Blockchain in Energy Markets The case of Electricity Sector

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I hereby declare that the work submitted is mine and that where I have made use of another's work, I have attributed the source(s) according to the Regulations set in the Student's Handbook.

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Abstract

This dissertation was written as part of the LLM in Transnational and European Commercial Law, Arbitration, Mediation & Energy Law at the International Hellenic University.

This dissertation focuses on blockchain relevance, as it emerges as a drastic solution in a series of problems, a panacea for decentralisation and more democratic approach to transactions. The paper provides an overview of blockchain technology as well as the basic model of blockchain transaction and concepts. Follows a thorough analysis about the possible uses of blockchain technology in energy, particularly in electricity sector. Afterwards the articles lists legal and regulatory implications on the energy field. Finally it takes a closer view on critical evaluation on legal and regulatory level in electricity sector. The analysis does not provide a definite position about the level of blockchain applications in electricity markets and points out criticism and the disadvantages or limitations due to "peculiarities" of the electricity industry. Either way the author is reluctant to take a unambiguous view, besides the extremely optimistic declarations of the tech industry.

I would like to thank my supervisor Dr iur Komninos Komnios, that accepted the challenge of supervising a theme that is quite technical with limited if none academic literature for the issue in hand. Though as he is pioneer and keen in solving legal riddles, we had a fruitful co-operation.

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Preface

Blockchain has emerged in economic life as the technological development that would revolutionize the way business is conducted, it will introduce new required skills and it will demobilise a number of professions. At the end of the day it will alter the social fabric itself.

This new technology entered the electricity markets field and caused a series of debates and discussions in electricity market participants, experts and academics. All that theoretical and practical confrontation on the theme between traditionalist and innovators, in the electricity markets, as well as her participation in relevant researches within PPC SA, based on Euroelectric's study, triggered author's academic curiosity to elaborate little further on the subject. The aforementioned Euroelectric study, titled "Blockchain in Electricity, a critical review of progress to date" serves as buzzard for this thesis.

This thesis discusses the current blockchain projects in the electricity sector. Chapter one makes an introduction to blockchain technology and its characteristics. In Chapter two there is an analysis on blockchain in the electricity sector. The presentation focuses on the possible "uses" – the potential of blockchain technology in the electricity sector. The chapter provides examples of blockchain projects in every case. Finally in Chapter three there is an analysis of legal and regulatory issues related with the central theme as well as critical evaluation of blockchain application in the field.

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It is important to mention that there is limited academic literature for the issue in hand, none of it in the form of books only in academic articles. As seen at the Bibliography section all the listed sources are either from academic journals or from specialized studies on blockchain.

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Introduction

Blockchain. It has emerged as the Holy Grail in business and it has been introduced as an expression of direct democracy, utopia[1] or business without intermediaries even in energy sector.

Recently the energy community noticed a remarkable increase in global recognition, on a worldwide basis of blockchain technology and its potential applications. Clear indication of that shift of mentality is obviously the number of projects using the Ethereum blockchain platform. The aforementioned platform's central purpose is the "smart contract" functionality. Furthermore on the Initial Coin Offerings (ICOs) area about a thousand (1.000) took place as an alternative venture capital funding method that generated about €3 billion. Respectively in the electricity sector EU data showed that there are almost 120 organisations involved in blockchain-based applications on a global basis. Accordingly there are several projects developing (around 40)[2] blockchain projects globally. European Union acknowledges the importance of Blockchain and decided to launch an observatory on the issue under examination[3] . It is expedient to point out that the main reason that Blockchain has been identified as innovative contributor in business activity and caught the attention both academics and the industry, it is actually its ability to ensure transaction validity due to multiple registration on a series of registers and not only on a main register and the bypass of any intermediary..

Generally speaking blockchain technology could be fruitful in those sectors where no physical – commodities exchange is required, such as financial, banking, and insurance. Accordingly electricity has similar characteristics since electricity sales and purchases are conducted and cleared on trading platforms runned by authorised entities, there are financial products bound to electricity and CO2 emissions (futures, derivatives, options) traded in particular platforms or energy exchanges. It should be pointed out that nowadays with the application of the Target Model in European

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[1] "Blockchain technology makes it more feasible for individuals to exit political -socioeconomic systems at the level of the system itself and elect to accede freely to institutional systems which formulate, promulgate, keep and verify institutions and public records without a centralised authority. B. Markey-Towler "Anarchy, Blockchain and Utopia: A theory of political -socioeconomic systems organised using Blockchain" , (2018) , Journal of British Blockchain Association , p1"

[2] Data from Euroelectric study (may 2018) at https://cdn.eurelectric.org/media/3114/paper2_blockchain_eurelectric-h-CD3AAA18.pdf

[3] https://www.eublockchainforum.eu/

Union countries; this pro-"stock market" direction will be enforced, since for competition purposes the vast majority of electricity will be traded via stock market. In Greece this transition from "pool market" to Target model is expected to start the sixth of June 2019[4].

As with every innovation blockchain could add value to the electricity sector but also poses risks and challenges to the sector.

It is of tremendous importance to point out that as the blockchain ecosystem continues to grow, policymakers and regulators ought to play pivotal roles. This has to do with the process of unlocking blockchain potential value but also to safeguard the market as well as the participants and the customers from potential risks. With appropriate regulatory support, blockchain technology could drive significant value for electricity customers, distributed energy resource providers, wholesale market participants, and regulated electricity network operators—distribution system operators (DSOs) and transmission system operators (TSOs). On the other hand, in case that the market will remain unregulated, blockchains could expose system operators' IT systems to unanticipated cybersecurity risks, and could develop in ways that undermine the efficiency of wholesale and retail electricity markets and eventually undermine security of supply. It is important to mention that regulators so far have done limited research on the area and thus provide with regulatory blueprint in developing blockchain market, the only organisation that has a thorough study on the phenomenon is Euroelectric. Blockchain could be incorporated to wholesale energy trading, retail market, peer to peer markets, flexibility services, electric vehicle charging and environmental attribute products.

The past five years we experienced the phenomenon business world as well as academia pose an increased acknowledgment of blockchain technology and its possible applications. The prices and the marketability of Bitcoin—the most widely-used and known blockchain-based cryptocurrency. Actually it showed a wide range price fluctuation from 742$ (November 2016) to 3690$ (December 2018)[5]. Furthermore the number of projects using the Ethereum blockchain platform (the smart contract platform) increased dramatically over thousand (1.000). Moreover Initial Coin Offerings (ICOs) expanded as well, since worldwide data showed that during 2017 210 successful ICOs took place as alternative venture capital funding process that rose over €3 billion. Adding to that Q1 2018 the ICOs that took place were 166 and the raised capital was €4.8 billion.

[4] https://energypress.gr/news/hrimatistirio-energeias-sis-6-ioynioy-xekina-i-agora-exisorropisis-septemvrio-i-ekpaideysi-gia (Greek article January 2019)

[5] https://www.statista.com/statistics/326707/bitcoin-price-index/ (last visited January 2019)

The most important innovation that Blockchains introduced that gained attention both of business and academia is that it provides a significant guarantee about the validity of any transaction which is achieved by recordings that take place not only on a main authorised register but on a decentralised - distributed level at a system of registers, all of which are connected through a secure validation mechanism. That means that in cases that there is lack of trust, for any reason, the parties could reach a closing agreement. Mainly due to the fact that the digital record could not be altered, unless all participants in the record agree,

Despite its potential to create value for participants and society, Blockchain's future in electricity sector is rather uncertain. It is a new technology that has not yet proved it commercial thus financial validity to the energy sector. As with any new technology blockchain is burdened with high cost, low return on investment rates as well as slow transaction speeds. Furthermore the "peculiarities" of the electricity sector which are the importance of economies of scale and scope of regulatory limitations – provisions in networks (distribution & transmission) undermine developments for large scale blockchain projects.

1. What is a Blockchain?

Blockchain has been defined as a decentralised (distributed) electronic ledger system that keeps records of any transaction which is considered of value for the system (i.e. money, goods, property, work or votes). Every participant- "peer" is interlinked and has access to the continuously expanding records the so called "blocks". That means that all the information are kept on every single computer of the system and not on one computer limiting the possibility of information corruption, cyber-attacks etc. Furthermore every "block" is connected to all the previous ones. The authentication process is been done via digital signatures and the ability to alter the existing records is rather narrow. Consequently any kind of regime or protocol change requires the consensus of all the network participants. Finally the participants provide the verification of transactions and not a third external party (i.e. state, banks etc.).
Verification of transactions is achieved internally, since the participants confirm changes with each other, replacing the need for a third party to authorize the transactions.
Decentralised accord makes blockchain platforms immutable to external threats and updatable only via consensus or agreement among peers.
This style is supposed to shield against domination of the network by any single PC or cluster of computers.

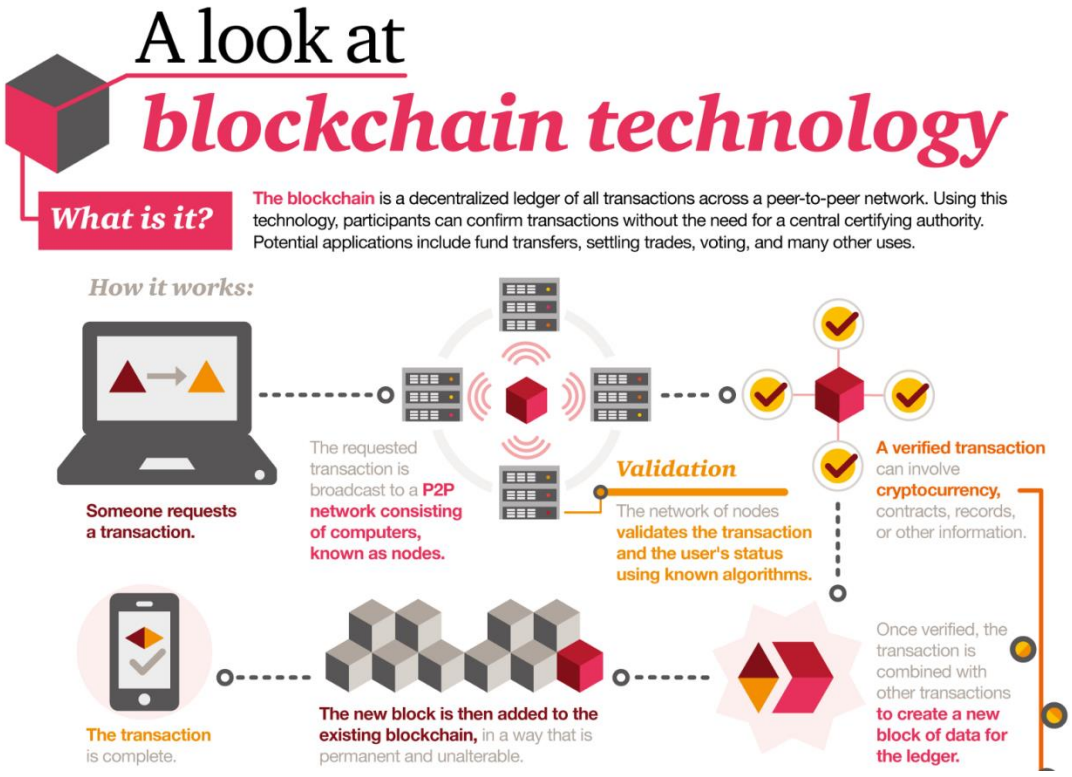

Figure1. "Adapted from https://medium.com/ignation/pulling-the-blockchain-apart-the-transaction-life-cycle-7a1465d75fa3"

Figure 1 illustrates the "modus operandi" of a blockchain transaction. The beginning of any blockchain based transaction proceedings begins with a blockchain user making a request to conduct a transaction— ("i.e. cryptocurrency, a smart contract, record, information"[6]). "The transaction is broadcast to a peer-to-peer network of computers (nodes) and network nodes verify the transaction (mining) attaching a unique "hash" to the transaction. When the transaction is verified it is combined with other related transactions to create a block of data for the ledger and a new block is added to the chain"[7]. The whole process of verification is called consensus and as a process provides to grow and simultaneously it prevents manipulation and "forking" the chain in a different direction.

