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BIOMASS BLOCKCHAIN AS A FACTOR OF ENERGETICAL SUSTAINABILITY DEVELOPMENT*

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Abstract. As the conjuncture of the energetic system in countries or different regions changes, renewable energy sources play a significant role. Thanks to them, it is possible to move from pollute fossil fuels to sustainable use of clean resources. It is widely acknowledged that the use of biomass waste promotes better environmental state and sustainable development because the waste that cannot be recycled is used for energy production. This article describes the usage of blockchain technology-based biomass systems that not only allows tracing the emergence of biomass, but also contributes to the development of sustainable energy. The research shows that a biomass blockchain enables simplification of biomass production process, thus saving resources and contributing to the expansion of forests and the development of common energy system.

Keywords: blockchain; biomass clusters; sustainability; biomass trading systems

JEL Classifications: O13, P34, Q56

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1. Introduction

During the past few years sustainable energetics development has manifested itself not only in the quantity of emerged new power plants but also in the scale of increased business efficiency. Seeking to diversify the supply risks and simultaneously increase the level of sustainability, attempts are made to extend the variety of used biomass resources as much as possible. The use of different biomass resources balances the effect on the

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environment as waste that is formed at the particular time can be utilized. According to Borowski (2008), the most effective way to secure the nation's energy supply is with a diverse renewable energy portfolio of clean, efficient, and domestically-produced energy sources. Energy security has become a priority as the World's population increases and their standard of living improves thus increasing energy consumption. The finite nature of fossil fuel reserves and the political instability of many of the countries which supply fossil fuels have caused concern over future energy security and costs. The likely result of fossil fuel deficit is that, as the cost of these commodities increases, they will only be affordable for large industrial processes and therefore cheaper renewable sources must be found for domestic purposes (Srovnalikova, Karbach, 2016). Seeking to stock biomass supplies it is necessary to concentrate information on the subjects of biomass supply and consumption simultaneously increasing the efficiency of their activities. It is commonly known that unified subjects that supply, process and realize biomass resources could become more competitive compared to the business units that use fossil fuels. Ballarin, Vecchiato, Tempesta, Marangon (2011) adds that energy production from biomasses can be an important resource that, when combined with other green energies such as wind power and solar plants, can contribute to reduce dependency on fossil fuels. Thar allows creating sustainable energy system that is based on waste utilization thus avoiding the negative environmental effects. Using biomass forms a synergic effect that multiply the positive effects of biomass use. When energy is produced from local renewable resources a positive effect is applied not only to the environment and sustainable development but also to other processes. According to Roberts (2007) bioenergy can be a solution for matters relating to economic, national, environmental and political security. All these factors are interrelated because the economic and social structure of the country can assist in strengthening national security. When local resources are used situations where hostile countries manipulate the resources and energy prices can be avoided. Other researchers have a similar view to the usage of biomass. Although the biomass energy sector can be seen as static and lacking novel management practices preconditions that could be transferred to this sector are forming within the market. New activity measures could help managing the constantly increasing data flows and make the activities of the subjects operating in the biomass energy business more efficient.

The efficiency of biomass usage can be increased using contemporary information technology tools. Blockchain is one of these tools, a system that concentrates relevant information. The blockchain technology can be identified as the transformed concept of clusters. Transactions are confirmed using encrypted information in an impenetrable system that is based on common activity. In the case of biomass usage, it could help ensure the quality of biomass and stock traceability. Transactions are confirmed by both, interested parties and all other actors within the system. Since the transactions are approved in virtual environment it saves time, material resources and fastens the work planning process. Generally speaking, indirectly it contributes to the expansion of sustainable development because a result that satisfies all parties is reached faster and with less resources. The literature analysis in this article is focuses on to two key aspects – the genesis of biomass energetics and principals of blockchain technology. The two can be combined to a unified system with the purpose of increasing the level of sustainable development within the area. This research will focus on the development of biomass energetics using the contemporary measures for transactions. A lot of previous studies researched the biomass energetics and blockchain technology as two separate occurrences looking in different directions. The purpose of this article is to research the possibility to adapt blockchain technology to traditional sustainable energy production using biomass. The purpose of the article will be fulfilled if the following goals are achieved: (1) analysis of the possibilities to use blockchain technology in biomass energetics business is conducted; (2) prerequisites for biomass clusters' conversion to blockchains are established; (3) ways how using blockchain technology could ensure the development of sustainable energetics are determined.

