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Master's Thesis

Blockchain technology as a part of Distribution System Operators' Platform
Business Model

1st Supervisor: Professor Sanna-Katriina Asikainen

2nd Supervisor: Assistant Professor Joel Mero

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ABSTRACT

Author	Milan Halas
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The aim of this study was to find out how blockchain technology can enable Distribution System Operator's (DSO) business model innovation towards multi-sided platform. The goal of the thesis was to find out what opportunities does the blockchain based platform business models bring to Distribution System Operator. The study followed abductive approach and theoretical part included business models, business model innovation, platforms, blockchain technology and electricity power system. Empirical part was carried out as qualitative research where semi-structured interviews were utilized as the data collection method and employees of DSO were used as primary sources. Benchmarking analysis and platform design was carried out where secondary sources were utilized. Findings identified the eight major challenges in DSOs business model that can be addressed with blockchain technology: metering frequency and accuracy, data privacy and monetization, cybersecurity of the systems, supply chain traceability, manual labor and coordination in procurement, customer billing inefficiencies, maintenance crowdsourcing, adoption of distributed energy resources. These challenges were addressed using benchmarking analysis revealing that blockchain technology provides the improvement opportunities in business processes and novel blockchain based multi-sided platforms. Findings recognized four blockchain based platform business models: P2P energy trading platform, crowdfunding platform, data marketplace and maintenance crowdsourcing platform. The study also used novel methodology approach Platform Design Toolkit (Cicero 2019) for designing platform business models.

TIIVISTELMÄ

Tekijä	Milan Halas
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Pro Gradu-tutkielman tavoite oli selvittää miten lohkoketjuteknologia voi mahdollistaa sähköjakeluyhtiön liiketoimintamallin-innovoinnin kohti alustamallia. Tutkielman tavoitteena on selvittää, mitä mahdollisuuksia lohkoketjuteknologiaa hyödyntävät liiketoimintamallit tarjoavat sähköjakeluyhtiölle. Tutkimuksessa hyödynnettiin abduktiivista lähestymistapaa ja teoreettinen viitekehys rakentui liiketoimintamalleista, liiketoimintamalli-innovaatioista, alustoista ja lohkoketjuteknologiasta. Empiirinen osa toteutettiin laadullisena tutkimuksena, jossa aineistonkeruumenetelmänä olivat puolistrukturoituja haastattelut ja primäärilähteenä sähköjakeluyhtiön työntekijät. Sekundäärilähteitä käytettiin vertailukehittämis-analyysissä ja alustamallin skenaarion muotoilussa. Tutkimuksessa tunnistettiin kahdeksan sähköjakeluyhtiön liiketoimintamalliin liittyvää haastetta joihin lohkoketjuteknologia vastaa: mittaustaaajuus ja -tarkkuus, datan suojaaminen ja kaupallistaminen, järjestelmien kyberturvallisuus, toimitusketjun jäljitettävyyys, hankintojen koordinointiin liittyvä manuaalinen työ, asiakaslaskutuksen haasteet, sähköverkon ylläpito ja hajautetun sähköntuotannon lisääminen. Lopputuloksena saatiin neljä lohkoketjuteknologia pohjaista alustamallia: P2P energian treidausalusta, joukkorahoituslataus hajautetun sähköntuotannon lähteille, datan markkinapaikka ja verkon ylläpidon joukkoistamisalusta. Alustajien liiketoimintamallin suunnitteluun tutkimuksessa käytettiin uutta Platform Design Toolkit metodologiaa (Cicero 2019).

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I strongly believe that the LUT School of Business and Management gave me the proper tools and skills to be successful in whatever I'll decide to foster. It is a place where character and positive attitude are cultivated. In the end it is important to understand that learning must be a continuous process, that is not dependent on grades but the impact that it can do on one's lives. I believe that constant learning and creating is the only way that enabled humans to enable better future for the next generations.