Blocks represent realised transactions (or data added to the ledger) and "consensus is the verification process in different time frames thus the confirmation time reflect transaction volumes, block sizes, and consensus algorithms"[8]. The consensus algorithms used are the following:

1.1 Blockchain Properties

There are four variations of blockchain properties currently used or under development and the most commonly used are the "Proof of Work," "Proof of Stake," "Proof of Authority," and "Practical Byzantine Fault Tolerance," and are discussed below. These four variations have pros and cons regarding issues such as "stakeholder roles, transaction throughput, information security, barriers to entry, and energy consumption[9]".

Proof of Work: Proof of Work (PoW) is the most common property and relies on "miners." for verification, which is solving mathematical problems, not easily solvable, on a trial or error basis. When the "miners" solve the mathematical riddles (the so- called hash), then they gain the concession to add the next block in the chain under a regime of compensation. The most famous blockchain networks operating under PoW are "Bitcoin", "Ethereum" and generally permissionless networks. These networks are energy consuming[10], and operate at "slower transaction speeds". Experience showed that confirmation period for Bitcoin is eight to ten (8-10) minutes while those for Ethereum are about fifteen 15 seconds.

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[6] https://cdn.eurelectric.org/media/3115/paper1_blockchain_eurelectric-h-CB8D6920.pdf , p.8

[7] Ibid 6.

[8] Ibid 6

[9] Ibid 6

[10] "To quote the *MIT Technology Review*, "It's been estimated that Bitcoin guzzles need about as much electricity annually as all of Nigeria."

Proof of Stake: Under a Proof of Stake (PoS) approach, the verification process is conducted by "validators" whose right to verify is "based on their percentage stake in the creation of a block[11]", therefore every member of the blockchain's base cryptocurrency can be a "validator". Method advantages are complexity reduction for the decentralised verification and lower energy consumption.

Proof of Authority: Under Proof of Authority (PoA), particular accounts or validators under license place transactions in blocks. The process is automated and does not require constant monitoring though it is crucial to provide high levels of safety to validators' computers ("authority nodes"). This method is more centralised, therefore sensitive to possible cyber-attacks but it provides faster transaction times.. Energy blockchains use this method such as the "Tobalaba Energy Web Foundation[12]", a test network whose validators include significant energy/electricity companies like "Shell, Engie, Statoil, Centrica, Tepco[13]". In this network the confirmation time is 3-5 seconds.

Practical Byzantine Fault Tolerance: The well-known term "Byzantine Generals' Problem," refers to "a dilemma that arises when a group is trying to make a collective decision about how it will act, and faces the possibility a risk that "traitors" within the group may send mixed messages about their preferences[14]". In blockchain networks case the "traitor" behaviour could be inconsistent information about transactions that could undermine blockchain reliability. The problem in hand is faced the concept of primary and secondary "replicas". A typical example of project relying on Practical Byzantine Fault Tolerance is Hyperledger, an open-source collaborative effort launched by Linux Foundation.

1.2. Blockchain Permission Models

Another distinction at blockchain systems is based on their "permission models," which actually define the types of permissions given to network members. The term "Public" and "private" blockchain designations are of high importance and describes who is allowed to see the transaction in the network. Obviously "public" blockchains are open to anyone whereas "private" are only for authorised members.

A well-known limitation of current public blockchains is their limited ability to cope with extensive number of transactions per minute. Several attempts have been

[11] Ibid 6, p.9

[12] Ibid 6 , p.10

[13] Ibid 6, p.10

[14] Ibid 6, p.11

made to cope with this limitation like “sharding and second-layer protocols[15]” that makes challenging the maintenance of desirable security as well as the decentralisation public blockchains.

It is important to mention that blockchain a technology has the “hype process” period, according to Gartner’s life cycle model for new technologies. Actually according to the aforementioned model during 2017 Q2 blockchain passed the peak of “inflated expectations’ and entered the phase of “disillusionment”[16] . That means that now this technology will prove itself as valuable tool that will alter not only business but the social fabric itself, not an ephemeral fad but an important asset to the technology agenda called “fourth Industrial Revolution”

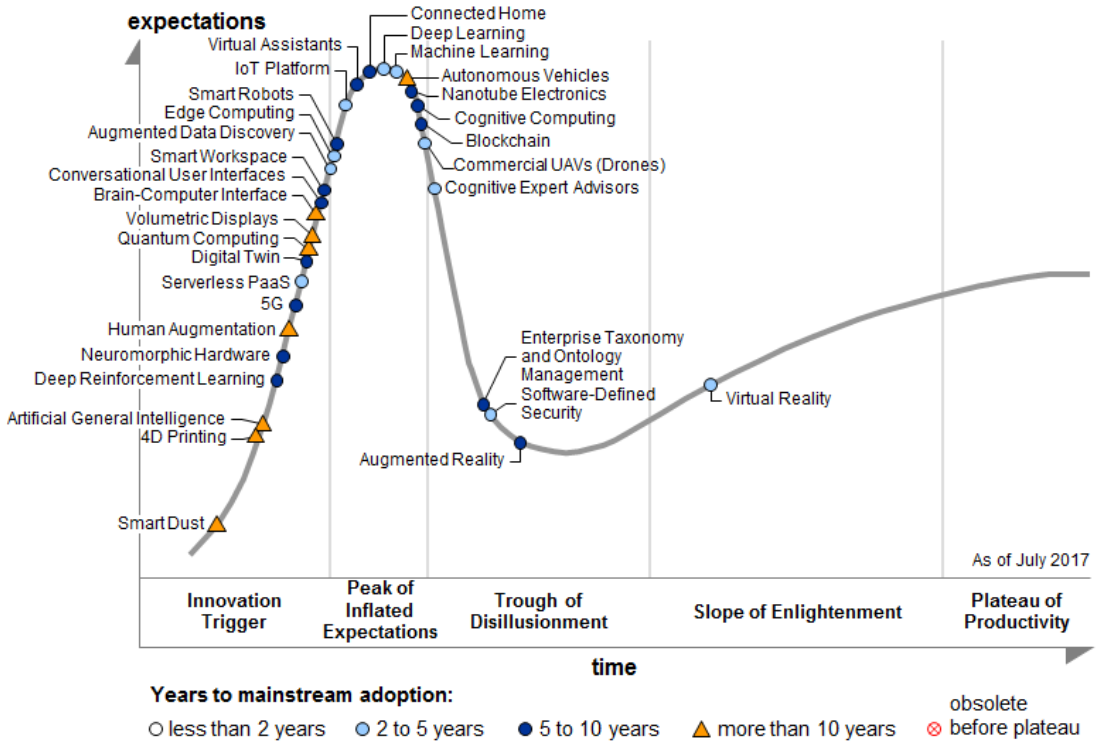

Figure2. Gartner Hype Cycle for Emerging Technologies , 2017

[15] Ibid 6, p. 13

[16]Source Gartner.com/SmarterWithGartner, (july 2017)

1.3 Blockchain in EU

European Union acknowledges the important role of blockchain for economic development and growth and according to European Parliament statements "We aspire to make the EU the leading player[17]" and "the European Union aspires to become the global leader in the fourth industrial revolution[18]". Furthermore the European Parliament adopted on the 16th of May 2018 a resolution regarding blockchain as proposed by Greek S&D member Eva Kaili in which she called for "open-minded, progressive and innovation-friendly regulation". Following to that, a resolution on the 3rd October 2018 was adopted providing guidelines for the issue in hand[19]. Furthermore a series of Commission initiatives for the exploration of DLTs have been launched such as 'Blockchain4EU: Blockchain for Industrial Transformations', 'EU Blockchain and Observatory Forum', 'Blockchains for Social Good' and 'Study on the Opportunity and Feasibility of an EU Blockchain Infrastructure[2021]'. Furthermore due to the fact of undeniable development of the blockchain technology all the related bodies- organisations call either to public consultations on the issue at hand or for regulatory reforms[2223].

[17] http://www.europarl.europa.eu/news/en/headlines/economy/20180514STO03406/blockchain-technology-we-aspire-to-make-eu-leading-player

[18] http://www.europarl.europa.eu/sides/getDoc.do?pubRef=-//EP//TEXT+CRE+20181001+ITEM-019+DOC+XML+V0//EN&language=EN&query=INTERV&detail=1-138-000 7th line

[19] http://www.europarl.europa.eu/sides/getDoc.do?type=TA&reference=P8-TA-2018-0373&format=XML&language=EN

[20] Ibid 17

[21] https://www.eubchub.eu/?kuki=ok

[22] http://www.mondaq.com/article.asp?articleid=772200&email_access=on

[23] http://europa.eu/rapid/midday-express-04-01-2019.htm

2. The Potential for Blockchain in Electricity Markets

The energy industry has shown an incising attention for blockchain or distributed ledgers as looming technology that could alter the energy field and the way business is conducted within it. The list of stakeholders include "energy supply firms, startups, technology developers, financial institutions, national governments, regulators and the academic community[24]", since first indications showed that blockchain has the potential to coercively introduce benefits and innovation. It is the energy sector that is more susceptible in integrating blockchain benefits.

Electricity sales and clearing, particularly within EU, due to the Target Model are stock market based activities, conducted either individually or through aggregators on centralised trading platforms and through financial – stock market instruments (i.e. futures, options etc.).

Lately business world saw the emergence of a series of startups and blockchain projects that seek to alter the electricity markets and its operations. According to Euroelectric data (2018[25]) there are more 120 energy companies involved in blockchain projects and about 40 pilot projects. The issues that those projects aim to face, under the blockchain technology are "the wholesale and retail electricity markets, peer-to-peer energy marketplaces, the provision of flexibility or balancing services, electric vehicle charging and coordination, network security, and markets for environmental attributes (such as renewable energy and carbon emission certificates)"[26].

Thought it should be pointed out that blockchain technology's future in electricity world is not clear yet, since its commercial value has not been proven, mainly due to blockchain's "high costs, slow transaction speeds, and other limitations and risks[27]". Simultaneously the main competitive advantage for every technological development in the electric power sector is the presence of economies of scale which is not yet evident in blockchain operation.

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[24] Andoni M. et all "**Blockchain technology in the energy sector: A systematic review of challenges and opportunities**" , Renewable and Sustainable Energy Review, Vol. 100, (2019).p. 145

[25] Ibid.6, p.6

[26] Ibid 6 , p.7

[27] Ibid 6, p.28

2.1 Potential applications and current projects

This section provides cases of existing blockchain projects and discusses the how's and when's blockchain technology will bequeath different segments of electricity sector. The potential applications and the existing projects reviewed have been examined in a relevant Euroelectric study[28]. The section illustrates methods adding value to "electricity customers (including DER providers) and network utilities (DSOs and TSOs)"[29]. In APPENDIX there listed a series of blockchain projects in the field of electricity.

2.1.1 Wholesale Energy Trading

Traders and financial institutions conducts electricity trading at online trading platforms After the conclusion of the trading day/ transaction all the participants in the electricity trading process fill in their IT systems (known as "energy trading and risk management - ETRM systems"). Transaction details are kept at ETRM systems for verification, tax etc. purposes and are constantly enriched by data exchanges between the participants in the transaction, brokers, stock market and clearing-settlement houses. Central aim is confirmation and closure- clearing of every purchase/ sell with absolute security of transaction. In Europe this is a totally automated process via EFETnet. Afterword's there is physical settlement through a TSO and financially cleared through a clearinghouse or bank. Accordingly external auditors and regulators receive reports about each transaction.

Trading uses IT systems which are "quite slow or inefficient which result in high transaction costs (costly exchange and broker fees, pricing agencies, etc.) as well as and operational costs (time-consuming reconciliation issues, costly back office processes, etc.[30])". Blockchain technology has been supported as main contributor for transaction cost reduction, particularly for large volumes trading due to the fact that it make far more efficient the operational processes via connectability of all trading offices. Furthermore by reducing transaction costs, blockchain provides the ability to smaller payers (i.e. producers) to participate in the electricity markets (i.e. via aggregators).

The existing pilot projects, such as Ponton's "Enerchain" and Blockchain Technology Limited (BTL)'s "Interbit" platforms, main objective wholesale trading costs reduction. "Enerchain," a proof of concept blockchain-based clearing platform, developed by Ponton an automation company specialized in energy markets. This

[28] Ibid 6

[29] Ibid 6 , p.18

[30] Ibid 6, p. 20

software conducts transactions directly between participants (traders, producers etc.) without the need of a centralised entity to verify each transaction (i.e. exchange, stock market). It provides the ability to wholesale energy traders to bid to a decentralised "orderbook", anonymously. In spite of low Enerchain trading volumes, to the moment, compared to the total volumes on the European Energy Exchange (EEX), the tendency is growing. It began in 2017 as a consortium of 15 European energy trading firms and in April 2018, the consortium reached the 42 firms[31]".