2. Prerequisites for biomass clusters' conversion to blockchains

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The efficiency of biomass energy is based on the cooperation of supply chain actors. The supply chain consists of subjects producing biomass, converters, transportation business representatives, energy distribution systems and energy power plants. Developing cooperation-based activities can help reach competitive advantage against business units that use fossil fuels. The activities of biomass clusters significantly contribute to sustainable development in the regions because local renewable resources are used that are in most cases not suitable to be recycled. Generally speaking the structure of the cluster is suitable for the development of biomass energy business and taking advantage of the latest technological solutions to the purpose of more effective energy sales expanding them and forming tighter relations with end users.

Biomass cluster is focused on fulfilling energy demands in a certain region and therefor is different form most of the business clusters that are focused towards a foreign consumer. Since the activity field of the cluster is local it involves a significant amount of human and capital resources. Campbell, Price (2008) describes the key advantage of biomass and sustainable energy: most renewable energy technologies are decentralized; and as such, reduce the impact arising from technological malfunctions or terrorist attacks which could seriously impair a nation's electricity grid. Valentine (2011) states that investments to biomass energy could help diverse the profit acquired from extraction of fossil fuels. Braun, McRae-Williams, Lowe (2005) claims that large firms internalize much of the lateral, horizontal and vertical scope of a cluster. They are able to do so because they have economies of scale. SMEs are limited in their access to specialized resources and intelligent capital (Virglerova, et al., 2016; Belas, et al., 2016). Grigoras, Scarlatache (2015) believes that the key benefits of biomass use are: energy efficiency, rational use of energy, competition policy, diversification of energy sources, availability of modular generating plants, ease of finding locations for smaller generators, shorter construction times, and lower capital costs. Korobeinikov, Read, Parshotam, Lermit (2010) says that land allocation policy with the aim to biomass production and forestry can play a major role in controlling greenhouse gas levels. This might result in a significant economical push for the countries because of the emerging necessity to reform the existing energy related policies. Significant investments that would stimulate the economic circulation are needed for this purpose. Kiriyama, Kajikawa (2014) adds that use of biomass is desirable for several reasons that include energy security factors, environmental concerns, foreign exchange savings, and socioeconomic issues. Rocha (2004), Mura, et al. (2017); Tvaronavičienė (2017); Razminienė, Tvaronavičienė (2018) signify the effect for the whole business system: clusters foster entrepreneurship providing established relationships and better information about opportunities; lowering entry and exit barriers; providing access to physical, financial, and commercial infrastructure; easing the spin offs of new companies from existing ones; reducing risk and uncertainty for aspiring entrepreneurs; and providing a cultural environment where establishing one's own business is normal and failure is not a social stigma. Bergman, Feser (2011) ir Adu, Shokunbi, Cole, (2014) extends the thought about the advantages of clustering to SME that later impacts the economy. When small manufacturing enterprises cluster together, they have the potential to gain from local and external economies through collective efforts. Thus, enterprises have the capacity to engage in flexible specialization where they perform certain operations or produce certain types for other enterprises. These joint actions enable small enterprises to derive competitive advantage from external economies (Srovnalikova, et al., 2018). Collective efficiency is facilitated by clustering on a number of factors including product specialization, rapid production of specialized products, emergence of suppliers, emergence of service producers, marketing agents, pooling of skilled labor and formation of consortia or association for specific services and lobbying. Gajšek, Kovač (2016) complements this idea indicating the benefits of cluster activity to its members: achieving synergies in the area of knowledge enhancement, joint purchasing and marketing, strategy and objectives, trust among members, as many as possible joint development projects with both long and short-term effects, financial independence from government incentives.

The information provided allows understanding under what conditions biomass energy sectors develop in different countries. Biomass is used to produce thermal energy, electricity and natural gas as well. Under these circumstances the activity of biomass cluster can be digitalized and adjusted to consumer needs. Energy produced through biomass cluster activities are most commonly realized through energy distribution subjects. Blockchain technology opens a possibility to communicate directly with retail clients and this way confirm electricity transactions. Smart contracts allow to exchange resources in the fastest way having the reliability insurance. A person who seeks to acquire electricity can approach the producer and pay him for the purchased amount using blockchain technology.