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Milan Halas

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List of key concepts

Blockchain technology	Completely distributed system for cryptographically achieving a consistent, immutable and linear event log of transactions between actors in the same network. Blockchain technology has been derived from the digital currency Bitcoin.
Business Model	Articulation between elements of business model, which are target customer, value proposition, value chain and value capture. It defines the way how enterprise creates and delivers value to customers and converts payments received to profits.
Business Model Innovation	Holistic concept used to deal with issues related to the search for novel business logics and novel ways for company to create and capture value for its stakeholders.
Distribution System Operator	Organization that is responsible for providing and operating low, medium and high voltage for regional distribution of electricity and lower-level distribution systems and directly connected customers.
Multi-sided platform	Intermediaries or marketplaces that facilitate exchange of interactions between two or more participant groups. All counterparts are investing their time or resources to participate in the platform.
Prosumer	An entity that owns renewable energy source and therefore both produces own electricity and consumes electricity when needed.
Smart Contracts	Set of computer code between two or more parties that run on top of blockchain and constitutes of a set of rules which are agreed upon by the involved parties.

List of abbreviations

AML	Anti-Money Laundering
BMI	Business Model Innovation
CRM	Customer Relationship Management
CRP	Collaborative Resource Planning
DSO	Distribution System Operator
EDI	Electronic Data Interchange
ERP	Enterprise Resource Planning
EU	European Union
EV	Electrical Vehicles
GDPR	General Data Protection Regulation
KYC	Know Your Customer
P2P	Peer-to-peer
PAAS	Platform-as-a-service
PoA	Proof-of-Authority
PoS	Proof-of-Stake
PoW	Proof-of-Work
TSO	Transmission System Operator
AI	Artificial Intelligence
IoT	Internet of Things

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1. INTRODUCTION

This master's thesis aims to understand what the potential effect of blockchain on business model innovation of Distribution System Operator is. The phenomenon is approached using case study on blockchain technology, in the context of the Finnish Distribution System Operator. Blockchain is a public, cryptographic database or a distributed cryptographic ledger (Swan, 2015), while Finnish Distribution System Operator is seen as diverting environment, since it's business model can potentially be shifting from pipeline to platform. Theoretical framework is constructed around Business model innovation and multi-sided platforms. Theoretical framework is applied to the case study context in order to study its applicability and contribution for academia and managerial decision making. Business model innovation is facilitated through case study by conducting semi-structured interviews with case company employees and using secondary source information about blockchain startups in energy sector.

1.1 Background of the study

Since industrial economy phase all firms were focused on pipeline business model; value was created upstream and consumed downstream (Choudary 2013). In this century digital platforms such as Facebook, Google, Salesforce and Uber are forming new constructions enabling us to do even wider scope of different activities - they progressively change the way we work, interact and create value in the economy (Kenney & Zysman 2016). Nevertheless, if we look back to history, platforms have existed for decades starting from bazaars in Persia connecting customers, merchants, manufacturers and bankers. In comparison to ancient times, information technology has decreased the need for having physical infrastructure which made scaling of platforms cost-efficient and empowers the ability to capture, analyze and exchange vast amounts of data (Van Alstyne et al. 2016). Platform businesses have also enhanced productivity by making the matching more efficient, asset utilization easier and innovation quicker (Evans & Gawer 2016). This has led to the situation where platforms have disrupted many existing markets as well as created a totally new one (Ailisto et al. 2016; Evans & Gawer

2016). Currently top 15 platform companies have 2.6 trillion-dollar worldwide market capitalization and because of their value creating power are seen as particularly lucrative investment objects (Accenture 2016).

Since the early beginning of the internet, business model research moved to dynamic approach towards development and innovations of business models (Chesbrough 2010; Teece 2010). Same cluster of research also sees that business model innovation is a serious competitive advantage source, due to constantly changing environment (Casadeus-Masanell and Zhu 2013). Due to regulation and physical nature of energy companies, their business models are slowly evolving. Sosna et al. (2010) recognized that established companies tend to struggle with innovating their already profitable business models and often neglect the future changes in technology or business environment. Studies on business models in energy sector have demonstrated that adoption of renewable energy resources are putting pressure on the contemporary business models of energy sector (Nimmons and Taylor 2008; Frantzis et al. 2008; Schoettl and Lehmann-Ortega 2011; Richter 2013). Similarly