Accordingly BTL launched a pilot project aimed at reconciliation issues in the European gas market that could be used to electricity market as well. The aforementioned project, in co-operation with Wien Energy, BP, Eni Trading & Shipping reduces the manual management of post-trade communications in which all the participants logged into a blockchain verify, in real time, all the transactions. The project was called Interbit and "in 2018, BTL announced a partnership with Eni Trading & Shipping, Total, Gazprom Marketing & Trading Limited and other companies to use the Interbit blockchain platform to deliver gas trading reconciliation through to settlement and delivery of trades[32]".

2.1.2 Retail Electricity Markets

Retail electricity markets could see tremendous enhancement due to blockchain, mainly through the use of crypto-currencies for bill settlement and other "meter-to-cash" processes. Variable costs of payment processing and accounting could be reduced via the execution of smart contract since the settlement is instantaneous. Several researchers contemplate that this "meter to cash" blockchain automation tools will totally reshape the wholesale-to-retail value chain by removing all intermediaries. Furthermore blockchain enthusiasts support the view that this technology could empower retail customers, provide greater transparency into energy charges, tariffs and direct or indirect taxes. Therefore the consumer can easier and faster change electricity provider and has greater choice and transparency into energy supply.

This period two startups "Drift" and "Grid+" are operating both in USA and in deregulated environment

"Drift" is developing a blockchain-based platform (Ethereum) that will enable it to act like a competitive energy supplier in deregulated markets. "Drift" aims to link electricity generators with consumers and small and medium-sized enterprises. It

[31] Ibid 6, p. 20

[32] Ibid 6, p.20

issues bills on a week basis, with elaborated information on fees, taxes and energy source. “Customers have a web dashboard that allows them to track transactions and choose whether they want zero-carbon energy or lowest-cost energy and operate on a contract-free basis[33]”.

Grid+ developed an automated, Ethereum-based platform that operates as retailer and provides automated billing and settlement, As it states “aims to provide customers with nearly frictionless access to the wholesale market.”[34]. Project basis “a two-token model and customer-located, Internet-enabled energy gateway[35]”. It is main use is as automated payment processing unit, that takes smart meter readings and issues payment (bills) in real time (15-minute to 1-hour intervals, depending on the market), executing smart contracts

2.1.3 Local Peer to Peer Markets, Local Communities & Cities

Blockchain technology has been identified as main “peer-to-peer” (P2P) markets developer. It could enhance the purchasing or selling power of what is called in EU legal documents as “prosumer”[3637], an economic and legal environment at which energy producers and consumers transact on a local scale[38]. Blockchain as technology contributes in mitigating risk for small producers or procumers and

[33] Ibid 6,p.21

[34] “Grid+, https://gridplus.io/ (last accessed , Consensys, “Grid+: Welcome to the Future of Energy (White Paper)” no date”

[35] Ibid 6, p.21

[36] “Brussels, 23.2.2017 COM(2016) 864 final/2 2016/0380 (COD) – Proposal for a DIRECTIVE OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL on common rules for the internal market in electricity art. (29)“*Consumers should be able to consume, store and/or sell self-generated electricity to the market. New technology developments will facilitate these activities in the future. However, legal and commercial barriers exist including for example disproportionate fees for internally consumed electricity, obligations to feed self- generated electricity to the energy system, administrative burdens such as for self- generators who sell electricity to the system to comply with the requirements for suppliers, etc. All these obstacles that prevent consumers from self-generating and from consuming, storing or selling self-generated electricity to the market should be removed while it should be ensured that self-generating consumers contribute adequately to system costs*”.

[37]http://www.europarl.europa.eu/RegData/etudes/BRIE/2017/595925/EPRS_BRI(2017)595925_EN.pdf

[38] https://ec.europa.eu/commission/sites/beta-political/files/executive-summary-study-residential-prosumers_en.pdf

eventually fulfill EU energy Directives objectives. Furthermore it could reduce the network costs as well as trading costs for small scale renewables and network costs.

Eventually it provides a greater fan of options and transparency for customers, that could par example trade their surplus from small scale RES production- such as net metering[39]- with their neighbours.

Actually experience has shown that within EU the majority of blockchain projects in electricity facilitate P2P energy marketplaces. Adding to that, Euroelectric data showed "that 57 percent of money raised for blockchain-in-electricity projects is for projects that use blockchain to verify and execute P2P transactions"[40]. Furthermore a 2017 European Commission study pointed out the importance of Blockchain in developing Energy Communities[41] , through neighborhood energy storage, direct energy exchange or automatic energy detection via neighbor nodes. Thought further study needed in examining the role and preconditions in blockchain use in the case of aggregators (i.e. RES aggregators) in the Target Model[42] .

It should be pointed out that blockchain use is absolutely bound to smart metering and smart grids, which is several countries, such as Greece, has not been developed or even started yet..

The smart meter is the contact and validation (entry and exit) for the transition system and the blockchain. The meter records electricity generation, imports, and exports and converts it into tokens. Afterwards the smart meter owner is allocated with charge or credit accordingly at an "e-wallet" either on fiat money or cryptocurrency.

The most famous example in this category is the "Brooklyn Microgrid Project". It was launched by US-based LO3 Energy at Brooklyn N. York and it capacitates its participants to trade energy through smart contracts via a blockchain on a local basis. The project was initially launched in 2016 and its first transaction was the connection of five homes with roof solar photovoltaic (PV) production to five customers within the same building. By the end of 2017, 60 small scale PV producers entered the Project and d 500 consumers.

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[39] https://www.deddie.gr/en/themata-stathmon-ape-sithia/fv-apo-autoparagwgous-me-energeiako-sumpsifismo-ne/

[40] Ibid 6, p.22

[41] European Commission, JRC Technical Reports, (2017) , "Blockchain in the Energy Communities, A proof of Concept".

[42] http://www.rae.gr/site/file/system/docs/various/anartiseis/140918_1 (see the Target Model details,)

"In Austria, Verbund and Salzburg AG launched a blockchain P2P proof of concept that enables tenants to exchange their shares of the PV generated electricity via blockchain app for android. These shares are stored on a proof-of-work blockchain, which is operated by the tenant themselves. The grid operator Salzburg Netz GmbH then collects the transaction data and conducts the clearing for each of the tenants"[43].

Experiences from these projects indicate that we have the optimum energy consumption behaviour within buildings (e.g. ability to shift spare energy uses) and savings due to lower grid fees. "Another case is "Jouliette," a blockchain-supported Microgrid a joint project of Amsterdam's De Ceuvel sustainable office park, Dutch DSO Alliander, and energy solutions developer Spectral. The project co-ordinates 16 ships/ buildings, rooftop PV panels, various types of businesses and appliances, and a single grid[44]". Jouliette was launched in September 2017 and it uses tokens trade, reward locally produced energy.

2.1.4 Flexibility Services

It is common ground that Transmission System Operators (TSO) face challenges in balancing the system since renewable energy production fluctuates severely. Both wind and solar generation have the obvious limitations and TSO invest large amounts in order to ensure system stability. Accordingly the benefits of achieving greater power system flexibility are great. Data showed that for 2016 TSO charges in Germany for balancing services were about €800 million (services include re-dispatch, grid reserve, wind power curtailment).

Balancing services are crucial for the wellbeing of the transmission system and interventional actions have been launched within EU, like the Capacity Mechanisms[45] or Balancing Markets[46] that increase costs of Transmission system for the users. "Blockchain could help provide such flexibility services by recording resource availability and automating demand response and DER activity in real time[47]".

[43] Ibid 6, p22

[44] Ibid 6, p.23

[45] http://ec.europa.eu/competition/sectors/energy/state_aid_to_secure_electricity_supply_en.html

[46] http://www.admie.gr/uploads/media/Balancing_Detailed_Design_-_Public_Consultation_201712.pdf

[47] Ibid 6, p. 23

Several pilot projects have been introduced and currently working like TenneT, and UK-based Electron's "Flexibility Marketplace."

TenneT, blockchain project is operating in collaboration with Vandebron, Sonnen, and IBM that enhances system stability and it will serve electric vehicle (EV) owners to use their vehicles as batteries that could infuse capacity- energy to the system when needed.

At the same project (TenneT') a series residential batteries has been placed in order to balance wind energy intermittency during periods of network congestion.
Future developments to TenneT project include a blockchain-based interface that will provide real time information about the availability of flexible resources, to dispatch to the system.
Another project is London-based Electron is also using blockchain technology for flexibility trading.

2.1.5 Electric Vehicle Charging & Coordination

Electric vehicles (EVs) acquisition and usage becomes more easy and common nowadays. Consequently Transmission and Distributions system operators (TSOs and DSOs) have increased energy consumption demands to face without undermining system stability and the energy supply of all the previous consumers. Studies and several projects showed that blockchain technology could improve EV charging coordination, simplify energy payments at charging stations, and providing drivers with all the possible alternatives in charging (i.e. energy provider, site of the charging station etc.) and real-time pricing data.

An existing project in the field of ecomobility is "Share&Charge"" app. It was launched in 2016 by Innogy (a subsidiary of German utility RWE) in cooperation with Slock (German blockchain startup). The project provides Peer to Peer service by allowing EV and charging point owners to rent/hire their chargers to other EV owners without intermediaries.

A second project is "MotionWerk" launched by Innogy's "Innovation Hub" in May 2017 that serves as digital payments method via a mobile app. The application provides information for available charging points and tariffs in real time. Until "April 2018, about 1,000 EV owners with 1,250 private and public charging points registered in Germany[48]" were listed to the application. The "MotionWerk" is both e-wallet app and smart contracts on the public Ethereum transaction layer; the project was the first e-mobility transaction platform using blockchain technology. Following

[48] Ibid 6, p.24

the paradigm of "MotionWerk" other projects evolved such as Oslo2Rome project Share&Charge etc both in EU and USA.

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2.1.6 Network Management and Security

The electricity system, thus DSO and TSO, face tremendous changes due to the concept of electrification, decentralization and Digitalisation[49], as a consequence distribution system operation becomes more complex due to the inclusion of DER and digital technologies. In modern era DSOs and TSOs face challenges on issues related network fitness and stability, storing and analysing "big data". Furthermore digitisation introduces the risk of cyber-attacks.

Based on one of its characteristics (decentralised, totally encrypted data) blockchain could improve network management since it maintains automatically verifiable network data. Moreover, blockchain technology it could reduce the risk of grid (transmission or/and distribution) cyber-attacks due to its inherent redundancy

Currently the blockchain based projects in the area of network management and security are limited, due to the difficulty of the task. The first one was launched by Guardtime, a company at cybersecurity services. "Guardtime is using permissioned blockchain-based systems to protect the UK's nuclear power stations, electricity grid, and other critical infrastructure[50]". The aforementioned service is called Keyless Signature Infrastructure (KSI), and it provides services on time verification, data authentication and location and enhanced veracity of historical data. In the field of system operation and cybersecurity it offers continuous monitoring of systems operation, real time systems monitoring and enhanced cybersecurity for the grid, the plants and the entire "critical infrastructure".

[49] "World Economic Forum, "The Future of Electricity New Technologies Transforming the Grid Edge" "The electricity system is in the midst of a transformation, as technology and innovation disrupt traditional models from generation to beyond the meter. Three trends in particular are converging to produce game-changing disruptions: – Electrification of large sectors of the economy such as transport and heating – Decentralization, spurred by the sharp decrease in costs of distributed energy resources (DERs) like distributed storage, distributed generation, demand flexibility and energy efficiency – Digitalization of both the grid, with smart metering, smart sensors, automation and other digital network technologies, and beyond the meter, with the advent of the Internet of Things (IoT) and a surge of power-consuming connected devices", p.4, http://www3.weforum.org/docs/WEF_Future_of_Electricity_2017.pdf, (January 2019)"

[50] Ibid 6, p. 25

2.1.7 Environmental Attribute Markets

There has been developed a whole financial market aimed at promoting renewable energy sources (RES), reducing greenhouse gas emissions particularly within EU, mainly through energy origin certificates[51] [52]and ETS market[5354]. Other jurisdictions have developed other schemes such as carbon offset mechanisms, carbon taxes, and cap and trade systems. All the aforementioned schemes focus on rather expensive manual audit practices and they are of limited geographic scale. As a consequence the participants as well as the states face difficulties due to possible fraud and high transaction costs. The industry participants turned to blockchain as a solution through "tokenisation" of renewable attributes. The existence of a blockchain could reduce cost of transactions and enhance marketability without a central verification agency. That means that it could provide freedom to industries to participate to environmental attributes market on a lower cost or even to create a secondary market with over the counter contracts for those financial products.