Furthermore, blockchain technology can help creating a smart grid that would ensure a more effective energy distribution. Blockchain would help creating a decentralized energetic system this way increasing the level of sustainability in the energy sector. At the same time, it would improve the utilization possibilities of electricity produced from biomass during the summer when the general energy demand is decreased. The essence of the smart grid is the possibility to address the supply and demand changes within the energy system in real time that ensures a more effective utilization of resources. Biomass energy stands out because it can balance the energy system in those cases when it is loaded with vast amount of sun and wind energy.

Finally, blockchain may make existing electric industry processes more efficient by serving as the backbone for utilities' "smart grid" management systems that automatically diagnose network emergencies and problems and reconfigure in reaction to them (Basden, Cottrell, 2017). That significantly reduces the level of resource waste speeding the pace of sustainable development. This makes it possible to supply the energy produced from biomass to consumers faster meanwhile the consumers would be able to create value through the use of green energy. This would extend the positive biomass effect on the environment because the smaller amounts of wasted fuels would attest for the proper utilization of renewable resources.

There are other ways that blockchain technology can be used to promote the consumption of renewable energy. Energy consumption could be connected to the assets of the powerplant that administrates the energy distribution and virtual currency. In this case it is suggested to create a cryptocurrency that would be connected to the amount of energy produced. This measure should encourage the consumption of renewable energy. In particular, cryptocurrency is a kind of digital currency rewarding energy producers. In addition to the usual way of getting coins through mining, cryptocurrency can be granted by the cryptocurrency foundation as long as you have generated the renewable energy (Zheng, Xie, Dai, Wang, 2016). Energy could be acquired both ways – using commonly recognized currencies or the virtual currency released by the energy producer. This way a synergy between different types of activities is reached and possibility to purchase green energy is promoted. That is very important for Y generation that is affected by the green movement.

The growing influence of the green energy movement formed the need to manage the demand. To balance the demand, negotiations with consumers take place to define the how intense the consumption of energy should be during certain times of the day. Blockchain technology would simplify the calculations of energy consumption and would allow to distribute the green energy more easily. Previous researches show that blockchain based distributed demand side management can be used for matching energy demand and production at smart grid level, the demand response signal being followed with high accuracy, while the amount of energy flexibility needed for convergence is reduced (Pop, Cioara, Antal, Anghel, Salomie, Bertoncini, 2018). When synergy is reached using previously mentioned smart grid it is possible to avoid the grid overload and properly calculate the amount of green energy consumed. At the same time energy produced from biomass would be directed towards the highest demand the particular time. Consumers that are committed to use higher volumes of energy during certain moments will rely on sun and wind energy and as its amount will decrease biomass volume will grow. It is stated that a blockchain provides a distributed software architecture that enables agents (human or artificial) to interact without a central governing institution. However, despite the absence of intermediaries during runtime, blockchain-based systems always rely on the correctness of predefined rules, and thus it is crucial to ensure they are secure, reliable and accurate. Moreover, blockchain technology is still at an emergent stage and struggles with a variety of problems (e.g., limited transaction loads), and the complexity of current protocols and implementations still provides challenges for researchers, practitioners, and users (Mengelkamp, et al., 2018).

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In conclusion it can be said that biomass energetics and blockchain technology has overlapping point that can help create additional value. Cluster based biomass energy system can be transformed to a blockchain if selling, accounting and payment activities would be processed in the digital environment. For this concept to come to life a common operating mechanism needs to be established. The model is created based on the positive effects of biomass consumption and the possibility for the blockchain technology to complement it extending at a wider range reaching a larger number of consumers.

3. Methodology

The study is based on scientific induction and deduction methods. Also, systematic, logical and comparative analysis of scientific literature is used. Blockchains are a relatively new phenomenon, so there are currently no objective statistics that can justify the scale of their creation. At the same time, comparable statistics cannot be obtained. The article presents theoretical assumptions on how biomass clusters could be transformed to blockchains, discusses current situation of the energy sector and methods that would strengthen the biomass cluster through the use of blockchain technology. The study reassures that the usage of the latest technology results in a positive impact on the economy and allows us to create guidelines for the dissemination of these technologies in the traditional business sectors.

4. The effect formed using biomass in energetics and its connection to the blockchain

The usage of biomass in energetics significantly changes the conjuncture of the market and contributes to the improving environmental situation. Synergy with the blockchain would significantly increase the sustainability level and would allow achieving even better environmental results. The main reason for business to do it is positive financial effect received from turning waist to energy. Traditional biomass energy system combined with blockchain technology would create possibility to increase the level of energetic security and to ensure fast energy and stock related transactions. Blockchain can improve the energy circulation when it is produced in a biomass cluster structure. Decreased waste of time and material resources increases the efficiency of the activities and general sustainability level.