Whole energy sector is facing a significant challenge presently. Governments across OECD countries are dedicated to reducing considerably greenhouse gas emissions (GHG) and carbon-dioxide (CO₂) by year 2050 (OECD 2016). Most of our electricity today is generated in large-scale and centralized facilities such as fossil-fuel-fired power plants, nuclear power plants and hydroelectric dams. In parallel, the trend for installing small-scale power generation plants is seen to proceed, as we see support from government subsidies and increasing economies of scale. Solar PV (Photovoltaics) costs are foreseen to descend by 60% by the year 2040 (Giannakopoulou and Henbest 2016). Trending small-scale power generation give individuals and businesses the ability to produce and supply to the power grid themselves. These Distributed Energy Sources (DERs) such as solar, wind power combined heat and power systems impact the way power grid functions.

Distribution System Operators traditionally have been asset-based businesses that manage infrastructure such as power lines and substations. However, according to a survey of 108 DSO executives from 24 European countries the change is coming; regulatory framework regarding the business opportunities will change, investment level of DSOs will increase considerably by 2020 and the business will become increasingly service-oriented by taking a role of datahub or distributed generation controller (Vlerick Business School 2015). As a part of digitalization process of energy sector installing smart meters is often a task of a DSOs and it requires them to develop models for data management and extend data processing capabilities in order to provide data to market. This way DSOs could operate as a regional platform that link data sources and data sinks (Buschmann 2017). Another business opportunity lays between system stability and flexibility on the distribution grid level. DSOs could provide ancillary services either through regional flexibility markets or price signals. The role of DSOs would become more interactive with network users by providing a market exchange platform for regional flexibility (Buschmann 2017). According to Cross-Call (2017) that vast complexity of electricity system, its physical nature and regulations are slowing the DSOs process to become a platform. Cross-Call (2017) also states the fact that business models of digital platform providers such as Uber aren't capital-intensive businesses so comparing them to DSOs is not relevant. Irregardless the complexity, largest DSO in Netherlands, Alliander, has taken steps towards transformation of its business to platform business model. Smart Society Services, a corporate startup of Alliander, developed scalable, secure and open source the Open Smart Grid Platform where community of developers can collaborate and build software or applications on top of the platform (Open Smart Grid Platform 2019).

The new shift in history started when new economy was issued on the Internet without backing central authority, but automated consensus among network of users (Swan 2015). 31st of October in 2008 an article "Bitcoin: A Peer-to-Peer Electronic Cash System" written by pseudonym Satoshi Nakamoto was published on the website bitcoin.org. Article introduced novel type of currency that can be transacted via Internet in decentralized system using public ledger called blockchain. Real breakthrough was set

in the fact blockchain technology didn't require users to trust each other and it acts as a trusted 3rd party (Swan 2015).

To really understand why the potential of blockchain technology is so massive, people should regard the fact that they let intermediaries handle the trust on a daily basis (Mattila 2016). Tapscott and Tapscott (2016) state that blockchains are as disruptive as the creation of the internet due to the amount of proposed applications and substantial optimization as well as new business models. As tamper-proof, censorship-resistant and disintermediated platforms of distributed trust, that have open access, blockchain technology introduces new questions about the ownership of the platform and how is value created and captured (Mattila 2016). Fundamentally we can deduct that features of blockchain have potential value for the emerging applications in the energy sector, since in the year 2017 3% of the blockchain use cases were in the energy and utilities sector (Hileman and Rauchs 2017). Trend is on the uprise, according to Eurelectric (2018), by March 2018, 122 energy sector companies were intricated in blockchain technology and 40 of which announced positioned projects.

1.2 Research gap

According Foss and Saebi (2017) business model innovation is seen as an expansion of business model literature. There exists an unanimity among scholars that externalities have impact on business model innovation (Schneider et al. 2013; Heij et al. 2014). These externalities can be technology and Chesbrough (2010) emphasizes that technology itself is not valuable until it is integrated as a part of the business model. Andreini (2017 p. 66) states that outcomes resulting from business model innovation are particularly actual theme recently, since they have a key role in management decision making. Some business model innovation research focuses on restructuring of business model as an outcome (Hwang and Christensen 2008; Gambardella and McGahan 2010).