So far the existing project in this field is "SolarCoin", which is a solar-incentivising cryptocurrency that reduces audit costs and provides transparency liquidity to solar-derived credits. Initially a consumer/energy byer registers a claim for energy generations to SolarCoin which in turn sent the request to solar generators to infuse the produced energy into the system and sent the certificate to the energy byer. It is possible that requests for generation may also posed to SolarCoin by smart meters As of March 2018 58 states granted permission for operation to SolarCoins .

Another running projects is that of "IDEO CoLab (integrated with Nasdaq's Linq platform and IoT company Filament's hardware) which utilises digital sensors with blockchain attributes to issue renewable energy credits (RECs) to producers for every KWh kilowatt of solar energy production[55]". The project aims to operate as aggregator for small scale solar projects and increase their marketability, trading power and eventually liquidity.

[51] https://en.wikipedia.org/wiki/Renewable_Energy_Certificate_System (January 2019)

[52] Law 4414/2016

[53] https://ec.europa.eu/clima/policies/ets_en (January 2019)

[54] https://www.eex.com/en/market-data/environmental-markets/spot-market/european-emission-allowances#!/2019/01/23

[55] Ibid 6, p. 26

2.2 The limitations and Risks of Blockchain

Despite the increased number of blockchain projects as well as the focus bot of academia and business on it, the future of blockchain in electricity is rather uncertain so far. Both Electricity market and blockchain characteristics, limitations and challenges contribute to this. Several well-known blockchain projects suffer from high costs and slow transaction speeds. On the other hand the characteristics of the electric power sector—such as economies of scale, distribution system limitations and regulatory issues reduce blockchain growth. Moreover, blockchains face competitive pressures from the existing – traditional elements of the markets, other technologies and public perception about it. The most important limitations are the following:

2.2.1 Technological Limitations and Risks

Public – permissionless blockchains face high costs and slow speeds, which mean that it cannot face the existing issues of the electricity sector satisfactory.

Though there are faster blockchains, such as the PoA-based Tobalaba Energy Web Foundation, that have great scalability but at the same time they don't entail properties of PoW-based blockchains. Generally blockchain user faces the "scalability trilemma" (decentralisation, scalability, and security) and the existing technological development could not successfully fulfill all of these for large scale deployment in power systems.

Another issue is blockchain's lack of flexibility. Blockchains networks are rather rigid once launched, inconsistent with the nature of the electricity market. It should be pointed out the electricity is traded in stock markets which means flexibility is only required is rather dictated. For instance when there are adversarial requests (i.e. two betters for one solar panel energy production) there is limited ability to cope with "forking" within the blockchain.

Due to the fact that there is asymmetric cryptography, each participant is required to safeguard his/her private key whiteout maintaining it to a central "depository". That means that in case of lost key we have loss of participant's digital assets?

2.2.2 Potential Limitations Associated with the Structure of the Electricity Industry

For the majority of countries Transmission and Distribution electricity networks are considered as "natural monopolies[5657]". Thus DSO's and TSO's are solely responsible for certain functions (i.e. grid frequency, balance between electricity supply and demand at all times. That means that all blockchain electricity trading ought to be reconciled with the TSO's aims or at least inform the TSO (or DSO) in order to maintain grid security. Therefore economic freedom and the very essence of blockchain (freedom from intermediaries) is rather limited.

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2.2.3 Competitive Pressure and Public Perception Challenges

There are alternative technological solutions for the problems the blockchain aims, such as telemetry systems for the participation of small scale producers in wholesale energy markets. That means that blockchain will joust with other technologies mainly on the issues of cost, speed transactions and flexibility.

It is important to mention the social obstacles. Generally blockchain has been mainly associated with the "shadow economy" possible illegal sources of money or persons avoiding tax. That means the public is not that pro- blockchain and rather skeptical for this technology.

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[56] https://ilsr.org/electricitys-unnatural-monopoly/

[57] Damien Geradin , "The Liberalization of Electricity and Natural Gas in the European Union", Kluwer Law International , p.4 (2001)

3. Legal Issues of blockchain & Critical Evaluation

As with any dramatic change, blockchain raises a series of legal issues, though answering those will address several legal – regulatory categories, such as private, public international law, financial or energy regulatory field, depending on the sector of blockchain use. Par example in electricity trading blockchain use should comply with the relevant regulatory – legal rules of the sector.

Blockchain application faces a series challenges general legal nature some of which are applicable for all blockchains and that could be charecterised as of "generic" nature

3.1. Applicable law

The first issue that arises in blockchain is the question of applicable law. In blockchain that the participants of every transaction might be in different countries the element of jurisdiction is vital since it dictates the applicable law. For example in a blockchain transaction between Greece and Germany might be conceivable that Greek civil law is applicable (the parties decided that) but the German tax authorities have the right to apply taxes on the transaction. This would be applicable for every transnational transaction within blockchain. In case that the parties of the transaction are within the EU the "Regulation of the European Parliament and of the Council on the law applicable to contractual obligations (Rome I[58])" determines the applicable law. The central rule is that the contractual parties choose the applicable on the transaction, in case that the choice has not been made then the characteristics performance country law will be applied[59]. But what happens in cases that the contractual parties are not within EU? Then, the issue should be addressed as a common choice of law international contracts and the relevant legal rules-instruments should apply[606162]. Though another issue arises here. It is doubtable, in

[58] https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32008R0593&from=EN

[59] For example, a Greek person buys a telephone from a French, the transaction is conducted in a blockchain with bitcoin. In this example the delivery of the telephone is the characteristic performance. Unless the parties choose differently it is not possible to depart from this. Accordingly the bitcoin transaction will be subjected to French law too. The question of the country in which the characteristic performance takes place is relevant for the civil law definition. As for issues of defining which country's tax law, general administrative law or the financial law applies to a transaction within a blockchain depends on other circumstances.

[60] https://www.hcch.net/en/instruments/conventions/full-text/?cid=135

small scale transactions if the participants have the means or mainly the knowledge the address those issues It might be a good solution that industry though smart contracts terms and conditions address the jurisdiction issue or point out it by providing a selection of alternatives about the applicable law that the participants would select by clicking on the preferred country.

3.2.Ownership of a blockchain

The original idea of building blockchain was that, it was not owned by anyone, neither public nor private entities. Apart from the philosophical appeal of this notion it is questionable if and to what extend it is legally evitable. As with any intangible or tangible created by someone there is ownership protected by Constitution (art. 17, 25, 106 etc.), International Conventions (ECHR protocol 1 art. 1)[63] and Civil or copyright law (law 2121/93). Therefore the blockchain that has both tangible (i.e. server) and intangible parts (the software) has actually owners and possible copyright owners. For example bitcoin as open source programme was built by a group of programmes, each of those developed a part of the programmes therefore has copyright for the part he/she developed. That means that the "owners" of the blockchain might pose charges for the use of it and found responsible for any unlawful use of the blockchain.

3.3. Identity within a blockchain

In public blockchain all the transactions are public. This does not mean that the identity of the person conducting the transaction is known. For example in bitcoin transactions the accounts are anonymous and there is lack of central organisation. Hence this has economical and philosophical advantages it also leads to problems in practice. In case the person is unknown it is far from evitable to hold him/her accountable for the transaction if something goes wrong either by mistake or deliberately. Accordingly in cases of unlawful use of the blockchain (i.e. trade of illegal substances, drugs, human trafficking, money laundering etc.) the state or states involved could not identify the persons involved and accordingly to press charges for the related crimes. Examples of this in Energy Markets could be money

[61] https://academic.oup.com/ulr/article-abstract/22/2/316/3884635?redirectedFrom=fulltext

[62] http://hk.lexiscn.com/asiapg/articles/applicable-law-and-jurisdiction---applicable-law.html

[63] https://www.echr.coe.int/Documents/Convention_ENG.pdf

laundering at ETS markets or due to anonymity, markets manipulation, therefore competition abuse by a major energy producers- supplier. Except for that unlawful use of the blockchain this could undermine the stability of the related – traditional market. This is the main reason that a series of regulatory initiative has been developed, mainly in the financial sector[64]. Though blockchain supporters commend that ii is relatively easy to pinpoint the actual identify of electronic profiles[65].[66] .

3.4. Smart Contracts

Generally speaking smart contracts and blockchain are interrelated, obviously due to fact that the objective circumstances, to trigger the performance of smart contracts, occur in a blockchain.

In the scenario that we have an electricity trade contact traded in a blockchain, a smart contract can stipulate that as soon as the blockchain confirms that the electricity contract has been conveyed, the price is paid automatically. That means that the risk of delayed or not being made payment is reduced since the transaction has not been made within the regulated environment of "formal" electricity trade platforms- stock markets, that have the mechanics and rules to ensure the flawless operation of electricity trade. Though it should be pointed out that regulators as well as legislators have done limited in providing legal basis to smart contracts providing solutions and norms for its peculiarities mainly their informal format. Generally speaking smart contracts, as an expression of the free will of the parties have already the legal framework (Civil Law) but there are the sceptics saying that a formed contract could not face all the problems- risk of a transaction , particularly in complex- specialized products (such as electricity). Adding to that the sceptic's support that it might be difficult for the parties to understand the terms and the risks that are set down in code[67][68]. Another question arises is the possibility to annul the transaction relied on error in smart contracts. Is the delivered what the parties expected to be? Though it should be pointed out that in several markets, mainly of

[64] http://www.mondaq.com/article.asp?articleid=774674&email_access=on

[65] https://kennisopenbaarbestuur.nl/thema/digitale-identiteit

[66] Regulation (EU) No. 910/2014 of the European Parliament and of the Council of 23 July 2014 on electronic identification and trust services for electronic transactions in the internal market and repealing Directive 1999/93/EC.

[67] https://www.technologyreview.com/s/610392/ethereums-smart-contracts-are-full-of-holes/

[68] https://medium.com/cryptolawreview/against-smart-contracts-4a1f43133215

technical nature, such as electricity, the delivered are described in common technical terms – language, which is internationally accepted i.e. in electricity MWh. Under these conditions is it questionable if it is possible to get a court to reverse smart contract's consequences (or annul the contract) and subsequently the enforceability of courts' decision. Generally speaking for "serious" (high volume) transactions where the parties have the knowledge and the means to understand terms and conditions of a smart contract then they can decide about the legal enforceability of the code, the competent courts etc. Though this is of little application for non-experts or small scale transactions (i.e. sale of electricity for a small Photovoltaic Panels on the roof to neighbours). In these cases it is of high importance for regulatory authorities to provide a kind of legal – regulatory guidance, so that to avoid problems of smart contracts application. Generally speaking electricity contracts are under a heavy regulatory framework that obviously blockchain contracts ought to follow in any case.

Finally it is important to pinpoint that not that all smart contracts are also legally-binding which in retrospect does not imply that all the smart contracts have no legal meaning, they might dealt as unilateral undertaking of performance of a contract condition precedent or condition subsequent in a contract or unilateral legal transaction[69] .

3.5.Liability and responsibility

Among the other issues that has been cleared, yet, is the legal status of any blockchain organisation (either DAO or distributed autonomous organisation), that operates via smart contracts without any interference of experts (i.e. lawyers) or other humans. This brinkmanship way of doing business could alter dramatically the foundations of legal science about what legal person is. It might be herald for recognising legal personality to non-human like Artificial Intelligence etc.

Under this mentality in case that a business has been formulated as a host of DAO, which is blockchain's and it's participants liability in case of harm to third parties. Adding to that in cases of transactions- contracts with third parties it could cause several problems since its legal personality is not defined , that constitutes a series of problems i.e. tax , administrative discrepancies with the rest of the legal entities.

Furthermore there has to be formulated a legal or regulatory framework that will determine issues of liability in cases of damages, breaches of the law , remedies etc.