According to do Carmo Farinha, de Matos Ferreira, Gouveia (2014), competitiveness creates the basic conditions for sustainable development and growth, to the creation of new production activities and new jobs, and for a better quality of life. McCauley, Stephens (2012) extends this idea claiming that sustainable energy cluster initiatives aim to stimulate local and regional economic development by creating the conditions that attract and promote innovative firms in the area of sustainable, renewables-based energy. Firms engaged in the development and implementation of renewable energy technologies, smart grid technologies, and low-impact transportation systems are particularly sought, as these sectors are seen as high growth sectors with potential to both address critical sustainability challenges and solidify and advance a region's knowledge-based economy. Varun, Prakash, Bhat (2009) distinguished sustainability assessment indicators: energy pay-back time; GHG emissions; cost of electricity generation. Lund (2007) adds that sustainable energy development strategies typically involve three major technological changes: energy savings on the demand side, efficiency improvements in the energy production, and replacement of fossil fuels by various sources of renewable energy.

Cluster activity ensures that natural waste that cannot be recycled will be used to produce the energy. Sustainable use of resources is a prerequisite for a cluster that distinguishes it in the context of other producers. Being able to produce economic and financial value from raw biological waste, cluster becomes an important economical subject that countrywide engages in politics of energetics within the regions. At the same time conditions for blockchain expansion turning waste to an object that can be realized. According to Lozano (2008), the important step in the quest for sustainability would be help to equalize the importance and integrate the three aspects, where

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the 'relative' importance and impact of the economic aspects should be equal to that of the environmental and social ones. López-Menéndez, Pérez, Moreno (2014) claims that sustainable energy policies should be promoted in order to spur economic growth and environmental protection in a global context, particularly in terms of reducing greenhouse gas emissions that contribute to climate change.

Sustainable energy management represents an important component in local development. This is of particular importance in agricultural regions where biomass resources are just inexhaustible (Kurowska, Kryszk, Bielski, 2014). The economic results of the production and use of biomass include: sustainable growth, diversity of fuels, more jobs in the countryside, higher income tax, more investment in the durable assets stimulating the development of agriculture, gaining an international competitive advantage (Sanchez, Cardona, 2008). Management can be expressed through both, traditional structures and the use of blockchains to realize resources. To avoid wasting resources it is recommended to modify the traditional biomass cluster structure adapting the concept of blockchain by moving the information on fuel extraction and transactions to digital environment.

Saxena, Adhikari, Goyal (2009) defines key benefits of biomass use in energetics:

- The combustion of biomass produces less ash than coal combustion and the ash produced can be used as a soil additive on farms, etc.;
- The combustion of agricultural and forestry residues and municipal solid wastes (MSW) for energy production is an effective use of waste products that reduces the significant problem of waste disposal, particularly in municipal areas;
- Biomass is a domestic resource which is not subject to world price fluctuations or the supply uncertainties as of imported fuels.

The structure of biomass sector satisfies the key principles of sustainable development. Following the direction of sustainable development, we seek balance between social, economic and environmental interests. The balance can be reached if the business is built around combined different interests. Figure 1 shows that merging different interests forms reactions that later contribute to the development of sustainable business model. By combining different interests, we can reach synergy and form a new type of positive effect to the business subject and the society. The sustainable development model is inherent to the inclusion of the society to the business processes. At the same time, it is a cornerstone for the biomass energy sector.