This proposed research aims to fill a research gap and examine how blockchain technology can impact the business model innovation towards platform business model in the context of Distribution System Operator. Studied phenomena is highly complex abstraction is used to scope the study within the boundaries of theoretical framework. Explicitly, fairly novel phenomena of blockchain technology is studied in the context of the Finnish Distribution System operator. Blockchain technology was derived from the Bitcoin network (Nakamoto, 2008), so just a bit more than a decade ago and among the first research of blockchain technology in energy sector were recognized about 5 years ago (Mihaylov et al. 2014).

The topic of business model innovation in the energy sector has been gaining popularity in the past three years (Richter 2012; Hall and Roelich 2016; Zheng et al. 2016; Hamwi and Iban 2016; Ilieva and Jayaprakash 2018; Bryant et al. 2018; Bhatti and Danilovic 2018; Chen et al. 2019). Used data, research method and findings regarding aforementioned studies are presented in Appendix 1. Ilieva and Jayaprakash (2018) discovered that conventional business models are losing to different ownership modes and operation of energy storage in the grid. Hall and Roelich (2016) concluded that appearing business models in the electricity supply market introduce considerable potential to usher substantive improvements regarding system efficiency and socio-economic situation. As an outcome of research Bryant et al. (2018) found four business models that have emerged as a result of the ongoing increase of renewable energy: green energy utility, cooperative utility, prosumer utility, and prosumer facilitator. Majority of the studies regarding the topic of business model innovation in energy sector use qualitative method and only Chen et al. (2019) study utilizes quantitative research method. The most similarity with positioning with this master thesis is recognized in Zheng et al. (2016) study as it examines how the smart grid impacts the Danish DSOs' business model and utilizes a qualitative case study method. However, the study (Zheng et al. 2016) aimed to create empirically grounded business model framework and developed "smart grid integrated business model framework" as an outcome. The goal of this master's thesis is not to formulate a concise business model framework, but

to understand how blockchain technology can impact the business model innovation of Distribution System Operator so that its business model becomes multi-sided platform.

Secondary research gap was found in the research is related to blockchain technology's impact on business models (Nowiński and Kozma 2017; Oh and Shong 2017; Kamal and Tayyab 2017; Lokøy and Nyberg 2018; Morkunas et al. 2019). The topic is very novel and all previous research related to that topic uses qualitative research method. Lokøy and Nyberg (2018) discusses disruptive business model innovation in their research. When disruptive innovation is initiated in business it occasionally spurs a conflict with the existing business model (Christensen et al. 2015). Findings of the study showed that public and consortium blockchain have characteristics of disruptive innovation while private blockchain doesn't, as well as blockchain technology affects all dimensions of business models (Lokøy and Nyberg 2018). Nowiński and Kozma (2017) see that business model innovation is occasionally connected to intangible resources that company have control over. In the findings Nowiński and Kozma (2017) found that blockchain affects business model by authenticating traded goods, via disintermediation and via lowering transaction costs. On the contrary to other reviewed studies related to blockchains impact on business models (Morkunas et al. 2019) study doesn't discuss business model innovation but architectural innovation (Henderson and Clark 1990). Regarding impact of blockchain technology on business model innovation none of the research has studied the impact on business model innovation towards platform business model, which is a concise research gap.

1.3 Research objective and research questions

Novel technologies have potential and aim to impact the business models of DSOs from both practical and scientific perspective. The application of blockchain technology could affect business model innovation of DSO and switch or remove activities within the

current core business of DSOs. Because there haven't been yet much research on blockchain technology in the context of DSOs, qualitative and exploratory perspective is needed to study the transformation.

Rooted from the research objective, the **main research question** is:

How blockchain technology can enable Distribution System Operator's (DSO) Business Model Innovation towards multi-sided platform?

To be able to answer the main research question the next three sub questions have been developed.