[69] statutory decision 11 See HR 5 April 2013, NJ 2013, 214 (Lundiform/Mexx) https://uitspraken.rechtspraak.nl/inziendocument?id=ECLI:NL:HR:2013:BY8101

One of the characteristics of blockchain is that all participants are considered equal, therefore it is difficult to determine ownership as well as the controller . Could the miner or the contributor of crypto- currency be considered something like owner of shares?

Finally due to the fact that there is a high level of distrust for blockchain from the public , it is considered as medium for money laundering or other criminal activities , it expedient legislators to define , particularly for penal sanctions, issue of liability. It is obvious that not all blockchain participants will be held responsible, in case they did not had information about any criminal activity.

3.6. Personal Data

One of the basic characteristics of blockchain, the unchangeable stored data is diametrically opposed with personal data legislation provisions under which personal data must be destroyed once they served their purpose or when the persons asks for "right to be forgotten" art. 17 GDPR[70], Accordingly, in private

[70] "Art. 17 GDPR Right to erasure ('right to be forgotten')

1. The data subject shall have the right to obtain from the controller the erasure of personal data concerning him or her without undue delay and the controller shall have the obligation to erase personal data without undue delay where one of the following grounds applies:

    1. the personal data are no longer necessary in relation to the purposes for which they were collected or otherwise processed;

    2. the data subject withdraws consent on which the processing is based according to point (a) of Article 6(1), or point (a) of Article 9(2), and where there is no other legal ground for the processing;
    3. the data subject objects to the processing pursuant toArticle 21(1) and there are no overriding legitimate grounds for the processing, or the data subject objects to the processing pursuant to Article 21(2);

    4. the personal data have been unlawfully processed;

    5. the personal data have to be erased for compliance with a legal obligation in Union or Member State law to which the controller is subject;

    6. the personal data have been collected in relation to the offer of information society services referred to in Article 8(1).

2. Where the controller has made the personal data public and is obliged pursuant to paragraph 1 to erase the personal data, the controller, taking account of available technology and the cost of implementation, shall take reasonable steps, including technical measures, to inform controllers which are processing the personal data that the data subject has requested the erasure by such controllers of any links to, or copy or replication of, those personal data".

blockchains the controller has control over the majority of the nodes, thus he/she could comply with GDPR by processing personal data. Though in public blockchains this is hardly the case and there is limited if none possibility to intervene to personal data even for the sake of GDPR compliance.

It is evident that blockchain processes personal data according to GDPR (art 4.1) such as name, address or even data that makes the person identified or identifiable Data that has been entirely anonymised irrevocably does not qualify as personal data. In those cases that a blockchain stores only anonymous data, there is no question of personal data usage therefore the GDPR does not apply. In cases that personal data are interpreted then the blockchain conducts data processing according to article 4(2) of GDPR. Adding to that the next question arises is who is data controller or/ and processor[71] (article 4, 5, 24 & 28)[72] thus has the responsibility for all legal obligations for personal data and who conducts data processing.

In those cases that personal data is processed within a blockchain, the data entries are made by various blockchain participants, but there is no strict, formal or unambiguous process about data handling since there is no hierarchy and all participants are equal. Therefore every blockchain participant can handle data as he/ she sees fit. Consequently defining the data processor according to article 4 GDPR provisions as far from evitable, since all parties to the blockchain are controllers.

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3. Paragraphs 1 and 2 shall not apply to the extent that processing is necessary:

    1. for exercising the right of freedom of expression and information;

    2. for compliance with a legal obligation which requires processing by Union or Member State law to which the controller is subject or for the performance of a task carried out in the public interest or in the exercise of official authority vested in the controller;

    3. for reasons of public interest in the area of public health in accordance with points (h) and (i) of Article 9(2) as well as Article 9(3);
    4. for archiving purposes in the public interest, scientific or historical research purposes or statistical purposes in accordance with Article 89(1) in so far as the right referred to in paragraph 1 is likely to render impossible or seriously impair the achievement of the objectives of that processing; or

    5. for the establishment, exercise or defense of legal claims.

[71] https://advisera.com/eugdpracademy/knowledgebase/eu-gdpr-controller-vs-processor-what-are-the-differences/

[72] https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32016R0679&from=EN

Besides under the GDPR data controller obligations it is difficult to define how the blockchain could participants jointly ensure the fulfilment of those obligations.

In those blockchains that one party has the control of all nodes it is conceivable that this party could be appointed as performing all legal duties on behalf of all other controllers. As for the issue of personal data processing is permitted only when there's legal basis (article 6 GDPR) and each time personal data is processed, there has to be an individual legal basis. This means that each time a participant in a blockchain inserts personal data. Accordingly in several other issues from GDPR like the right of withdraw from any permission (article 7),) data minimisation (article 4.6), personal data removal (article. are difficult to handle in a blockchain since there is no sole handler of data and there is limited on none ability to change data stored within the blockchain. Blockchain characteristic, about unchangeable information that ensures the sense of trust for the participants , is actually the one that is the source of incompliance with GDPR.

The sixth European Union Blockchain Observatory & Forum workshop[73], held in Paris on 12 December, 2018 highlighted several areas that may cause legal uncertainty in blockchain application which are:

- Liability
- Legal recognition of smart contracts
- Decentralized autonomous organizations (DAOs) recognition
- Legal value of a blockchain-based proof
- Blockchains and transfer of value

In European legal regime answering those questions are of vital importance. Besides a solid regulatory and legal framework it vital for blockchain to flourish and give opportunities to entrepreneurs and small companies to evolve.

Focal point for EU is the legal recognition of smart contracts, since they are not contracts in the legal sense, but code of business procedures or transactions

Another issue that should be addressed according the Workshop is the digital assets represented by cryptographic tokens. Legal treatment of those assets dictates the token categorisation. The issue has already being handled in Austria and Switzerland that proposes three types:

- Payment tokens
- Security tokens

[73] https://www.eublockchainforum.eu/events/workshop-blockchains-smart-contracts-legal-and-regulatory-framework-paris-0 (visited February 2019)

- Utility tokens

The categorisation could enlist the tokens to existing financial, currency, consumer or investor protection frameworks. Additionally categorisation could clarify issues such as tax and accounting treatment of blockchain-based digital assets-participants.

Finally the Workshop identified the importance of the automation for governance activities as decentralised autonomous organisations (DAOs) that will lead eventually to the development of new structures for organisations. This would most definite require new types of legal personality thus new legal and regulatory frameworks.

3.7. Blockchain and Energy Law – Regulatory Issues

It is critical to evaluate blockchain application under the scope of the current energy law framework and address the subject of future legal developments, prosumers[74] or active customers[75] (as the new directive under amendment calls them) and consumers.

[74]"Electricity "Prosumers" 11-11-2016
Active energy consumers often called 'prosumers' because they both consume and produce electricity, could dramatically change the electricity system. Various types of prosumers exist: residential prosumers who produce electricity at home – mainly through solar photovoltaic panels on their rooftops, citizen-led energy cooperatives or housing associations, commercial prosumers whose main business activity is not electricity production, and public institutions like schools or hospitals. The rise in the number of prosumers has been facilitated by the fall in the cost of renewable energy technologies, especially solar panels, which in some Member States produce electricity at a cost that is the same or lower than retail prices. Profitability depends partly on the share of the electricity produced that prosumers can consume themselves. But while this can reduce their bills, it can create problems for traditional energy generators and grid operators. The EU has no specific legislation on prosumers, self-generation or self-consumption, nor a common definition of prosumers. But the Energy Efficiency Directive, the Renewable Energy Directive and Guidelines on State Aid include provisions which relate to small-scale electricity producers. The European Parliament has called for a common operational EU definition of prosumers and for new energy legislation to provide measures for encouraging investment into self-generation capacity. (source : http://www.europarl.europa.eu/thinktank/en/document.html?reference=EPRS_BRI(2016)593518)"

[75] "Article2.6. 'active customer' means a customer or a group of jointly acting customers who consume, store or sell electricity generated on their premises, including through aggregators, or participate in demand response or energy efficiency schemes provided that these activities do not constitute their primary commercial or professional activity; COM(2016) 864 final/2 2016/0380 (COD) https://ec.europa.eu/transparency/regdoc/rep/1/2016/EN/COM-2016-864-F2-EN-MAIN-PART-1.PDF"

Hellenic Regulatory framework Regulatory Authority (RAE) provides the framework and the guidelines for energy supply contracts aimed at balancing consumer protection interests, competition and those of energy suppliers.

The existing legal- regulatory texts have being imbued with the general civil law and public administrative law basis (relative provisions of the Greek Civil Code & Administrative Law) as well jurisprudence on the issue. Thus the relevant legal framework and a series of other acts (i.e. Administrative, Ministerial Decisions) and regulations should be taken under consideration and acted upon in blockchain projects. Additionally provisions emanating from consumer protection and data protection laws are also applicable.

Central aim of the European energy law is the establishment of a competitive internal market in electricity since 1998 with a series of directives and regulatory documents. The most resent initiative is called "Third Energy Package"[76] and lately the "Green Energy Package[77]" a series of legal documents (directives and regulations are either issued or under formulation)[7879] . The Third Energy Package's point of convergence is competition in energy markets. The main tool achieving that as listed in the relevant legal documents (Directive 2009/72/EC, art. 13 & 14) are horizontal or vertical ownership unbundling which is actually segregation between network, production and supply business activities. Ownership unbundling introduced the so-called "Independent System Operators" (ISOs) or "Independent Transmission Operators" (ITOs)". Another focal point of this initiative is empowering energy consumers thus consumer rights mainly by providing easier switching processes to electricity suppliers (article 12 new electricity directive) as they see fit. Furthermore

[76] http://europa.eu/rapid/press-release_MEMO-11-125_en.htm?locale=en

[77] https://ec.europa.eu/energy/en/topics/energy-strategy-and-energy-union/governance-energy-union

[78] "Proposal for a REGULATION OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL on the Governance of the Energy Union, amending Directive 94/22/EC, Directive 98/70/EC, Directive 2009/31/EC, Regulation (EC) No 663/2009, Regulation (EC) No 715/2009, Directive 2009/73/EC, Council Directive 2009/119/EC, Directive 2010/31/EU, Directive 2012/27/EU, Directive 2013/30/EU and Council Directive (EU) 2015/652 and repealing Regulation (EU) No 525/2013 https://eur-lex.europa.eu/resource.html?uri=cellar:ac5d97a8-0319-11e7-8a35-01aa75ed71a1.0024.02/DOC_1&format=PDF "

[79] https://ec.europa.eu/transparency/regdoc/rep/1/2016/EN/COM-2016-864-F2-EN-MAIN-PART-1.PDF

the new electricity Directive at recital 26[80] promotes flexibility and self-generated electricity whereas in recital 29[81] and article 15.1 say that all consumers should be able to produce and sell their own energy to the market and new technologies are the means to succeed that .i.e smart meters (art 19) or blockchain.

All blockchain models have in common the transferred control of data to all blockchain participants – consumers. Blockchains and smart contracts "can be a catalyst for strengthening the role of individual consumers in the market by enabling them to buy and sell energy directly without the need for intermediaries,[82]"according to European Commission Vice President for Energy Union **Maroš Šefčovič.**

The basic amenity is that they give consumers the ability to manage both their consumption data and electricity supply, therefore have control over energy consumption.

3.8. Applicable primary and secondary domestic legislation

In energy contracts civil law principles – provisions apply as well as several legal-regulatory requirements emanating from energy law mainly of EU origin. Central goals are to ensure affordable, efficient and eco-friendly electricity, according to EU 2020 targets[83], competition in electricity supply and security of supply.

Up till now there has not been any legal or regulatory text aimed at blockchain or smart contracts in Greece. Several issues should be addressed particularly for small scale producers – active customers. In the case of large scale electricity producers there is a series of regulatory documents or administrative acts that are totally

[80] "(26) All customer groups (industrial, commercial and households) should have access to the energy markets to trade their flexibility and self-generated electricity".

[81] "(29) Consumers should be able to consume, store and/or sell self-generated electricity to the market. New technology developments will facilitate these activities in the future. However, legal and commercial barriers exist including for example disproportionate fees for internally consumed electricity, obligations to feed self- generated electricity to the energy system, administrative burdens such as for self- generators who sell electricity to the system to comply with the requirements for suppliers, etc. All these obstacles that prevent consumers from self-generating and from consuming, storing or selling self-generated electricity to the market should be removed while it should be ensured that self-generating consumers contribute adequately to system costs".

