

Crypto-Trading: blockchain-oriented energy market

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Abstract—Blockchain - software technology used for peer-to-peer transaction platforms - is being increasingly applied to alternative opportunities for a variety of industries and use cases such as also in the energy sector. As of now all energy related to blockchain applications are still in a concept stage. This paper aims to present the preliminary ideas of a research project that we have launched in collaboration with a small Fintech company: the Crypto-Trading project. From a research perspective we have explored how a blockchain-based system integrating smart contract functionality can be used to share energy in order to promote smart grids for the management of electricity in the Sardinia Region. From a technical perspective the project will implement a modular blockchain-based software platform for extending the features of cryptocurrency exchanges to the renewable Energy Market, including a robo-advisor which will suggest prosumers the best selling strategy. Blockchain technology shows a lot of promise. In our opinion this might boost the growth of renewable energy production and consequently also have a positive effect on the regional economy.

Keywords—Smart Grid; Energy Market; blockchain; smart contracts; renewable energy.

I. INTRODUCTION AND MOTIVATION

In 2015, the Sardinia Region launched a policy document titled “Smart Specialisation Strategy” (S³)¹ within the wider Europe Horizon 2020 strategy. This document, aiming to promote smart growth, sustainable development and social inclusion, identifies the regional excellences in terms of research and innovation and their growth potential. S³ defines six specialization areas (priority - P) that represent the priority for its future public investments. These areas are: ICT (P1), Smart grids for the management of electricity (P2), agro-industry (P3), aerospace (P4), biomedicine (P5), and tourism, culture and environment (P6). Among these six areas ICT has a transversal role, namely it provides platforms and connected environments that make effective new research results. Particular attention was given to cloud computing, internet of things, open data, and cyber-physical systems.

Starting from careful reading of technological and development opportunities, our research idea takes inspiration from the smart grids area - priority 2 in S³, whose general objective was to improve the technologies adopted to generate energy that is collected from renewable resources and to allow a more economic and efficient management of the local resources. This paper aims to present the preliminary ideas of a research project that we have launched in collaboration with a small fintech company: the Crypto-Trading project. The project aims to implement a blockchain based system which extends the features of cryptocurrency exchanges to the renewable Energy Market. The blockchain concept was introduced with the Bitcoin payment system in 2009 [1]. The purpose of our project is to perform the following actions related to the specialization area - Smart grids for the management of electricity: i) Efficient management of energy demand and supply in order to improve the distribution networks and regulate the consumption in an energy saving perspective; ii) Monitoring and analysis of electricity consumption by final consumers (private and business) independently of the electricity supplier.

In the scenario of an intelligent energy distribution network in Sardinia, the two above-mentioned actions will be realized through the creation of a platform based on a token system for the purchase and sale of energy enabled to record the amount of energy purchased. Each user can become an holder of a certain amount of energy and resell it at any time at the bid price. The transition from virtual trading to energy delivery is decentralized thanks to the use of energy-oriented systems that are geared to new and advanced paradigms. According to Barenergy Report², six typologies of barriers are slowing the progress in efficient energy and diffusion of renewable energy systems: physical, political, socio-cultural, economic, knowledge based and individual barriers. In particular, socio-cultural barriers are obstacles to the changing

¹ Available at:
<http://www.sardegnaprogrammazione.it/index.php?xsl=1384&s=278012&v=2&c=12950>

² The BarEnergy project - an acronym for ‘Barriers to changes in energy behaviour among end consumers and households’ - is an EU-funded collaborative research project, undertaken between 2008 and 2010. The project team comprises eight different organisations from six European countries. Available at:
http://www.crisp-futures.eu/download/attachments/4128781/Barenergy_Final_Report_screen.pdf

of consumers' behavior. For this reason, the civil society should be involved in the changing by providing new positive points of view.

Crypto-Trading project is able to serve the needs in promoting the transformation of an energy model characterized by a centralized production toward a decentralized and intelligent production and distribution, tailored to the needs of proximity and aimed at satisfying local consumption. Crypto-Trading aims to provide a tool to overcome the current *"inadequacy of the regional energy distribution system in relation to the new demands arising from the advent of distributed production"*, which is one of the weaknesses of the Sardinian energy system identified in Sardinian S³ policy document.

