Blockchain Application in Digital Platform FieldWork 4 RES used for Planning and Realization of Renewable Energy Sources Projects

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***Abstract* - Considering the global warming and negative effects of greenhouse gasses on the Earth's atmosphere, renewable energy sources (RES) are of key importance for the planet's sustainability. In a view of the EU's 2050 long-term strategy, it is expected that the RES capacities will continue to rise significantly, as one of the main goals of the strategy is to fully decarbonize Europe's energy supply. This paper describes a FieldWork 4 RES system intended for providing the application support for planning and realization of RES projects, from their infrastructure construction until asset management and maintenance. The main objective of the FieldWork 4 RES platform is to tackle the problems of legal inconsistencies and uncertainties, administrative complexities, and a long journey from idea to execution when dealing with RES projects. FieldWork 4 RES system uses Common Data Environment (CDE) concept and is based upon a clearly defined catalog for construction and maintenance of RES power plants. The system is designed as a support application for monitoring and managing existing business processes which consist of multiple modules. That ensures adaptability to each business scenario and different types of users from RES developers to contractors and project offices.**

Keywords – renewable energy, fieldwork4res, blockchain, BIM, CDE

I. INTRODUCTION

FieldWork 4 RES is a platform currently in the research and development phase as part of the Development of an integrated asset management solution and support for investment processes in the design, planning, and implementation of renewable energy construction project. It will be used for all phases, from investment planning to operational maintenance of power facilities and equipment. The main three phases are:

- Planning and preparation of RES projects
- Realization of RES projects
- Maintenance of RES assets

It will include a full range of functionalities to meet the needs of everybody involved in a project such as end-users investors, designers, contractors, and managers, and will be based on private and shared Software as a Service (SaaS) environments.

Through separate modules, it is possible to adapt the operation of the system to each business process and put emphasis on the business process that is of the utmost importance to the business entity. The system also supports quantitative monitoring of planned and performed services, works, materials, and mechanization, but also financial monitoring of project implementation according to the project plan. Accompanying effects relate to raising awareness of business users about existing business processes, achieving better standardization of existing business processes, defining unambiguous rules and restrictions within business processes, achieving greater management and operational discipline, removing redundant or unclearly defined processes.

II. FIELDWORK 4 RES UTILIZATION AND FUNCTIONALITIES

FieldWork 4 RES will include basic functionalities:

- Investment project planning
- Planning activities for the maintenance of renewable energy sources
- Management of contractors, subcontractors, and contracts
- Project quality and dynamics management
- Financial management and ensuring the profitability of projects
- Material and inventory planning and management. Procurement and invoicing of Maintenance, repair, and operating supply (MRO) (spare parts)
- Application of Building Information Management (BIM) methodology and integration with other appropriate tools in the function of design and management of renewable energy assets
- Inventory and asset management - facilities and components

- Digitization and automation of business processes related to asset management of renewable energy facilities
- Management of regulatory processes
- Integration with Enterprise Resource Planning (ERP) systems
- Integration and retrieval of data from new or existing management systems in the function of maintaining RES in a secure and authorized manner
- Secure and authorized communication in the function of the investment process, exploitation, and maintenance with the exchange of information using distributed technologies
- Management of predictive and preventive maintenance requirements. Tracking maintenance history
- Mobile application with a responsive interface to support the work of field staff.

During the implementation of the RES project, the emphasis of the system is on ensuring timely decisions based on the information available to the system. The system of notifications and warnings facilitates operational decision-making during implementation. Measuring Key Performance Indicators (KPIs) during project implementation ensures compliance with contractual Service Level Agreement (SLA) parameters. After the implementation of the RES project, the system supports the possibility of comparison through reports and graphs:

- Quantitative quality of planning and implementation of different projects of the same type
- Financial quality of planning
- Time monitoring of planned and realized
- Monitoring KPI parameters

The possibility of identifying weaknesses, erroneous estimates, and appropriate comparisons of the quality of planning and implementation by comparing several projects provide management with relevant information that serves as a corrective in future planning and implementation of projects.

For the planning, design, construction, use, maintenance, and removal of production plants and production units that produce electricity from renewable energy sources and high-efficiency cogeneration, the provisions of regulations governing environmental and nature protection, protection and preservation of cultural property, state aid, spatial regulation, construction, electricity market, concessions, maritime domain, water management, the performance of economic activities, right of ownership and other related rights and provisions of other regulations. Regulations in the field of physical planning and construction apply to the construction of a RES plant that is considered a construction. Holders of wind farm projects are obliged to make detailed environmental impact assessments, so, especially in the initial phase of the project, regulations in the field of environmental protection are applied. On the issue of acquiring rights on land on which RES is built, it is necessary to apply general regulations on establishing easements or building rights on land owned by private persons, while special regulations apply to establishing easements or building rights on state land. The course of the RES plant construction project can be divided into regulatory phases into the preparation and environmental protection and Licensing phases, which will be supported by the Business Process Management (BPM) solution.