[82] https://www.neweurope.eu/article/sefcovic-blockchain-empower-energy-consumers/

[83] https://ec.europa.eu/info/energy-climate-change-environment/overall-targets/2020-targets_en

binding for electricity producers. So, there is legal framework that provides rules for those obliged to issue license and those exempted for electricity producers (i.e. RES producers- farmers[84]). Accordingly large scale producers are obliged to follow the existing framework (i.e. issue production permit, preconditions for connection to Transmission System etc.) even if electricity sale is conducted through smart contract and blockchains. In the case small scale production the extra bureaucracy burden should be omitted, a good practice that could apply is net metering framework[85], the threshold of 20-100 KW the exemption from licensing, the treatment from the tax authorities not as trader but as individual etc. All the aforementioned could enhance dramatically blockchain application and consumer participation to ledgers.

Another issue that should be addressed is the alternative resolution procedures available to "blockchainers". Alternative "out of court" resolution (Article 26 Right to out-of-court dispute settlement, under amendment Directive[86]) is strongly suggested though in blockchain it would be viable only if included as term in smart contract.

It is specialists view[87], energy bodies (Euroelectric[88]) as well as the writer's view that blockchain application is far more valuable for procumers and community electricity trading than for large scale electricity trading. Apart from that a series of existing projects focus on this field without exempting future expansion to the segment of bigger electricity producers – traders. Furthermore blockchain could contribute in reducing energy poverty if proper incentive will be introduced i.e. tax exemptions and for state entities to ensure the statutory obligation to provide at least the "basic" electricity supply (universal services, Supplier of last resort etc.).

[84] http://www.desmie.gr/ape-sithya/adeiodotiki-diadikasia-kodikopoiisi-nomothesias-ape/periechomena/diadikasia-adeiodotisis/adeia-paragogis-kai-exaireseis/ (Greek document)

[85] https://www.dei.gr/el/oikiakoi-pelates/xrisimes-plirofories-gia-to-logariasmo-sas/net-metering

[86] https://ec.europa.eu/transparency/regdoc/rep/1/2016/EN/COM-2016-864-F2-EN-MAIN-PART-1.PDF

[87] https://www.pwc.com/gx/en/industries/assets/blockchain-technology-in-energy.pdf

[88] Ibid 6

3.9. How the blockchain could alter network operators regulation

It is obvious that energy regulation will be affected by blockchain, that it might provide the ability to simplify the process of regulation and increase efficiency. Giancarlo (2016) suggests that regulators have the opportunity to have access to real-time ledger(s) of all the participants, therefore they could analyse all the transactions – procedures processes the regulated entities are involved in.

Obviously this could change the regulatory agenda i.e. Distribution System Operators codes. DSOs could use either public or private blockchains to operate additionally to the traditional methods Therefore the regulator should be connected to those blockchains in order to monitor their operation.

For purposes of transparency the communication between the regulated entities and the regulator could be via blockchain. There is discussion within EU about the DSOs and how they could enhance the provided flexibility to market parties and the feed in the system of RES. There is concern about possible market distortions from network operator's interaction, at least as long DSOs are not fully unbundled from the competitive businesses in generation and retail (CEER 2015).

3.10. Charging Station Regulation

Currently in Greece there is no regulatory – legal framework for charging stations, apart from specifications for public EV charging infrastructure. It provides a set of specifications on issues like the power output (kW), plugs etc. Though there is no restriction about the transaction method that it could be via blockchain, though specific provision about blockchain does not exist.

3.11. Critical evaluation

3.11.1. Outlook on possible long-term social consequences

An increased use of blockchain technology, would definitely fundamentally transform, economy and society. The central points of this technology, which is decentralisation, without intermediaries to verify transactions (a central authority) shift power to the participants, which are self- governed.

Internet of Value and data storage no longer requires central locations leading to a universal space of information that central control is omitted,

Blockchain technology thus provides independence from human authority and as such is has been charecterised "utopia"[89]. This obviously would effect social structure to a more decentralised models, the power of certain authorities will be questionable and norms will cease to exist. Studies showed that several professions will be dramatically affected by blockchain application, such as that of lawyers[90].

Blockchain technology promotes a self-regulating, self-governing economic and social system.

3.11.2. Regulatory challenges posed by blockchain in the electricity sector

It is common that blockchain as decentralised transaction model would alter the market, thus the regulatory regime. What will happen is that every electricity consumer will control their electricity balance (production/ supply) and all transaction will be recorded in a blockchain. Basically what is altered with blockchain applications are market roles.

3.11.3. Changed market roles

The most important advantage of blockchain transactions in electricity market is that the clearing for the infused energy to the system will be in real time eventually. This means that the clearing of all electricity produced and consumed can be done very fast and precisely at variable prices. The situation of physical delivery will not change, though the improved data will allow electricity suppliers to customize their tariffs and be more precise in matching distribution and transmission levels. A faster clearing process would lead to a decrease to charges for balancing market since DSOs and TSOs have actual, real time knowledge of system energy balance.

Furthermore blockchain application permits direct contractual relationships among consumers and producers with intermediaries- suppliers, thus reducing the cost of energy – no supply charges. Therefore both producers and consumers could act as procumers. Though it is important to mention that smart metering is vital for the success of blockchain application. Smart meters not only collect data about

[89] Ibid1

[90] https://blocklr.com/news/blockchain-unemployed/ (visited February 2019)

consumption but transaction data, exchanged automatically, through blockchain. Though the question arises that none regulatory authority has replied , should the transaction and consumption data , particularly from private blockchains , be public or notify the DSO or TSO, in order to adjust-network tariffs or charge the seller and buyer for the infused energy.

The most serious obstacle in the adoption of blockchain is the strict regulatory regime in energy markets, that obviously its role in ensuring network fitness and security of supply but at the same time undermines innovation- blockchain. Studies showed that small businesses will benefit from blockchain since they could reduce energy cost, have fewer barrier to entry the energy market, therefore competition will be enhanced.

Another obstacle to blockchain implementation is the current legal and regulatory uncertainty.

3.11.4. Blockchain potential from a regulatory perspective

Blockchain application could deliver benefits on the area of direct peer to peer transactions settlement: Customers become producers and suppliers, particularly in community level, enhancing self-sufficiency, regional energy supply. Potential benefits highlighted by relevant PWC study include the following:

“Verification & certification: Blockchain’s synchronicity (generation and consumption) and capability verified data and verifiable records; blockchain would be the first technology to make it possible for the source of electricity to be determined. Guarantees of origin could be issued with greater certainty. This would also make it easier to issue certificates for emission allowances and energy efficiency improvements, which would in turn simplify the complex systems currently used.

Clearing & settlement: It is not only prosumers who may stand to benefit, but also transmission system operators, as using blockchains would allow them to clearly attribute clearing data to individual market participants. The planned introduction of smart meters will only help to allocate consumption quantities to a balancing group and to the electricity suppliers using that balancing group. A blockchain-based system would make it possible for the energy consumed to be clearly traced back to

the point where it was generated. Overall, this would lead to significant cost reductions, with end users directly benefiting from a more efficient system[91]".

3.11.5. Blockchain Advantages in the Energy Sector

The first and maybe the most important benefit from blockchain application is lower energy bills. Since all blockchains operate without intermediaries, energy producers transact directly with customers without third parties intervene like traders, energy suppliers, banks etc. this means that all the related costs will be omitted. We could identify the following as costs that either will be omitted or reduced:

- Operating Cost and Marginal Profits of all the intermediary companies active in the energy market at the moment
- Operating Costs for metering , billing, mail bills
- Cost for unpaid debt, and debt collection processes
- Cost for bank payments and transactions

Tough it should be suggested that the operating costs of blockchains do not exist , simply are far lower and there are not yet defined in detail.

Apart from all the aforementioned, blockchain application provides the ability for greater flexibility and suppliers shifting thus money savings, since energy customers are on a constant supplier shifting. However this money saving would not compromise ethical – ecological considerations of the customer. Blockchain provides an equilibrium between personal economic gain and ethical considerations, customers could tract exactly the electricity source of their purchase energy, because the transaction is conducted directly from the energy producers without intermediaries. That means that the energy is not thrown to an energy basket and sold from the energy supplier. .

3.11.6. Value Creation for Local Communities.

Blockchain has been identified as major booster of micro- generation and the concept of prosumer by EU[92] as well as academia. The level of transaction costs ,

[91] https://www.pwc.com/gx/en/industries/assets/pwc-blockchain-opportunity-for-energy-producers-and-consumers.pdf (visited December 2018)

[92] "Blockchain in Energy Communities, A proof of Concept", 2017, JRC Technical reports, EUR 29074 EN

the simple belling process could provide small scale producers to participate in the market, either via aggregators (i.e. Energy stock market RES aggregators) or within their community. Self-generated electricity could either consumed within the house, stored in batteries or infused in energy system or sold directly to neighbours for i.e. charging their e-mobiles.

Therefore the owner of roof installed photovoltaic panels could have and extra income and improve its economic viability. Also blockchain could be applicable for crowdfunding of community funding of energy projects.

3.12. Blockchain Criticism - Limitations for the energy sector

Blockchain technology is in infancy stage which means that it bears a high level of uncertainties and risk. Apart from Bitcoin that has proven its abilities through time a limited experience exist. Skeptics suggest that blockchain is not that scalable, since the rate of data growth is far more than it has cope with. The new transaction model entails a shift in mentality, public opinion, administrative and legal regimes which is not easy to accomplish, taking under consideration several headlines unlawful use, blackmailing etc. using Bitcoin.

Another issue of huge practical importance is personal access details storage and the consequences for the blockchain participant in he/she will lose them. Under the existing regime the participant irrevocably loses access to the account thus information and assets stored in them.

The overall impact of blockchain applications and the overall equation on energy consumers and energy industry will also depend on blockchain utilisation.

3.12.1. Suggested Issues for Regulators

Several researchers (i.e. World Energy Forum) pointed out that innovators and market participants have to give the pace to blockchain development and afterwards the regulators should intervene. Though their contribution will be crucial for the success of blockchain technology application in energy markets. Up till now the majority of regulators are taking a 'wait and see' approach to blockchain[93]. This approach gives time to the regulators to see where the developments lead but at the same time it creates uncertainty for businesses or blockchain innovators. Obviously the regulatory questions will be faced on line with the existing legal regulatory framework, though it is necessary laws to adapt in the new technological development

As seen with any dramatic development so far, the arising legal issues will be dealt with the "old" legal regime. Besides it is common ground that the technological development pace is far more agile and sharp than that of legislators- regulators. Consequently blockchain companies or persons will face a "legal gap" until new laws or regulations will be launched to fit all the aspects of this new technology.

As noted above, records on a blockchain are intended to be immutable and difficult to change. On that basis it is quite difficult for blockchains to adapt to future legal developments. Thus one of the characteristics of blockchain (lack of plasticity) could constitute direct threat to blockchain legitimacy or at least adaptability to legal

[93] https://www.esma.europa.eu/sites/default/files/library/2016-773_dp_dlt.pdf

reforms. The research indicated that regulators should focus on parameters listed below.

Defining key terms

Terms that have been defined in regulatory texts such as consumer, prosumer and other relevant terms should be defined under the blockchain mentality since in several cases one person might have more than one role.

Regulators must clearly state their philosophy and long-term vision

The existing regulatory texts focus on the issues like unbundling, completion etc., issues that are valid mainly for vertically integrated utilities. Therefore regulators have to redefine their policies under new, more flexible business models and transaction behaviour as well as codes of conduct between DSO, TSO and blockchain users. The higher the level of entry to energy markets of blockchain the more possible is regulation will alter but for the near future will depend on local context – size of market, nature of market, population density etc. due to technological limitations.

New Tariffs

Regulators should create new tariffs that represent the actual use of the grid, differentiate the sources of energy based on the distance between the energy infuse and the user- consumer of energy. That means that there should be different tariffs for those electricity producers that are close to the consumers (i.e. same community) that those that produced outside the y defined zone.

Enabling the integration

The existence of common operating platforms will enable the integration of all assets/participants in order to succeed to energy transition and blockchain success.

Empowering utilities

Properly developed utilities could enable consumers to be transformed to procumers (production and consumption of electricity) provide them with the means to participate in energy markets (i.e. energy stock market through aggregators.