The paper is structured as follows. Section I provides introduction and the motivation for the work presented. Section II contains a brief discussion of related works. In Section III, Crypto-Trading project and a conceptual scheme is discussed. In Section IV a discussion about the feasibility and implications is provided. Section V concludes the paper.

II. RELATED WORKS.

The use of blockchain technology for the implementation of a decentralized electricity market is currently being studied. In recent years, there has been a growing interest to study the scenarios of the creation of a decentralized and local Energy Market (LEM) by using the blockchain technology to enable development of intelligent energy networks and the advancement of measurement and control systems [2]. In [5], the authors give particular emphasis to the innovation that the blockchain technology could give to power distribution networks. There are many possible scenarios for self-produced energy from prosumers resident in European territories, as reported by Bitcoin Magazine [7]. In [3], [4] Mihaylov et al. introduce NRGcoin, the value of which is determined by an open currency exchange market. In their paper the prosumers in the smart grid trade locally produced renewable energy by using NRGcoins. On the same line of Crypto-Trading project there are similar initiatives such as powerledger (see: <https://powerledger.io>) operating in Australia and currently under study. Moreover energy market projects, based on blockchain and smart grids, should take in consideration the issue of sustainability. In a recent work, Mengelkamp et al. [8] proposed an agent model in order to investigate the feasibility and the sustainability of a LEM based on a private blockchain.

During the phases of development of Crypto-Trading project, we will take into account all the previous proposed solutions. Furthermore, the Crypto-Trading project intends to consider the opportunity to develop a solution based on the implementation of a public blockchain on a continental-scale Energy Market. Moreover the sustainability issues will be faced during all the project. In particular the use of the

blockchain instead of conventional ICT centralized system leads to some energy issues. For instance, Cocco et al. [9] have recently discussed the energy efficiency of a blockchain-based banking system, by highlighting the cost saving that the use of the decentralized system could bring. Previously, the blockchain energy footprint was discussed by O'Dwyer et al. [10]. The recently acceptance of the Bitcoin protocol called "SegWit" [11] overcomes some technology limitations (for instance it allows an higher number of transaction per block). On the other hand, current discussions about the necessity of technology adjustment are the proof that the blockchain is still an immature technology [14], and in particular, also the SegWit protocol could not be a sustainable solution [12]. It's also true that the blockchain technology represents a possible solution for a sustainable development [13, 25] and can be seen as a promising software connector [24].

Crypto-Trading system is a complex system that will include an heterogeneous set of research fields. let's note that the use of the blockchain technology involves the study of a specific solution in order to preserve the users' privacy. This relevant aspect will be taken in consideration during the development of the system and the related research activities will start from previous works [15,16].

III. CRYPTO-TRADING PROJECT.

A. Project description

Crypto-Trading project aims to apply and extend the knowledge of the proponent consortium about the financial trading and blockchain technology in the field of the energy trading by exploiting the cryptocurrency technology. The main goals will be two:

- i) to introduce a European Energy Market trading system by using "token" and smart contracts that will simplify the trade of electricity distributed by intelligent networks;
- ii) to develop a platform for the optimal allocation of a cryptocurrencies portfolio.

The project will start from the partner company's current business field. The company operates in the financial trading and have implemented a web application called *Selfiewealth*³. Such platform provides advanced financial services empowered by a robot-advisor. This Robo-advisor is the result of the implementation of a prediction algorithm studied and developed by the company itself. This algorithm is developed in order to perform the financial analysis on over 80,000 different stocks or funds and over the principal fiat currency. *Selfiewealth* added recently an financial analysis of many popular cryptocurrency. The platform provides a guided creation of a personal portfolio. A simple preference survey

³ For further information visit: <http://www.selfiewealth.com>

identifies users' financial preferences, in particular in terms of the risk-reward ratio. Crypto-Trading project aims to bring this solution in the world of the Energy Market, by taking advantage of the cryptocurrency and blockchain technologies. In the project, three development steps will be identified:

- 1) to include Bitcoin and other cryptocurrency in the trading platform;
- 2) to develop a new algorithm and a platform to manage the cryptocurrency in the system;
- 3) to implement an energy trading system for the European community and to develop the related platform.