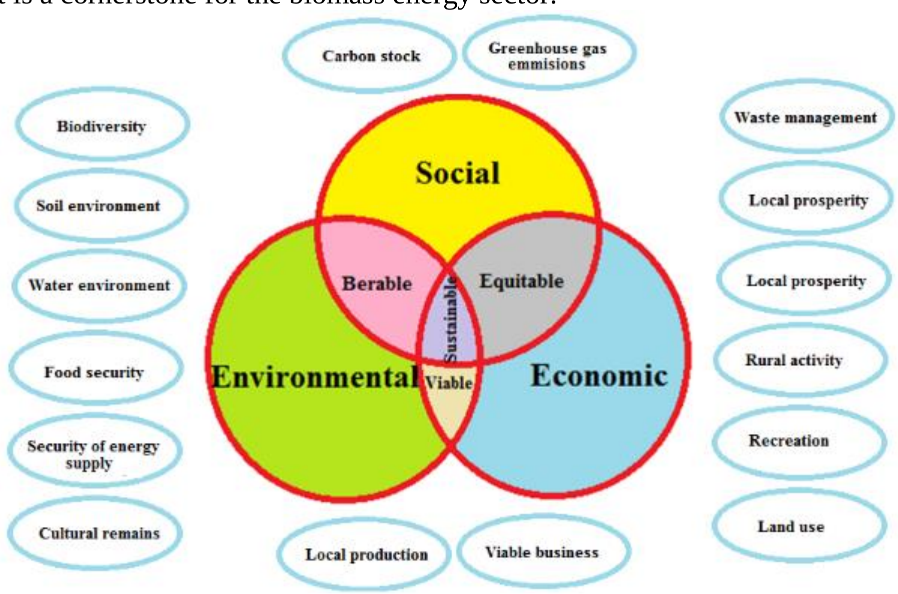

Fig.1. Sustainable development connections and interactions

Source: Ladanai, Vinterbäck, 2009; Hjulfors, Hjerpe, 2010

Moving towards the cluster activity mechanism based on blockchain technology it is important to note that a significant amount of efficiency and sustainability in ensured through the digitalizing the accounting of transactions. That would simplify the energy supply procedures, ensure the energy supply security and would allow producing the amounts that the market would realize in real time. This would save natural resources and help prevent energy overproduction. The waste of resources in case of overproduction would be prevented at the base level. The production of biomass would be regulated based on the contracts that would be approved using blockchain. Afterwards when biomass is turned to energy it would be distributed to the subject that have purchased it.

There is also an alternative view to the effects of using blockchain in energetics. It is related to optimization and simplification of existing operations. It covers both, administrative and technical processes. Mylrea, Gourisetti (2017) claims that additional potential blockchain benefits, may also: (1) enhance the trustworthiness and preserve the integrity of the data; (2) support multifactor verification through a distributed ledger; (3) secure integrity of transaction data; (4) reduce costs of energy exchanges by removing intermediaries; (5) all transactions would be executed in real time and settled on the basis on actual consumption; (6) enabling consumers to also be producers could provide additional storage and help substation balancing from bulk energy systems; (7) enable a more secure distributed escrow to maintain ordered time stamped data blocks that can't be modified retroactively; (8) rapid detection of data anomalies may enhance the ability to detect and respond to cyber-attacks; (9) help align currently dispersed blockchain initiatives and facilitates technology deployment through easy to implement and secure applications; (10) potentially help reduce transaction costs in the energy sector; (11) distribution system operators can leverage the blockchain to receive energy transaction data required to charge their network costs to consumers; (12) transmission system operators would have reduced data requirements and constraints for clearing purposes. Based on the amplitude covered by the blockchain technology we can recognize a perspective extending it to the energy sector. By utilizing existing resources more efficiently and adjusting to consumer needs, sustainable development growth can be achieved.

Biomass blockchain structure is based on the use of traditional resources but the transactions are processed exclusively in digital environment. This is covered by smart contracts that speed the transaction administration procedures. In this case a deposit equal to a certain amount of cryptocurrency is needed. It serves as an insurance policy ensuring the credibility of both business subjects. With the help of the blockchain synergic effect can be reached as based on smart contracts the energy would be transferred through the smart grid. It allows to know the precise amount of energy and time when it is transferred to the consumer also ensuring real time payment for the energy. In this case the activities related to energy production (upper part of the scheme) take the most time and the following activities are executed parallelly or at the same time.