Empowering consumers and providing simplicity

Regulatory texts should provide an clear and simple procedure that will to enable consumers to actively participate in energy market. Information, transparency and active participation is mainly valid with blockchain users. Furthermore regulators

must protect consumers and businesses. In P2P transactions regulators protect the energy transactions and their validity. Other issues that should be faced are the accessibility to grids and data/ blockchains, as well as security of supply.

Cybersecurity

In decentralised markets there are no intermediaries to ensure the validity of transactions; it is the role of the regulator to ensure that. In order to energy need to develop their own knowledge on the issue at hand. Apart from that Energy Regulators, particularly in EU should extend their expertise and level of responsibility under a broader scope and take under consideration legal documents such as NIS Directive.[94]

[94] https://ec.europa.eu/digital-single-market/en/network-and-information-security-nis-directive

Conclusion

Euroelectric's relevant study indicates that "blockchain offers a solution to guarantee the validity of a transaction by recording it not only on a main register but a connected distributed system of registers, all of which are connected through a secure validation mechanism. It offers a way for untrusted parties to reach agreement on a common digital history that might otherwise be easily faked or duplicated, all without using a trusted intermediary. Because of this, some industry experts predict blockchain technologies will accelerate a transition to a more distributed energy industry, in which more accurate and rapid transactions can occur. Many companies and consortia in the electricity sector are actively investing in blockchain projects. Potential applications span the whole electricity sector from local, retail, and wholesale electricity markets to network support services, electric vehicle integration, and environmental attribute markets[95]". As clearly stated at a relevant article "The energy companies running blockchain pilot projects [are embracing] a fundamental change that is increasingly being demonstrated as viable at a time when concerns about torrents of newly- available data, the mass deployment of sensors, increasing machine-to-machine communication, and rising security threats demand a move from legacy processes and technical debt to a scalable, automatable, and trust-less solution[96]".

Nonetheless, blockchain longevity in electricity markets has not been determined yet, particularly since it has not demonstrated yet long scale commercial benefits for the users. Given the fact that blockchain is at the very early stages of its life cycle it is burdened with high costs at slow transaction speeds. Besides the "unique characteristics of the electric power sector—such as the presence of economies of scale and scope in network operation—challenge the ability of certain blockchain-based applications to grow[97]". Other pitfalls include competitive technologies and public opinion. Experience, practice and further technological developments on the field will determine blockchain application rate in the electricity sector.

[95] Ibid 6, p. 32

[96] https://energypostweekly.eu/blockchain-energy-majors-and-utilities-grab-multi-multi-billion-dollar-opportunity/ (February 2019)

[97] Ibid 6, p.32

Blockchain technology could be seen as a legal minefield, since several legal subjects and challenges arise. What is absolutely certain is that it will alter the legal regime, the role of regulators/ legislators and the fields of expertise required in order to successfully accomplish their role and it. Time will substantiate the role of blockchain as metamorphosing technology or an ephemeral fad.

Closing with the words of Euroelectric experts "however, the technology has to mature before the more robust vision becomes reality. For that to happen, some key requirements need to be tackled and met: scalability of transactions, consensus and governance, user experience and data protection, integration with the existing regulatory requirements and monitoring of the future European legislation"[98] .

[98] https://www.eurelectric.org/news/a-new-year-for-blockchain-from-hype-to-reality/

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Appendix

Examples, as adapted by the publication: “Blockchains and Energy Transition, What Challenges for Cities?” , Energy Cities, 2018

EXPERIMENTS IN THE PYRÉNÉES ORIENTALES DEPARTMENT - TECSOL

COUNTRY

France

NAME

Sunchain solution - Collective self-consumption in the Pyrénées Orientales department

INITIATOR/PROFILE

Sunchain – a TECSOL start-up

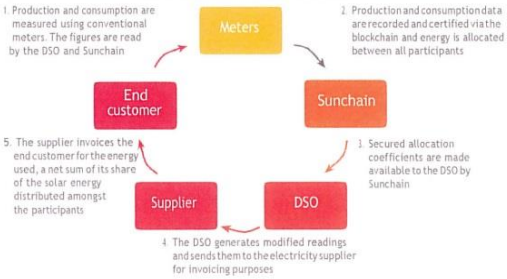
This young start-up creates virtual networks of producers and consumers using electricity meter data. Solar production and the participants' electricity use are encoded, signed and recorded in a blockchain.

Electricity allocation between the participants is automatically executed and certified based on tamperproof conditions programmed in the blockchain.

DESCRIPTION

Uses the Linux Foundation's Hyperledger Fabric open source platform. It is a "closed" blockchain with a limited number of players. This solution computes and communicates to the distribution system operator (DSO) Enedis the allocation coefficients used to distribute the energy produced between the participants in the self-consumption operation.
(see architecture below)

Sunchain Solution Architecture



Source: Sunchain

This project is covered by an experimentation agreement with Enedis

Types of applications considered:

- Solar electricity in social housing and housing developments - 1,000 flats and/or houses
- Solar electricity on close detached buildings
- Solar electricity for recharging electric vehicles (roaming)

RESULTING INNOVATION

- Certified transactions
- Traceable solar kWh and ability to invoice each housing unit for its actual share
- Automatic transfer to the DSO's software
- Automatic transfer to the DSO's software
- Facilitates the integration of solar energy into municipal buildings with various uses

FOR FURTHER INFORMATION www.sunchain.fr

BROOKLYN MICROGRID

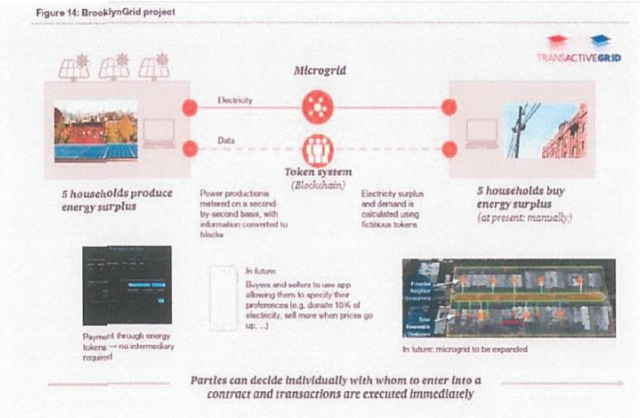
COUNTRY United States

NAME Brooklyn Microgrid (BMG)
Decentralised community electricity system at the scale of a neighbourhood

INITIATOR/PROFILE TransactiveGrid is a joint-venture composed of Lo3 Energy, a consultancy developing decentralised systems for the energy and environmental sectors and ConsenSys, a start-up developing blockchain-based applications. Two other players also have a key role in the project: ConEdison, a local supplier with a conventional grid to which BMG is connected and CLEAResult, which proposes energy efficiency solutions to both private individuals and businesses. The project is supported by the State of New York, via the New York State Energy Research and Development Authority.

DESCRIPTION Launched in 2016 in the Park Slope and Gowanus neighbourhoods, this microgrid was built using the Ethereum platform. Solar panels installed on the roofs of five residential buildings produce electricity, the surplus being sold to neighbours. These buildings are connected to a conventional grid and their transactions are managed and recorded via a blockchain. One of the objectives of the project is to create a local renewable energy community. 130 new households have reportedly expressed their intention to join the network.

Figure 14: BrooklynGrid project



"Source Blockchain - an opportunity for energy producers and consumers"? - PwC

RESULTING INNOVATION
- Peer to peer
- Smart contract technology and payments in a virtual currency (Ether)
- "a shared community energy marketplace", surplus electricity is exchanged with neighbours via secured transactions

FOR FURTHER INFORMATION www.brooklynmicrogrid.com

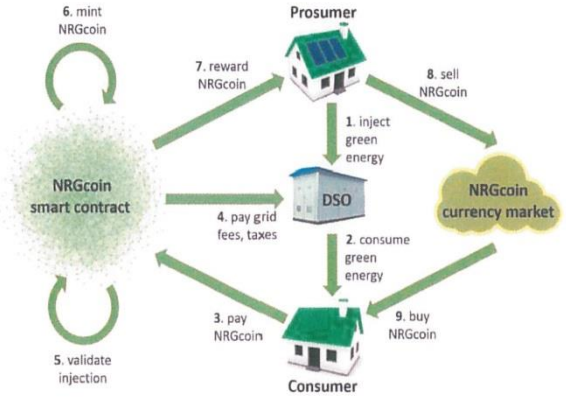
NRGCOIN

COUNTRY Belgium

NAME NRGcoin

INITIATOR/PROFILE The NRGcoin concept was developed by researchers at the Vrije Universitet Brussel (VUB), in partnership with the SME Sensing & Control Systems based in Barcelona as part of the European project Scanergy. The Belgian start-up Enervalis, based in Limburg, now aims to market NRGcoin, first in Belgian and Dutch cities and then in other European cities. Enervalis has already obtained a 3-year financial support from the Flemish innovation and entrepreneurship agency VLAIO to develop its project.

DESCRIPTION The idea behind NRGCoin is to compensate for the inadequate (not flexible enough) subsidising of renewable energy and encourage citizens to use local renewable energy by paying them in a cryptocurrency called NRGcoin. Smart contracts from the Ethereum blockchain are used to automatically and immutably mine new NRGcoins for each KWh of renewable energy injected into the grid by a prosumer at the right time - when there is local demand. Oversupply is therefore not rewarded. Another feature is that smart contracts are used to manage energy sales and purchases (not the exchange of energy). Prosumers can sell their NRGcoins on the NRGcoin currency market. On this market, consumers can also buy NRGcoins with fiat money (e.g. Euros). NRGcoins can therefore be converted into real currency if the prosumer wants to cash in on their profit.



Source: NRGCoin

RESULTING INNOVATION NRGcoin benefits from the advantages of the Ethereum blockchain (no intermediaries, transparency, decentralisation, reliability and indelibility). NRGcoin also aims to increase the value of prosumers' renewable energy installations, ensure management of a local marketplace that does not negatively impact the capacity of the network and reduce the cost of using locally-produced renewable energy.

FOR FURTHER INFORMATION www.nrgcoin.org

EXPERIMENT CONDUCTED BY ETH ZURICH IN WALENSTADT - POWER-ID

COUNTRY

Switzerland

NAME

Power-ID

INITIATOR/PROFILE

Sandro Schopfer is a researcher at the Swiss Federal Institute of Technology ETH in Zurich. After 5 years in the energy industry, he now teaches information management and is part of ETH Zurich's Bits to Energy Lab which explores new digital technologies and their applications in the energy field.

DESCRIPTION

Power-ID is a pilot project led by ETH Zurich and financed by the Swiss Federal Energy Agency that is being tested in the village of Walenstadt (5,000 inhabitants) in the St. Gallen canton. An energy service company - in fact a cooperative - is also involved. The objective is to create a small local peer-to-peer energy marketplace of 20 prosumers and 20 consumers using blockchain technology.

This decentralised network focuses on solar energy and storage (batteries) and aims to cover at least half of Walenstadt's energy needs. Connecting local players helps reduce the system's costs for all and encourages local renewable energy production and consumption.

ETH Zurich and the energy service company have not decided yet whether they want to use a public or private blockchain for this pilot project. The stakeholders have agreed to use the Ethereum blockchain for payments.
The blockchain will fulfil three functions: ensuring payments between the players involved, serving as a matchmaker and fairly allocating network costs, taking fluctuations in energy demand and supply into account.

Network costs will be flexible and will depend on the degree of self-sufficiency achieved at a given time - when a lot of local energy has been produced (because it is a sunny day), the participants will only pay for their own network costs. However, if energy from other (local) networks has to be used, participants will also have to pay for using these external sources.

RESULTING INNOVATION

- Peer-to-peer transactions across a small decentralised network; the value generated (the energy produced and used) remains in the local area.
- Network costs are transparent thanks to the blockchain.
- The energy service company is involved in the project but does not play its traditional intermediary role, thus allowing prosumers and consumers to make their own decisions.
- Instead of paying a premium price for locally produced energy, this pilot project aims to reduce the cost of local energy and enhance its value, thus making it more attractive to citizens.
- In this pilot project, the cost of the network is determined in a bottom-up way instead of being imposed top-down by the large network operators.