FieldWork 4 RES architecture overview is shown in Fig. 1.

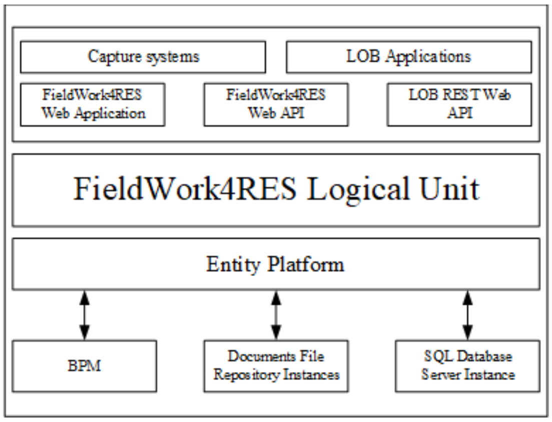

Figure 1. FieldWork 4 RES Overview Diagram

The product consists of the following basic components:

- Platforms for business process and digital content management, records management, and system security.
  - Implemented on Microsoft .NET 5 open-source platform
  - The database is Microsoft SQL Server
  - BPM is Camunda - an open-source platform for business process automation
- Responsive web applications for office and field data manipulation
  - Implemented on REACT open-source JavaScript library
- Integration services
  - Implemented on Microsoft .NET 5 open-source platform
  - The database is Microsoft SQL Server
- Security mechanisms for information exchange and processing
  - Implemented on Microsoft .NET 5 open-source platform
  - The database is Microsoft SQL Server.

III. Blockchain Technology in FieldWork 4 RES

A. *Distributed Ledger Technology*

Distributed Ledger Technology (DLT) is a way of storing and sharing data that is distributed in different geographically dislocated nodes. Data is replicated or synchronized between nodes. A fundamental part of distributed book technology is the way to reach a consensus on data accuracy because there is no central point.

Although the technology of distributed books can be realized in several ways, in this research the usability of blockchain technology in the function of data exchange for asset management of energy markets and correlation with BIM technology as a subject area has been dealt with [1].

B. The Basics of Blockchain

BIM provides investors, designers, contractors, and other stakeholders with insight and tools for more efficient planning, design, construction, and management of RES, but the exchange of information, especially financial, is a challenge and involves a lot of paperwork. BIM software should not be limited to generating 3D models, but can also be used to collect all information and documentation about the project, such as work orders, invoices, and payment data. Blockchain can solve problems around secure access to the BIM model and allow for a reliable audit of who made the changes, when they were made, and what the changes were. Contract processes that typically require human intervention and oversight can be partially or fully automated using smart contracts, which stem from blockchain technology.

Blockchain is a data container. It differs from traditional databases in the way data is stored in the database - data in the blockchain is stored in a chain of blocks. Each block consists of a digital print of the previous block, a timestamp, and the data itself, most often transactions. The timestamp is our guarantee that the data existed in a specific form at the time the block was published. The digital fingerprint is used so that the blocks can be arranged chronologically and is used to check the integrity of the data [2].

If a public blockchain is used (or any decentralized chain of blocks), a key component becomes an algorithm for reaching consensus on the correctness of the data. There is always the possibility of the competitive formation of new blocks at different nodes. New blocks can also be created by a malicious user. Nodes always store only the version of the data or the branch that the algorithm determines to be the most likely to be the branch with the correct data. Blocks belonging to a branch that is not retained are called orphan blocks.

In such a system, there is no guarantee that any data will always remain in the branch that is retained. For this reason, the algorithm for reaching consensus on the correctness of the data is usually set in such a way that preference is given to supplementing the chain with new blocks over inserting new blocks over old blocks. In this way, the ability to overwhelm a block of data with newer ones decreases exponentially as blocks are added to the chain [3].

The blockchain network can be private or public. A public blockchain network implies that any individual or organization has the right to read and write to the chain, thus gaining the right to participate in reaching a consensus on the correct version of the data in the network. Public blockchain networks are organized in such a way that a malicious user who wants to insert a block with manipulated data into the network must have more than half of the nodes under control. Otherwise, the probability that the manipulated block will become an orphan is very high [3].