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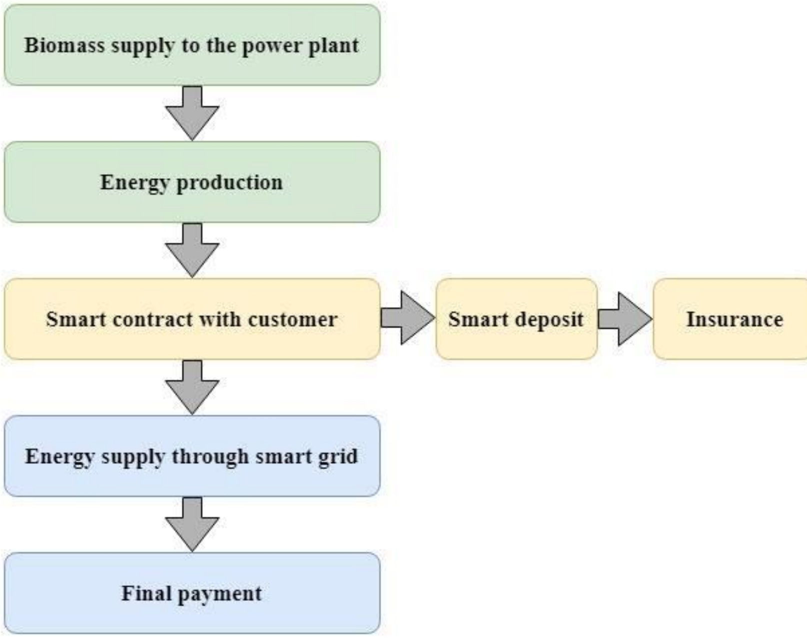

Fig.2. Blockchain technology-based energy distribution scheme

Source: Own evaluation

Based on the scheme provided we can see that in order to complete the deal smart contracts are signed between the biomass energy producer and the customer. The contract is based on smart depository which is a blockchain based monetary system expressed in cryptocurrency. If the transaction is completed the amount is returned to the business subjects and in case of failure it is allocated to the injured party. Both popular cryptocurrencies and currency spent by the business subjects may be used. When the transaction is confirmed with the smart depository the energy is provided to the consumers in real time. This is rounded up in the phase of final payment and the essence of it is that the producer can take back his deposit after he proves that the energy is already provided. The structure provided significantly increases the level of transparency within the transactions, eliminates several traditional transaction execution levels, speeds up the accounting process and that allows faster execution of environmental decisions – removal of biological waste, clean the lowland greenery and water bodies. Afterwards electricity is produced from the waste is realized in real time.

Processes are more complicated and take longer in traditional energy business. It is related to the lack of control in real-time and deposit system, also inability to quickly respond to changes in demand. Furthermore, the maintenance and communication using existing information technology is more expensive compared to blockchain development. After transaction is completed it is also important to confirm it with a purchase-sale act. Blockchain technology can also prevent from cases of fraud, eliminates the possibility of fake orders used to avoid taxes.

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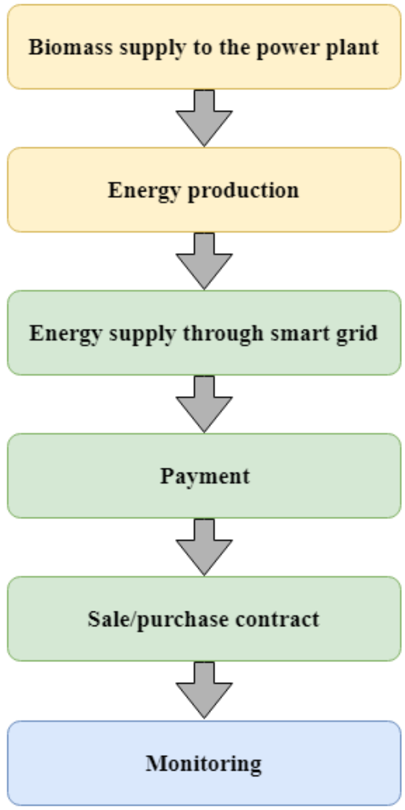

Fig.1. Traditional biomass trade structure

Source: Own evaluation

Blockchain technology-based biomass clusters would become more efficient, if would be possible to plan production more accurately simultaneously increasing the level of sustainable development within the region. Seeking to achieve synergic effects it is necessary to digitize the sales and accounting processes. That would not only create an effect on economy but would also save renewable resources thus improving the environment. This would reduce air pollution that is caused by imbalanced supply of fuels and physical expenses that occur due to excess bureaucracy and agreement handling. Traditional biomass distribution system is limited and impeds the possibility to essentially increase the efficiency of the processes and save resources. A cluster that is based on the blockchain technology is enabled to seek direct contact with the customer using intermediate distribution structure to provide the service, but not a mechanism that would generate the demand-supply flows.