The first step will include the study of the current most important cryptocurrencies (such as Bitcoin, Ethereum, Ripple and so on) and the related trading opportunity in terms of alternative currency. The second step will include the development of a specific trading platform focused on cryptocurrencies by studying and adopting new typologies of market indicators, that are evaluated including the analysis of blockchain data. Such analysis will include transaction volumes and users behaviors [17,18,19]. This step also will include the update of the company's business model, adapting the current one to the specificity of the cryptocurrency system.

If the previous two steps are preparatory, the last step represents the realization of the core of the project. In fact, the Crypto-Trading project may enable local prosumers to buy and sell energy, and at the same time to produce it from renewable sources. The three steps will drive the achievement of the project goals. Furthermore, Crypto-Trading introduces a new typology of Energy Market. It will be characterized by simplicity and reliability and promise a new business opportunity for small producers. By using Crypto-Trading system the electricity could be traded following the free market rules, at the price established when supply and demand meet at the equilibrium point. The robo-advisor, thanks to the implementation of an adapted version of a proprietary algorithm, will help prosumers to choose the best selling and buying strategy in order to maximise the profits. The system will provide advanced tools which will make the prosumers aware about the current Energy Market trend and historical trend and easier the price formation and overcoming regional boundaries. Furthermore the users could know the energy origin and the typology of the source. The Energy Market will become an individual, decentralized and free market.

It is reasonable to imagine that in the near future we will see the coverage growth of smart grid and connected technologies devoted to the control and distribution of the energy similar to the Internet network in the past [20]. For example, the Sardinian region was electrical isolated until the 2010 when the High Voltage Sardinia Island – Italian Peninsula link (SAPEI) was tested [21]. For this reason in the future the majority of the energy sources and the energy consumers will be physically and digitally connected to smart

grid systems. In this scenario, local energy storages are not mandatory. The Crypto-Trading system has not geographic coverage limitation and could base its IT infrastructure on a public blockchain such to allow the creation of a particular typology of computer program called smart contracts.

B. Conceptual scheme

The system will take into account the complexity of a smart and efficient energy distribution and will combine the smart grid technology with the blockchain technology. In particular, in our system, the blockchain technology is the ICT upon which the system works. The blockchain works both as a ledger (i.e. a database of all transactions in which energy sales are recorded and can not be longer modified) and as a control system which by means of existent technology drives smart meters.

Overall, the Crypto-Trading system can be described as the composition of three functional subsystems: the prosumer system, the blockchain system and the trading system. The prosumers system is composed of the energy sources, smart meters and final users who sell and buy energy. Each user is the owner of an energy account that is associated to a smart meter. Smart meters have the task of measuring the energy production and energy consumption and interrupting the energy availability if the related energy account is empty. Smart meters must be ready for the internet connection and enabled to host a blockchain light client.

The blockchain system provides the possibility to store and run decentralized computer programs called *smart contracts*⁴ that will be able to receive messages from the smart meters and from the trading platform. By definition the blockchain makes publicly available all the historical data, including the energy trading operations. For each prosumer, the energy availability (described by means of the definition of an energy token⁵) is recorded in a specific smart contract that represents the energy account of each user of the system. A token describes the tradable energy unit. Each prosumer can buy and sell tokens at any time and thanks to the blockchain technology it is not possible to sell twice the same energy token. The exchange currency, with which users pay the energy, may be the cryptocurrency associated to the blockchain system (i.e. *Ether* inside the Ethereum blockchain) or a different specific token, having an independent value. The currency availability is recorded inside the users' blockchain accounts.

The trading system is the web application which allows the prosumers to access the robot-advised trading services. This system reads the energy production data from the blockchain and sends control messages to the smart meters through

⁴ For further information about a blockchain implementation that support smart contracts (or decentralized application), see the Ethereum white paper available at the address:

<https://github.com/ethereum/wiki/wiki/White-Paper>

⁵ At the same address a description and an example of token is provided.

related smart contracts. The trading services include personalized solutions based on user's preferences. In particular, the robot-advisor continuously produces reports and suggestions, basing them on the energy price trends, and on the constraints imposed by each user.