Subq1. *What are the major challenges in DSOs current business model and related processes that can be addressed with blockchain technology?*

At first the major contemporary challenges of the Distribution System Operators core business need to be understood. This sub question will be answered using the case company interviews conducted to employees of Finnish Distribution System Operator.

Subq2. *How blockchain technology could impact Business model Innovation of DSOs?*

Since blockchain technology is relatively novel and has many definitions, for this thesis it is crucial to build a certain understanding about possibilities and operativeness that it provides. This subquestion will be answered using a variety of technical, business and non-scientific publications. In addition BMI typologies of the business models will be defined in the latter chapter.

After resolving Subq1 and Subq2 the scenarios for platform business models derived from the results will be analyzed with Platform Design Toolkit (Cicero 2019). This study is ordered by the case company and therefore, scenarios for platforms are designed as a part of the study.

1.4 Theoretical Framework

The aim of theoretical framework is to demonstrate relationship between main theories and concepts as well as help to comprehend the study aim. Theoretical framework covers business model and business model innovation through the lens of multi-sided platform.

In this study business model is defined as architectural structure of target customer, value proposition, value chain and revenue model (Gassmann et al. 2014). Multi-sided platforms are defined as intermediaries that enable direct interactions between two or more distinct counterparts and all counterparts are affiliated with the platform itself (Hagiu and Wright 2015). Business model innovation is a holistic concept that is used to deal with issues to the search for novel business logics and novel ways for company to create and capture value for its stakeholders (Andreini and Bettinelli 2017 p.55).

As shown in Figure 1, study aims to clarify how phenomena of blockchain technology will affect the business model of Distribution System Operator (DSO) by affecting its business model innovation, with the aim to shift to multi-sided platform. Additionally, study aims to interpret what challenges of the current Distribution System Operators (DSO) business model could be addressed with phenomena of blockchain technology.

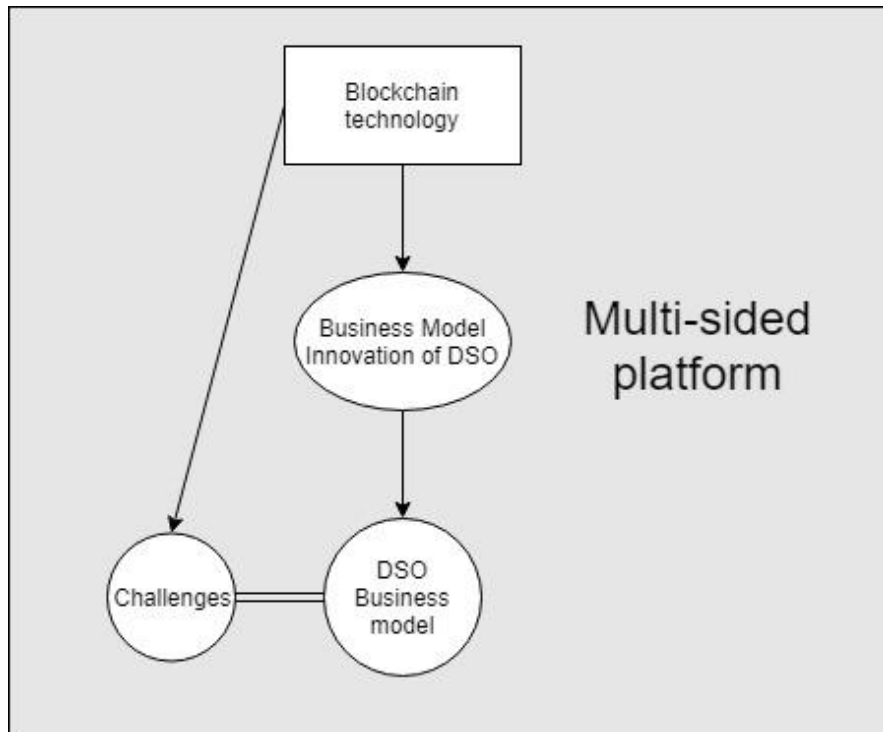


Figure 1. Theoretical framework of the study

1.5 Expected contribution

There hasn't been research concerning blockchain technology applications in platform business model and the context of Distribution System Operator (DSO). Therefore, this study is probably among the first to provide the Finnish Distribution System Operators with knowledge about what opportunities does blockchain technology bring to Distribution System Operator and how it can enable business model innovation towards becoming a platform.