Conclusions

Biomass cluster activity can be a suitable medium to develop blockchain technology. Key areas that could be digitalized are: transaction accounting, payment and deposit mechanism, transaction security verification. Blockchain technology allows increasing the pace of sustainable development growth because in this case natural resources would be saved and conditions for more efficient utilization would be created. The technology contributes to the growth of sustainable development as it allows calculating the energy demand in real-time, distribute the orders and supply energy faster to consumers. Comparing traditional biomass sales structure with blockchain structure it is notable that the latter is more flexible, less time consuming, improves the monetary flow and saves resources. Energy is supplied based on real-time demand data and that allows to adapt key principles of Industry 4.0 concept – production is personalized and based on real-time demand. The use of biomass reduces air pollution and the blockchain helps multiplying the primal positive effect of biomass usage.

References

Adu, J.T.; Shokunbi, M.O.; & Cole, B.M. 2014. Building Sustainable Business Clusters towards Global Competitiveness: Case Study of Furniture Making along Owode - Ajegunle Axis of Lagos State, *Journal of Poverty, Investment and Development* 4: 46–51. http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.842.5341&rep=rep1&type=pdf

Bastden, J.; & Cottrell, M. 2017. How utilities are using blockchain to modernize the grid. *Harvard Business Review*, Brighton, p. 3. https://www.oliverwyman.com/content/dam/oliver-wyman/v2/publications/2017/may/How_Utilities_Are_Using_Blockchain_To_Modernize_The_Grid.pdf

Belas, J., Vojtovic, S., Kljucnikov, A. 2016. Microenterprises and Significant Risk Factors in Loan Process, *Economics & Sociology*, 9(1): 43-59. https://doi.org/10.14254/2071-789X.2016/9-1/3

Bergman, E.M.; & Feser, J.E. 2011. *Industrial and Regional Clusters: Concepts and Comparative Applications*. Morgantown, WV: WVU Regional Research Institute Web Book. https://www.researchgate.net/publication/269709907_Industrial_and_Regional_Clusters_Concepts_and_Comparative_Applications

Braun, P.; McRae–Williams, P.; & Lowe, J. 2005. Small Business Clustering: Accessing Knowledge through Local Networks, *Journal of New Business Ideas and Trends* 3(2): 57–63. http://www.jnbit.org/upload/Braun_McRae-Williams_Lowe-3-2-2005.pdf

Campbell, K.M.; & Price, J. 2008. *The global politics of energy*. USA: The Aspen Institute. https://assets.aspeninstitute.org/content/uploads/files/content/docs/pubs/ASG_GlobalPoliticsofEnergy.pdf?_ga=2.72447444.619057303.1544820091-925425757.1544820091

do Carmo Farinha, L.M.; de Matos Ferreira, J.J.; & Gouveia, J.J.B. 2014. Innovation and Competitiveness: A High-Tech Cluster Approach, *Romanian Review Precision Mechanics, Optics & Mechatronics* 45: 41–48. http://www.incdmtm.ro/editura/documente/Pag%2041-49.pdf

Gajšek, B.; & Kovač, J. 2016. Key Factors for the Successful Operation of Clusters: The Case for Slovenia, *Organizacija* 49 (2): 150–161. https://doi.org/10.1515/orga-2016-0011

Kiriyama, E. & Kajikawa, Y. 2014. A multilayered analysis of energy security research and the energy supply process, *Applied Energy* 123: 415–423. https://doi.org/10.1016/j.apenergy.2014.01.026

Kurowska, K.; Kryszk, H.; & Bielski, S. 2014. Determinants of biomass production for energy purposes in north-eastern Poland, *Engineering for Rural Development* 13: 417–422. http://tf.llu.lv/conference/proceedings2014/Papers/71_Kurowska_K.pdf

López-Menéndez, A.J.; Pérez, R.; & Moreno, B. 2014. Environmental costs and renewable energy: Re-visiting the Environmental Kuznets Curve, *Journal of Environmental Management* 145: 368–373. https://doi.org/10.1016/j.jenvman.2014.07.017

Lund, H. 2007. Renewable energy strategies for sustainable development, *Energy* 32: 912–919. https://doi.org/10.1016/j.energy.2006.10.017

McCauley, S.M.; & Stephens, J.C. 2012. Green energy clusters and socio-technical transitions: analysis of a sustainable energy cluster for regional economic development in Central Massachusetts, USA, *Sustainability Science* 7: 213–225. https://doi.org/10.1007/s11625-012-0164-6

Mengelkamp, E.; Notheisen, B.; Beer, C.; Dauer, D.; & Weinhardt, C. 2018. A blockchain-based smart grid: towards sustainable local energy markets, *Computer Science-Research and Development* 33(1-2): 207–214. https://doi.org/10.1007/s00450-017-0360-9

