

In recent years, P2P energy trading has also been investigated at the distribution network level. TransActive Grid is a community energy market, which combines software and hardware that enables members to purchase and sell energy from each other securely and automatically, using smart contracts and the blockchain. The current prototype uses the Ethereum blockchain and is located in Brooklyn. The Brooklyn Microgrid allows users to buy and sell locally generated solar energy within their community. The Brooklyn Microgrid is evaluated against the following seven components: i) Microgrid setup, ii) Grid connection, iii) Information system, iv) Market mechanism, v) Pricing mechanism, vi) Energy management trading system, and vii) Regulation. This study shows how The Brooklyn Microgrid fully satisfies three and partially satisfies three of the seven additional components. Showing how the use of blockchain is an ideal technology to operate in decentralized microgrid energy markets. It also shows how like other proposals the current regulation does not allow the operation of local energy markets between peers in most countries [10].

PeerEnergyCloud was a project in Germany. It developed cloud-based technologies for a local electronic trading platform for dealing with excessive local production. It was established in order to investigate innovative recording and forecasting procedures for device-specific electricity consumption, to establish a virtual marketplace for power trading, and to develop value-added services within a Microgrid. [11]

Electron is a revolutionary new platform for gas and electricity metering and billing systems, which is still under development. It will open the way for new and innovative consumer energy services. It is an entirely secure, transparent, decentralized platform that runs on a blockchain and provides provably accurate metering, billing, and switching service using Smart Contracts and the power of Distributed Consensus. The platform will be open-source and operate for the benefit of all users. It will not be owned or controlled by suppliers or brokers [12]

3. Smart power management

In order to carry out simulations of a P2P energy trading system within a Smart City environment, a realistic assessment of the transfer of energy between producers and consumers should be made. Thus, it is necessary to accurately calculate the energy needs of homes, shopping buildings, commercial buildings, etc., on the consumer side, as well as the amount and characteristics of energy production capacities available on the local energy market. This information will enable to create a holistic picture of how the energy negotiation process would be carried out in the most efficient way, based on real data.

BEIA building is a living lab for intelligent energy use by SMEs, having 100 solar panels installed on its premises and storing excess energy produced during peak production hours in crypto currency using blockchain technology [13]. The photovoltaic system consists of 100 solar panels connected in series of three and then in parallel, amounting to an installed power of approximately 25.5 kW, as shown in Figure 1. The Verbund equipment [14] will transmit the output parameters to a visualization platform for energy production monitoring. The consumption parameters are monitored using Fibaro smart plugs [15].

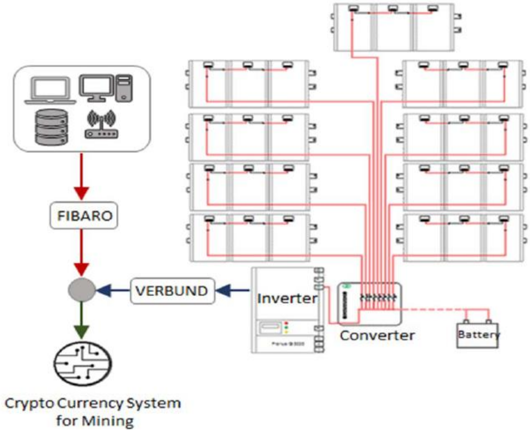

Figure 1. BEIA power system.

Figure 2 shows the power flow within BEIA's premises. The power sources of the building can be the PV system or the electric grid itself, connected via an electric meter. Inside the premises, a hybrid inverter captures either the direct or alternating current. The output of the device will be transferred towards the UPSs (Uninterruptible Power Supplies) or to the building load, consisting in the everyday devices used within the work environment, or it can transmit direct current (DC) to the battery system. The energy surplus is transferred to the crypto currency system that generates Ethereum.

For a realistic assessment of the energy flows within the building, several types of data are being monitored using several devices. Smart meters measure the power consumption at every floor, sensors measure the indoor climate, IoT devices measure the environmental data.

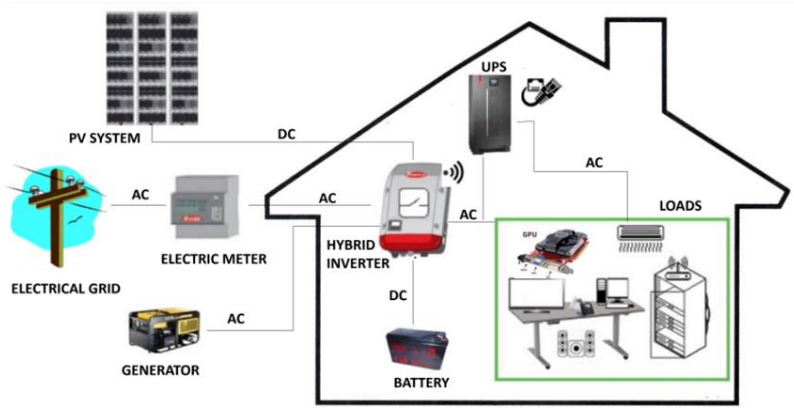

Figure 2. BEIA power system.

