Blockchain-based Marketplaces for Crowdsourcing Renewable Energy Forecasting

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Abstract

In line with the ambitious goal of net-zero carbon emission, the deployment of renewable energy sources is accelerating rapidly in the power sector. However, the energy production of these renewable sources, such as wind and solar, is volatile due to changes in weather conditions. This issue impacts the reliable planning and operation of these energy sources in the power systems. Therefore, accurate forecasting methods are essential for the proper usage of renewable sources. This piece explores how blockchain technology can be employed to implement crowdsourced platforms for renewable energy forecasting where participants are incentivised to provide truthful information. The main application, which is the focus of this work, is the blockchain-hosted prediction markets. Other platforms, including data markets, as well as the possibility of the integration with the internet of things are also mentioned. All these kinds of platforms benefit from access to massive and diverse sources of information which improve the quality of renewable energy forecasting.

Introduction

For supporting the high penetration level of renewable energy in the power sector [1], blockchain may offer promising solutions to make such technologies more reliable. As a result, applications of blockchain technology in the renewable energy sector are attracting considerable research interest recently. Most of these applications are related to local peer-to-peer energy trading [1]

[1]https://www.iea.org/reports/renewables-2021/executive-summary

schemes since blockchain is hoped to provide a faster, secure, and flexible transacting process through cryptocurrency-based payments and by removing the role of intermediaries. These features enable the exchange of energy between neighbouring consumers and renewable producers closer to real-time and therefore better manage the renewables' volatile energy production.

While the trading application as well as other use cases of blockchain in the electricity industry such as green certificate trading and data collection and metering in smart grids via the Internet of Things (IOT) have been significantly covered in the literature ([2]–[5]), the role of this technology in renewable energy forecasting has not yet received adequate attention. Renewable energy forecasting is well-investigated in literature [6] including physical, statistical, and machine learning techniques, however, all the existing methods can remarkably benefit from decentralised and trusted exchange of data by the adoption of blockchain technology [7]. Moreover, the combination of forecasting models [8] which is a common practice to improve the aggregated forecasting results can be accomplished through blockchain-based marketplaces. In this regard, blockchain-based marketplaces for the exchange of data and forecasts include *prediction markets* and *data markets* with the integration of the IOT, which we explain each of them in the following sections.

Blockchain-hosted Prediction Markets

In prediction markets [9], the outcomes of unknown future events are traded. For instance, two shares associated with *Will tomorrow be rainy ? (yes or no)* can be defined and participants trade these yes/no shares. In such settings, participants can be a large crowd accessing a variety of diverse and dispersed sources of information and various forecasting models and the price of shares reflects the aggregated forecasting result. Prediction markets in centralised forms have a long history of applications in various sectors such as forecasting the outcomes of elections and sports matches. In these types of markets, a trusted entity runs the market, records the trades, determines the outcome of the events, and finally performs market settlements tasks and distributes payoffs to the winners who speculated the outcome correctly. Examples of such platforms are Iowa Electronic Market [2] and PredictIt[3].

[2]https://iemweb.biz.uiowa.edu/
[3]https://www.predictit.org/

However, centralised prediction markets have their own limitations: they put restrictions on global participation and on the types of markets that can be created and the amount of money that can be wagered on trades. Moreover, they require traders to trust the market operator resolving the market [10]. These challenges can be efficiently overcome through blockchain technology. A blockchain platform as a trustless distributed data ledger records the cryptocurrency-based transactions and validates these transactions through a decentralised consensus process among the users [11]. In prediction markets, blockchain can be applied to record and verify transactions associated with trades happening in the market. Gnosis [4] and Augur [5] are examples of such platforms for implementing blockchain-hosted prediction markets. The medium of exchange in such markets can be cryptocurrencies such as Ethereum as well as stablecoins such as Dai. Recently, NFT-based platforms such as RealityCards [6] are also emerging where outcomes are not bet on, instead, they are owned via NFTs. In such a market, a single NFT is associated with each outcome and can be owned at a rental price. The final payoffs will be based on the duration of the ownership of the true outcome share at different time periods. In other words, the total rent collected will be distributed to the owners of the winning outcome resulting in an ownership-time-based approach.

Prediction markets can also be useful for forecasting the relationships between variables which are called combinatorial prediction markets [12]. In these markets, forecasters can link the questions, giving different probabilities for the first question conditional on different answers to the second question. Therefore, conditional probabilities and joint distributions of the events related to each other can be elicited from these types of prediction markets. SciCast [7] is an example of a combinatorial prediction market platform.

Prediction markets depending on the contracts' payoff structures [9] can reflect different expected information as the aggregating results of the crowds' consensus. In binary prediction markets, also known as winner-takes-all, the events have yes/no outcomes and the price of shares represents the probability of the outcome. While in a scalar, also called index contract, the expected value of the continuous variables is predicted. In [13] renewable energy probabilistic forecasting using a set of

[4]https://gnosis.io/
[5]https://augur.net/
[6]https://realitycards.io/
[7]https://scicast.org/

binary prediction markets is implemented. In this approach, the price of shares (contracts) is taken as the probability of the renewable output lying within a certain range. Finally, the cumulative density function of renewable energy output is extracted. The idea of hedging the financial risk of renewable sources against electricity market imbalance costs through participating in the scalar prediction market in the Augur platform is implemented in [14]. In [15] it is demonstrated how binary prediction markets can resemble the function of weather derivatives for renewable energy producers and by participating in them they can stabilise their revenue streams.

Blockchain-based Data Markets

Secure and transparent transaction of data can be accomplished through blockchain where data can be traded between buyers and sellers while ensuring the privacy of the data owners. In [16] and [17], blockchain-based data markets are employed for renewable forecasting and data providers are rewarded based on the improvement in the electricity market imbalance costs according to the accuracy of data. Examples of the readily available platforms of blockchain-based data markets are Ocean Market [8] and Enigma [9].

The mentioned blockchain-based marketplaces for the purpose of renewable energy forecasting can benefit from the integration with IoT. In this way, weather information can be communicated through a network of IoT devices where collected data will be stored and processed in cloud-based services. The idea of incorporating blockchain for supporting IoT have been discussed in terms of improving the security of the network in [18]. The work in [19] mentions the role of IoT in renewable generation forecasting through capturing real-time data transmitted by digital devices which together with considering past generation and weather patterns improves the accuracy of prediction. In [20] controllable IoT devices for energy load forecasting has been employed but incentivising the data providers has not been considered. A multi-layer platform consisting of IoT sensors for collecting weather-related data and a blockchain-based marketplace for exchanging

[8] https://market.oceanprotocol.com/
[9] https://www.enigma.co/

the data and trading forecasts results and rewarding the participants can provide an effective decentralised crowdsourced forecasting approach for the renewable energy. Existing platforms include WeatherBlock [10] and Observer [11] which both have a blockchain weather data market.

Summary

The applications of blockchain technology in the renewable energy sector are attracting considerable interest in recent research studies. The inherent features of this technology, as a decentralised and flexible data ledger make the use of such variable weather-based energy sources smoother. In this piece, we proposed how the renewable energy forecast-related input data or results can be exchanged in a blockchain-based marketplace and this provides an incentivised crowdsourcing approach in a decentralised and trusted way. We mentioned the existing platforms in this regard including blockchain-based prediction markets and data markets and the implemented ideas in the related renewable energy literature. Finally, we discussed how the integration of IOT with such markets can strengthen the proposed approach.

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