Mura, L., Haviernikova, K., Machova, R. 2017. Empirical results of entrepreneurs' network: case study of Slovakia, *Serbian Journal of Management* 12(1): 121-131. https://doi.org/10.5937/sjm12-10418

Mylrea, M.; & Gourisetti, S.N.G. 2017. *Blockchain for smart grid resilience: Exchanging distributed energy at speed, scale and security*. In Resilience Week (RWS), IEEE. 18–23. https://doi.org/10.1109/RWEEK.2017.8088642

Pop, C.; Cioara, T.; Antal, M.; Anghel, I.; Salomie, I.; & Bertoncini, M. 2018. Blockchain based decentralized management of demand response programs in smart energy grids, *Sensors* 18 (1): 162. https://dx.doi.org/10.3390/s18010162

Razminienė, K.; Tvaronavičienė, M. 2018. Detecting the linkages between clusters and circular economy, *Terra Economicus* 16(4): 50-65. https://doi.org/10.23683/2073-6606-2018-16-4-50-65

Roberts, D. 2007. Globalization and Its Implications for the Indian Forest Sector. TIFAC/IIASA Joint Workshop *"Economic, Societal and Environmental Benefits Provided by the Indian Forests*", New Delhi, India, April, 2007. https://doi.org/10.1505/ifor.10.2.401

Rocha, H.A. 2004. Entrepreneurship and Development: The Role of Clusters, *Small Business Economics* 23: 363–400. https://doi.org/10.1007/s11187-004-3991-8

Sanchez, O.J.; & Cardona, C.A. 2008. Trends in biotechnological production of fuel ethanol, *Bioresource Technology* 99: 5270–5272. https://doi.org/10.1016/j.biortech.2007.11.013

Saxena, R.C.; Adhikari, D.K.; & Goyal, H.B. 2009. Biomass-based energy fuel through biochemical routes: A review, *Renewable and Sustainable Energy Reviews* 13: 167–178. https://doi.org/10.1016/j.rser.2007.07.011

Srovnalíková, P.; Havierniková, K.; Guščinskienė, J. 2018. Assessment of reasons for being engaged in clusters in terms of sustainable development, *Journal of Security and Sustainability Issues* 8(1): 103-112. https://doi.org/10.9770/jssi.2018.8.1(9)

Srovnalikova, P.; Karbach, R. 2016. Tax Changes and Their Impact on Managerial Decision Making. *Proceedings of the 1st International Conference Contemporary Issues in Theory and Practice of Management*. Czestochowa: CITPM, pp. 410-415. ISBN 978-8365179-43-2. Accession Number: WOS: 000385693000059

Tvaronavičienė, M. 2017. Clusters, innovations and energy efficiency: if relantionship could be traced, *Marketing and Management of Innovations* 2: 382 - 391 http://doi.org/10.21272/mmi.2017.2-35

Valentine, S.V. 2011. Emerging symbiosis: Renewable energy and energy security, *Renewable and Sustainable Energy Reviews*, Vol. 15 (15), 4572–4578. URL: http://www.sciencedirect.com/science/article/pii/S1364032111003406

Varun; Prakash, R.; Bhat, I.K. 2009. Energy, economics and environmental impacts of renewable energy systems, *Renewable and Sustainable Energy Reviews* 13: 2716–2721. https://doi.org/10.1016/j.rser.2009.05.007

Virglerova, Z.; Kozubikova, L.; Vojtovic, S. 2016. Influence of selectedfactors on financial risk management in SMEs in the Czech Republic, *Montenegrin Journal of Economics* 12(1): 21-36. URL: http://repec.mnje.com/mje/2016/v12-n01/mje_2016_v12-n01-a12.pdf

Zheng, Z.; Xie, S.; Dai, H. N.; & Wang, H. 2016. *Blockchain challenges and opportunities: A survey.* Work Pap. 1-25. https://www.henrylab.net/wp-content/uploads/2017/10/blockchain.pdf

Žižka, M.; Hovorková Valentová, V.; Pelloneová, N.; Štichhauerová, E. 2018. The effect of clusters on the innovation performance of enterprises: traditional vs new industries, *Entrepreneurship and Sustainability Issues* 5(4): 780-794. http://doi.org/10.9770/jesi.2018.5.4(6)

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