4. Peer-to-peer trading

The conventional architecture of electricity markets is hierarchical, inflexible, with restricted scalability, dependent on centralized generation and with a limited number of bidders, with a few sellers and buyers [16]. This structure is not efficient because of restricted demand response management options caused by centralized control algorithms and less adaptability to distributed generation integration, as depicted in figure 3.

Many of the energy trading platforms presented in chapter 2 cannot be characterized as having a true peer-to-peer process, as they only allow unidirectional energy transmission. These platforms facilitate the contacts between the unregulated energy suppliers and their potential customers, rather than promoting two-way energy exchange between network members. Therefore, the envisioned platform will allow any user with a smart meter to be part of the market as a buyer, a seller, or both. The energy tariffs will be established within the market, depending on the amount of energy traded through the platform. Such platforms should also include a business intelligence tool that will provide information regarding the opportunity in investing in storage solutions for load balancing. The wide adoption of smart meters will also facilitate a change in user’s habits associated with demand response, thus lowering the overall energy spending.

The functionality of the envisioned platform will allow to study the behavior of consumers and producers and the pricing trends, as shown in figure 4. The premise of introducing prosumers with available solar energy is the fact that as technology prices for renewable energy production have lowered, the trend is that solar energy auctions will close at lower prices.

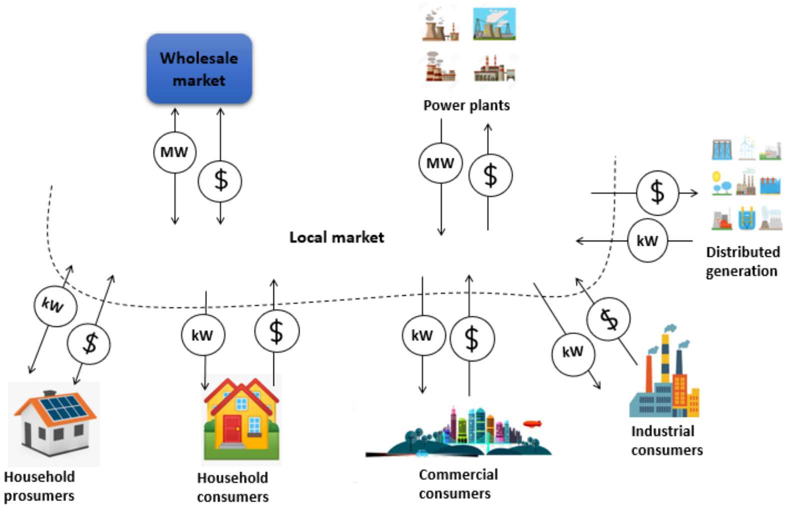

Figure 3. Traditional energy trading model

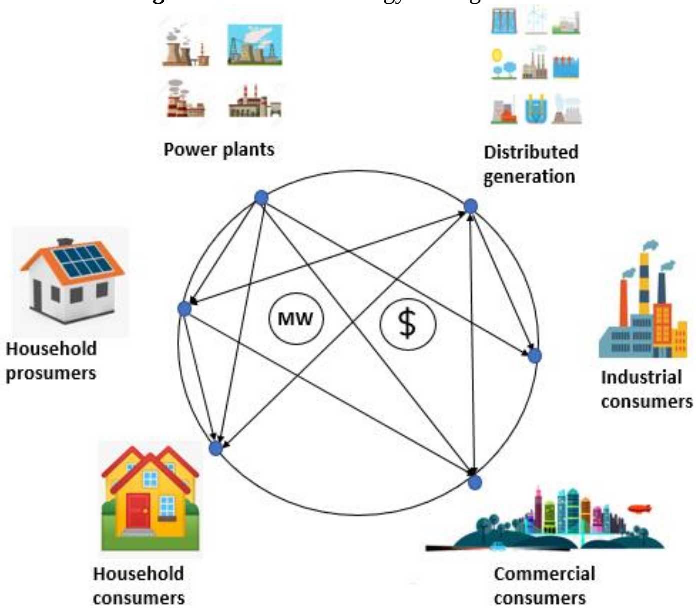

Figure 4. P2P energy trading model

Therefore, the closing energy price from solar production will be much lower than the present wholesale market price. Simulation processes will be performed using real data to establish rules to simulate the application of market regulations and to assess the impact of such a trading platform on a smart city.

5. Conclusions

P2P energy trading platforms will facilitate the transition from the currently static power grid infrastructure to a more dynamic model, allowing the integration of distributed generation resources, including renewable technologies, of advanced electricity storage and peak-shaving technologies and of smart technologies for metering, communications and distribution. For municipalities, especially in the context of smart cities, proactively operable energy systems will encourage more sustainable neighborhoods and more involved and energy conscious citizens. For the business community, the emergence of new markets will allow the involvement of consumers in the energy supply, thus responding to the transition to renewable energy sources and the challenges of rising demand for electricity.

In the future, the authors will create and test models for P2P energy trading platforms, using real data from the testing site, in order to assess how intermittent small-scale generation can be integrated into the system at low costs. Future steps will consider the possibility of introducing the blockchain technology to simplify the metering and billing systems.

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