The private network is owned by a particular organization and the organization decides who has access to the chain. A private network may also be decentralized, but it does not have to be. Although the main strength of blockchain networks is high distribution and single point of failure, private networks that have far fewer nodes and centralized parts of the system also have their advantages:

1. Efficiency: access to private networks is limited and potentially malicious users do not have direct access to them. This makes consensus algorithms simpler, requires fewer computing resources, and is more environmentally friendly (energy saving).
2. Privacy: access to data does not need to be provided to the public, it is possible to define access rights to certain parts of the data and monitor access to data.
3. Stability: validation of a new block always costs money. This cost in public networks can vary greatly depending on the number of new transactions in the network at a given time. In private networks, the cost of new transactions is stable and can be controlled.
4. Legislation: Public blockchain networks are distributed so that they are less likely to be controlled or shut down by a single state or government organization. For business organizations, this feature of public blockchain networks can be a barrier to use. Private networks can control and select according to their needs and legal regulations [4][5][6].

C. Digital Signature

A ten-step method was used to investigate the applicable business scenarios for distributed technology. The ten-step decision method helps to determine whether the application of distributed technology is justified and, if so, what type of technology to use.

As part of the research, three ways in which can be used the technology of distributed books in the function of data exchange for the needs of asset management and energy markets with an emphasis on RES were identified:

- Time stamping of the digital signature
- Timestamp
- Asset tracking

A digital signature is a form of proving the preservation of data integrity (integrity and non-modification of the message) and authentication of the sender of the message. A digital signature is created using asymmetric cryptographic functions and a digital print of a document.

A digital print is a one-way digital summary of a document. It must not be possible to recreate the contents of the document from the print. Even the slightest change in the content of the document drastically changes the footprint of the document. Therefore, the digital print of the document serves to confirm the integrity of the document.

Asymmetric cryptographic functions are based on a pair of keys. Keys are created using one-way cryptographic algorithms. A message that is encrypted with one key from a pair can be decrypted with only one key. Once the keys are generated, one of the keys is declared a private key. The owner of the key must keep the private key in strict secrecy. The second key is declared to be a public key that can be freely distributed. If the message intended for a certain person is sent, the public key of that same person used to encrypt the message must be found. If the recipient's secret private key remained secret - only the recipient will be able to decrypt the message and find out the content.

Public keys are exchanged through the Public-Key Infrastructure (PKI). The keys are exchanged in the form of a certificate - a digital document containing the public key, the data needed to identify the owner of the public key, and the digital signature of the issuer of the certificate. The keys are distributed by private organizations, so-called authorities, which are the central point of trust of all parties involved in data exchange.

The core of PKI are the following authorities:

- Certification (English certificate authority, CA) - issue a certificate
- Registration authority (RA) - ensure correct registration of users
- Validation authority (VA) - confirm the validity of the certificate.

D. Timestamps and Resources Monitoring

A way to extend the digital signature of a document is to use the authority of a reliable timestamp. The authority guarantees that the document existed at the time the seal was issued and has not been changed since then. If the authority uses a long-term certificate, it has been achieved that we can believe in the intact integrity of the document even if the certificate with which the document was signed has expired. The authority and its certification can be trusted.

The authority of a reliable timestamp can be used not only for signed documents but also for tracking the time of creation and modification of any document - signed or not.

The main disadvantage of issuing a timestamp through authority is that authority is the central point of trust. Compromising the certificate used by the authority calls into question the integrity of all documents marked with the timestamp of the given authority. In addition, users must have confidence in an organization that is not potentially controlled by any regulatory body. Users have no guarantee that such an organization will not manipulate documents.

The central point of trust is also in the hands of attackers who gain control over a large amount of information by breaking through protection at one point.

A chain of blocks is a distributed network that can completely replace the authority of a reliable timestamp. Instead of adding a timestamp to the digital fingerprint of the document and the result signed by the authority, the digital fingerprint of the document can be included in the transaction and saved in a chain of blocks. This proves that the data existed in a certain form at a certain point in time. In this case, too, the purpose is not limited to digitally signed documents. A digital print of different types of data in a chain and thus guarantee integrity can be stored. Examples of such data can be the results of sensors in IoT devices, recordings from surveillance systems, insurance policies, etc.

Different industries are highly dependent on the quality of raw materials, semi-finished products, and parts used in production. Monitoring resources in the supply chain is a complex process that must monitor where and how the raw material originated, in what quantity and quality, and which processes were used in further processing.

The use of blockchains imposes itself as a simple tool for tracking resources. In such a system, units of raw materials, semi-finished products, or finished products receive a unique label (barcode, serial number, etc.) that represents them in a chain of blocks. Any processing of the raw material, change of composition, or change of owner is recorded as a transaction in a chain of blocks.

The distribution of blockchain technology guarantees us a low probability that any individual can manipulate the system. In public chains of blocks, we know the author of the transaction, so that only the current owner of the raw material can enter a change over the raw material. Public chains of blocks are open and offer easy access to a wide range of users.