FOR FURTHER INFORMATION

Project leader: Sandro Schopfer, ETH Zurich
www.im.ethz.ch/people/sschopfer.html

EXPERIMENTS CARRIED OUT BY STADTWERKE ENERGIEVERBUND - GRÜNSTROMJETON

COUNTRY

Germany

NAME

Grünstromjeton

INITIATOR/PROFILE

Stadtwerke Energieverbund (SEV) is a grouping of 8 Stadtwerke from the Kamen region in North Rhine-Westphalia, i.e. the municipal utility companies of the following towns: Emmerich, Hamm, Ahlen, Froendenberg, Haltern am See, Herten, Wickede, plus the Gemeinschaftsstadtwerke of Kamen, Boenen and Bergkamen. SEV only promotes locally-produced renewable electricity and targets households in particular.

DESCRIPTION

SEV is offering a new service to encourage customers to increase their renewable energy use. Any customer with a smart meter (capable of recording energy use in real time) can access this new service, which measures precisely the share of electricity produced from renewable sources in the customer's total electricity consumption.

Customers can therefore monitor their energy mix and adjust it. Customers with a high renewable share are rewarded with a cryptocurrency called Gruenstromjeton. This cryptocurrency has real value and is therefore an incentive to use more renewable energy produced within the SEV area.

The blockchain used in this model processes data transactions between consumers and SEV and also ensures rapid and efficient invoicing of the energy used. Moreover, transactions can be automatically managed via smart contracts in the blockchain ledger.

GrünstromIndex und GrünStromJeton

Uhrzeit	Grünstrom	Graustrom	Verbrauch	Grünstrom Jetons	Graustrom Jetons
10:00-11:00	60%	40%	100 Wh	60	40
13:00-14:00	20%	80%	100 Wh	20	80
16:00-17:00	100%	0%	100 Wh	100	0

Source : stromstunde.de/Thorsten Zörner

RESULTING INNOVATION

- Citizens are encouraged to increase the share of renewable energy in their energy mix; they therefore contribute to promoting renewable energy in the local area but also benefit from it themselves.
- SEV uses the blockchain to reduce transaction costs (smart contracts) as well as the costs of the invoicing process.
- The blockchain has an open source architecture, which means SEV does not have to pay licence fees.

FOR FURTHER INFORMATION

www.energieagentur.nrw/eanrw/sev_gruenstromjetons_blockchain-anwendung_macht_gruenstromverbrauch_sichtbar

TAL.MARKT BY WUPPERTAL STADTWERKE

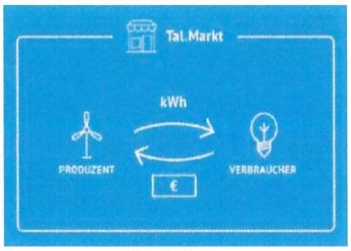
COUNTRY Germany

NAME Tal.Markt

INITIATOR/PROFILE **Wuppertal Stadtwerke Energie & Wasser AG (WSW)** is the municipal energy provider supplying the city of Wuppertal, in Western Germany.

DESCRIPTION

In collaboration with the Swiss company Elbox, WSW created the blockchain platform Tal.Markt to operate a local and regional marketplace for renewable energy produced in the Wuppertal area. The objective is to connect citizens and local renewable energy producers, in particular the 5,000 wind turbines that will no longer receive subsidies after 2020.



Source : www.wsw-talmarkt.de

For these transactions, Tal.Markt uses a private blockchain. It is less energy-intensive that a public one and allows WSW to manage users' access to the platform. Citizens can use the platform for free, whereas local producers have to pay WSW a fee to sell their energy on Tal.Markt. For the time being, only local producers with a minimum capacity of 30 KWh can access the platform. Tal.Markt's business model is therefore an on-line platform marketplace like Amazon.

The Tal.Markt platform has been designed to suit the needs of the Wuppertal area, which has many medium-sized towns. With Tal.Markt, WSW aims to ensure that the value created remains at the local and regional level. WSW would also like to meet the increasing demand from Wuppertal citizens, who want to buy energy from green, sustainable and locally-rooted producers.

RESULTING INNOVATION

- Tal.Markt's blockchain is flexible and transparent and enables citizens to monitor how much renewable energy is being produced in real time and by whom. The provenance of renewable energy is guaranteed by the infallibility of the blockchain.

- With this service, WSW benefits from a new source of income and can support local producers, who will no longer receive subsidies under the German law on renewable energy (Erneuerbare Energien Gesetz) after 2020.

- In the event of a shortage of renewable energy on Tal.Markt (e.g. for lack of wind or sun), WSW is responsible for securing the supply.

- Tal.Markt also encourages investors to set up community groups of sufficient size to encourage the construction of new wind turbines or solar installations, with no support from the Erneuerbare Energien Gesetz.

FOR FURTHER INFORMATION www.wsw-talmarkt.de/#/home

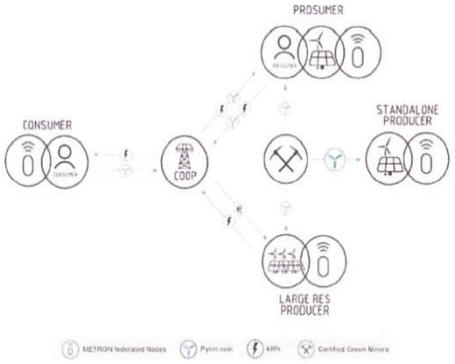
PYLON NETWORK

COUNTRY Spain

NAME Pylon Network Project

INITIATOR/PROFILE **KLENERGY TECH**
A European start-up based in Spain. Has already been approached by major energy suppliers (e.g. ENGIE, ENDESA, etc.)

DESCRIPTION Pylon Network proposes to use blockchain technology to help energy sellers have better knowledge of energy flows. Their product targets renewable energy cooperatives. Combines a smart meter (Metron) and blockchain technology to certify energy flows and enable virtual transactions using tokens (green kW production units/coins). This allows the renewable energy community to manage demand and optimise the energy flows in real time. Pylon Network uses the Ethereum platform. Pylon coin is based on the ethical Fair coin cryptocurrency algorithm developed by FairCoop.



Source Pylon white paper - Klenergy Tech

A full-scale pilot will be launched in 2018 with the Spanish basque cooperative Goiener (a member of RESCoop.eu). The project is currently sized for the Spanish market but aims to expand to other countries like the United Kingdom and Germany.

RESULTING INNOVATION
- Flow transparency
- Reliability and security
- Accessible to all
- Low energy server running on surplus renewable energy

FOR FURTHER INFORMATION www.pylon-network.org

I-NUK

COUNTRY France/International

NAME I-NUK

INITIATOR/PROFILE

I-NUK is a young French start-up which aims to shake up the carbon credit systems by creating a blockchain application enabling individuals to offset their daily carbon emissions easily and reinvest them in the construction of new solar power stations.

DESCRIPTION

I-NUK uses the Ethereum public blockchain in its application. Offsetting users' emissions requires computing their equivalent in green power. To do so, I-NUK uses a methodology that was developed by the UN and is recognised on the carbon credit markets.

The I-NUK application computes in real time the carbon footprint of all sorts of daily activities, like taking a cab, having goods home-delivered, shopping or travelling by plane. In addition to this carbon offsetting activity, I-NUK also works with small solar energy producers (including local authorities) in France and abroad with installations of between 200 and 300 KWh to help them monetise their energy production. The energy produced is certified by the I-NUK blockchain in the form of carbon credits which are then sold on the market.

I-NUK asks its partners for real-time access to their sensor-generated production data. At the beginning of the partnership, an I-NUK staff member visits the site to check the solar installation. Based on the data provided, I-NUK then evaluates its clients' income and certifies their energy in carbon credits.

I-NUK's income is obtained through commissions, meaning I-NUK is paid a commission for each service provided (carbon certification and carbon offsetting). I-NUK is still currently being tested by its partners: the public launch is planned for April 2018.

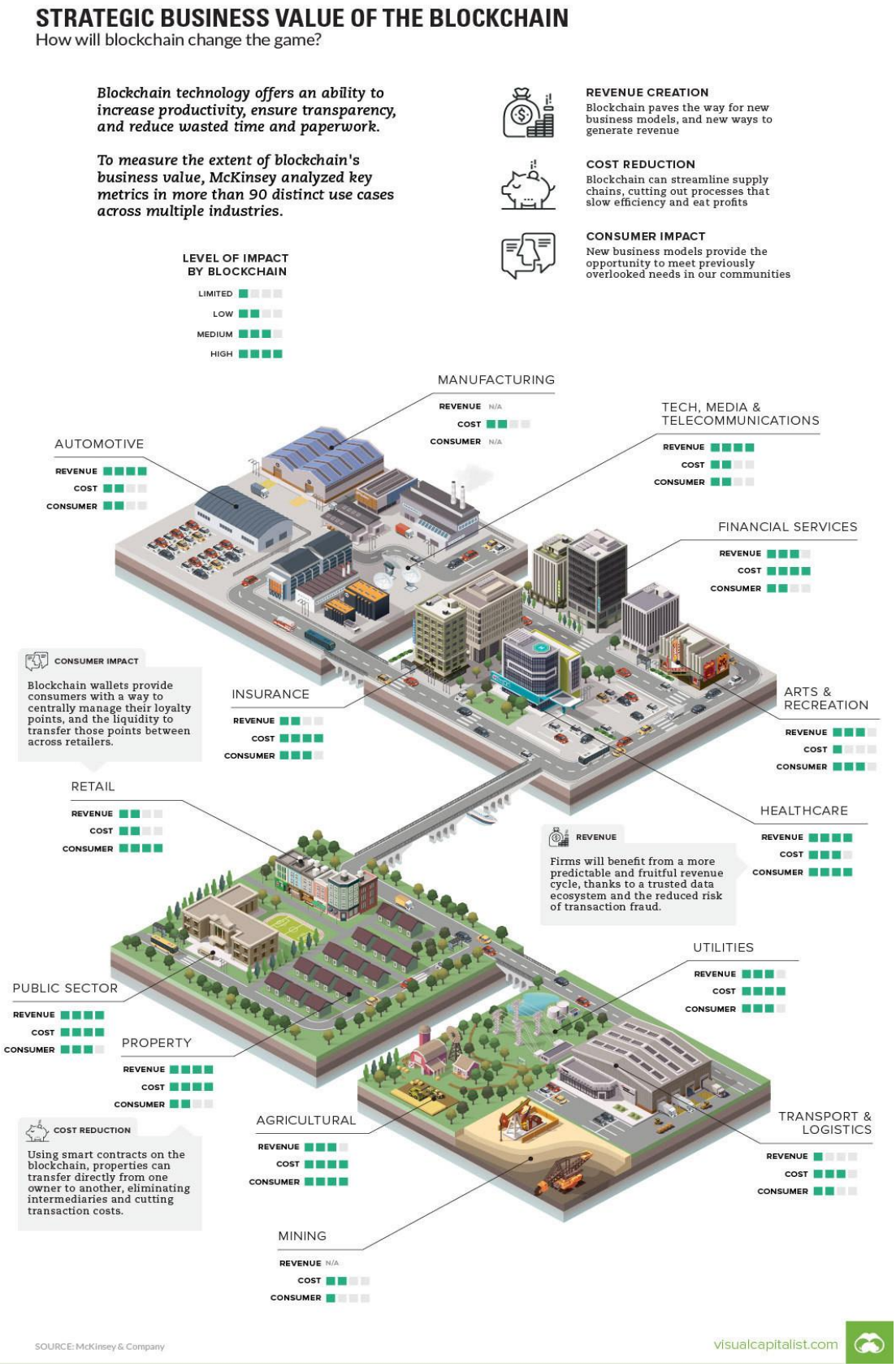
RESULTING INNOVATION

- The current carbon certification process used for example by the UN Framework Convention on Climate Change (UNFCCC) is considered insufficiently transparent, too bureaucratic (monitoring the installations is difficult as audits are not carried out on a regular basis) and not tangible enough.
  By using the Ethereum blockchain and its smart contracts (contracts whose execution is based on predefined conditions), I-NUK can guarantee a transparent, efficient, secure and automated certification process. The I-NUK blockchain permanently audits the system and publicly verifies the exactness of the certification process.

- I-NUK includes the energy used by the Ethereum platform in the carbon offsetting process, thus ensuring a fully carbon neutral approach.

- The I-NUK model enables small solar energy producers to obtain higher prices for the energy produced, thus contributing to the development of local clean energy.

FOR FURTHER INFORMATION www.inuk.co



adapted from https://www.weforum.org/agenda/2018/12/the-business-value-of-the-blockchain/