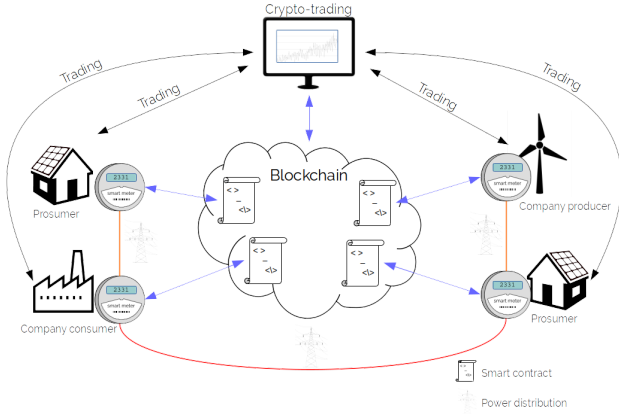


Fig.1 Representation of the Crypto-Trading system.

In Fig.1 we show a conceptual representation of the Crypto-Trading system. In this figure it is possible to identify the three typology of subsystems. Prosumers are represented as nodes of the power network (red line). In particular, two of those nodes represent a typical domestic prosumer: a node represents the commercial/industrial prosumer and the other one a power generation station. Each node includes a smart meter that it is at the same time connected to the power line and the blockchain by means an internet connection (blue arrows in Fig.1). Whenever the prosumer's plant produces an unit of energy, the smart meter sends a message to the blockchain. In particular the message is directed to a smart contract that is developed in order to store and upgrade the number of energy tokens of every energy account.

In addition, a smart contract receives messages from the trading system in accordance with the prosumer's necessity. Whenever a prosumer sells an amount of energy, the trading system sends a message to the related smart contract, which, in turn, sends the equivalent number of energy tokens to the buyer's energy account. In this way, the transaction of energy tokens prevents the double selling of energy. In parallel, by means of a blockchain transaction, the value of the sold energy is transferred from the buyer to the seller. Prosumers can trade the energy using the web based trading system (black arrows in Fig. 1). Basing on the robot-advisor suggestions, prosumers can set up a strategy for the energy trading, aiming to maximize revenues (or minimize costs) and have a satisfactory coverage of their energetic needs. In particular, the robot-advisor can advise users for the best offering who can plan a personalized strategy, or operate autonomously, by

managing the user's energy account in order to satisfy user's requirements.

IV. DISCUSSION

A. Research and development

The Crypto-Trading project will be carried out in three stages:

- 1) analysis and design of the general architecture for the local management of a energy distribution network;
- 2) integration and development of Smart Contracts for the Energy Market;
- 3) development of the prototype of Crypto-Trading system.

More specifically, we will discuss the system requirements for the local management of an intelligent energy distribution network, including a market where small producers and users interact to optimally allocate and economically optimize the various resources. Smart Contracts will also be analyzed and designed for the management of the interaction among intelligent tools (IoT) [22], manufacturers, users and the market, including exchanges with other intelligent electrical grids.

From the analysis, the design of the Energy Market will be carried out, integrating it into the market with the aim of allowing payments and quotations of electronic exchanges in cryptocurrencies and reusing prediction and risk control algorithms. Technological architecture and security infrastructure approaches, as well as the security for each element working on the infrastructure, will be defined.

B. Methodology

The project will be defined and developed using Agile methods. The heterogeneity of the components of the system leads to the need of a modular and iterative approach that enables the parallel and test driven development. The Agile methods will provide the process that allow the incremental development of the Crypto-Trading project. Since the blockchain technology will be widely used, the modeling and development phases will face the lack of proper guidelines [23]. In order to have short iterations and an Use Case driven development, the development of the prototype (that includes backend and web interface of the trading web application) will be done using an Agile methodology. In particular the practices of continuous integration, automated testing and the refactoring will be used.

The prototype will be validated through a testing phase, including a laboratory simulation in operational conditions.

V. CONCLUSION

This paper presents the Crypto-Trading project and its characteristics. In particular, we have highlighted the key role of the blockchain technology and smart contracts in the

management and control of an innovative typology of Energy Market. Taking inspiration from the Sardinian Region S³ goals, Crypto-Trading aims to facilitate the creation of a decentralised Energy Market, enabling the final user (the prosumer) to self manage the supply of energy and the sale of the excess energy. The new business opportunity will help to overcome barriers that slow the growth of the adoption of state-of-the-art technologies in the field of smart grids. In particular, Crypto-Trading will provide a robot-advisor which will help the users to optimise the energy trading. The project will face several challenges. These include the immaturity of the blockchain technology, the privacy issues and the sustainability of the whole system.

In our opinion, the proposed system may facilitate the transformation of the energetic model in the direction of a decentralized and smart production of electricity.

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