In energy markets and the production of energy from renewable sources, resources in the supply chain can be monitored from two aspects:

- Monitoring components of the plant and spare parts during the construction and maintenance of the power plant and ancillary facilities
- Monitoring of energy produced from plant to producer.

By monitoring the parts that are installed in the power plant, the owner of the power plant receives a guarantee of the quality of the part itself. In case of failure, it is possible to monitor all phases in the formation of an individual part, determine if the cause of the failure is a defect in the production process of the part and thus reduce downtime due to failure.

Energy monitoring can give the consumer a guarantee that the energy came from 100% renewable sources. In addition, it is possible to eliminate billing intermediaries and charge directly from the manufacturer. It should be borne in mind that the energy market and distribution are highly regulated and a detailed analysis of the feasibility of the solution in each individual market is needed.

Achieving consensus on the correct version of the data in most public blockchains is achieved by using algorithms that require a considerable amount of processing power (proof of work), and thus consume a considerable amount of electricity. This energy largely comes from non-renewable energy sources, so the correctness of using these principles in the production of energy from renewable sources is questionable. To reach a consensus, it is desirable to use either private blockchains or chains that use other algorithms that are not based on processing power, such as proof of stake.

E. The Conceptual Design of the Prototype with Blockchain Utilization

In the function of researching the possibilities of using blockchain technology for the project in question, external blockchain services will be used in integration with the blockchain prototype, which will be considered as an optional module of the final FieldWork 4 RES product.

The prototype of the optional module would consist of the following main modules:

- Interface prototype
  - Represents a client application with relevant blockchain data and actions
  - Blockchain integration components
- Integration blockchain components:
  - Blockchain data model
  - Blockchain Application Programming Interface (API)

The prototype interface also represents a conceptual representation of the functionality provided by the blockchain module in the context of extending the functionality of the FieldWork 4 RES product in question. Fig. 2 shows the overview of Blockchain utilization with FieldWork 4 RES.

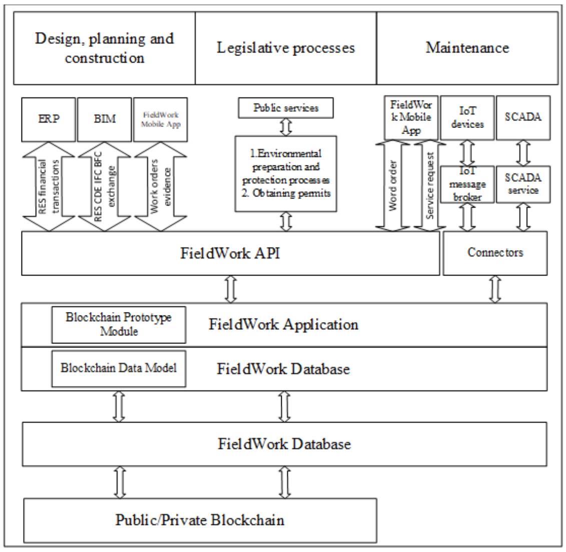

Figure 2. Conceptual design of the utilization of Blockchain module

The prototype interface contains the following functionalities:

- Screen to view the list of added records/documents
- Screen for adding a new record/document
- Screen for viewing record/document details and preview
- Record / document verification screen

The planned blockchain integration components will be used to enable the following functionalities:

- Saving relevant data that is entered into the blockchain - data model
- Integration with blockchain service providers - API

The blockchain content model is additional metadata important for storing relevant blockchain data in the FieldWork 4 RES database model itself and contains the following data:

- A digital fingerprint of the document
- Name of the blockchain of the service provider
- Blockchain enrolment status
- Blockchain enrolment time
- Link to the data entered with the blockchain service provider

Blockchain API is a Representational State Transfer (REST) API for software management with various blockchain service providers. Given the planned possibility of using multiple blockchain service providers, different program connection points specific to each service provider would be used. Since different service providers have a common set of methods, the goal of the API is to reduce standard methods to the same logical units.

IV. Conclusion

In the research, three main ways in which distributed technologies can contribute to asset management in energy markets are identified:

- Digital signature storage in a chain of blocks
- Replace trusted timestamp authority to verify document integrity
- Monitoring resources in the supply chain

Further considerations will certainly be the application of technology to scenarios such as:

- Contracting and realization of contracts in the function of realization of design, construction, and maintenance of RES
- Exchange of FieldWork 4 RESsystem information with external services that do not require real-time availability
- Timing of events within the FieldWork 4 RES system

As part of the research, a conceptual design of a prototype using blockchain technologies was developed, which will be further modelled and developed in the function of application as an optional solution module and whose applicability will be further analyzed.

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