Academia is lacking the theoretical and practical knowledge about what effects blockchain have on business model innovation. Results of the study aren't generalizable because they are based on the interviews conducted in one Distribution System Operator. Outcomes of this study shall serve as a ground for the future research or foundation of knowledge for organizations or individuals.

1.6 Delimitations

Delimitations are intended decisions to limit the scope of the conducted research. As any other research there needs to be both theoretical and contextual delimitations. Business model innovation studies can be approached from many angles. This study is scoped to elements of Business model innovation defined by Gassmann et al. (2014). These four elements are target customer, value proposition, value chain and value capture (Gassmann et al. 2014). This study is aiming to understand how business model can be switched to platform using blockchain technology. This study is mainly focusing on industry platforms, which by definition act as an orchestrator within a network of companies and individual external developers, which have been commonly identified as platform's "innovation ecosystem". (Adner and Kapoor 2010; Nambisan and Sawhney 2011; Gawer 2014). In the empirical part of the study is delimited to Ecosystem Canvas and Motivations Matrix of Platform Design Toolkit (Cicero 2019). This study focuses on platform ecosystem consisting of impact entities, demand entities and supply entities (Cicero 2019). Impact entities are engaged in constant interactions occurring in the ecosystem. Demand entities are focusing on consuming the value in the platform ecosystem. Supply entities are focused on generating the value consumed in the ecosystem.

This master's thesis is delimited to the study of DSOs Distribution System Operators which are in control of the electricity distribution in the area that they operate in. Majority of Distribution System Operators have regulated monopolistic business model including case company. Latter delimitation is on the Finnish electricity distribution market, which is chosen due to specific regulatory framework and different physical nature of the business. As the aim of the thesis is to pre-study the potential of blockchain application for a Distribution System Operator, it won't provide a detailed technical implementation process for blockchain in platform business model. This master's thesis neither will evaluate the optimal future business model of the DSO platform.

2. BUSINESS MODEL DEFINITIONS AND CONCEPTS

This chapter provides an overview of the literature related to business models, platform business model, value creation, value capture and business model frameworks.

Reviewed literature explains what academic findings exist regarding platform business model and platform design.

2.1 Definition of Business Model

The use of “business model” term has become increasingly popular in recent decades and there are plenty of variations (Zott et al. 2011). According to Osterwalder et al. (2005) the earliest usage of the term has been found with Bellman et al. (1957). Surge of business model concepts and theories are synchronous with the creation of internet (Teece, 2010). Since then business model wasn't seen just as an operative plan for creating a suitable IT system, but as an element contributing to the success of management's decision making (Wirtz et al. 2016). During dot-com bubble era tremendous amount of funds were raised for deficient business models (Shafer et al. 2005) and according to De Silva (2012) the problem is not related to the term but to the lack of comprehension, leading to the misuse of the term.

Starting from the year 2000 the amount of research addressing strategic perspective of business models has been recognized. Hamel (2000) stated that both better strategic decisions can be made as well as competitive structure can be analyzed easier, using business models. During the rapid economic growth in early 2000s the term was widely used in business newspapers and along with that the criticism towards it. Famously Porter (2001 p. 73) stated “*The definition of a business model is murky at best. Most often, it seems to refer to a loose conception of how a company does business and generates revenue. Yet simply having a business model is an exceedingly low bar to set for building a company.*” Criticism has driven researchers towards studying the issue

further and starting from 2004 the amount of practice-oriented and scientific books has grown (Afuah 2004; Debelak 2006; Osterwalder and Pigneur 2010). Strategy has vital influence on the development of business model - works of Afuah (2004), Yip (2004), Tikkanen et al. (2005) have references to strategy or representation as independent interface elements. Apart from strategy some of the business model literature incorporates a network oriented view, which sees networks and partnerships as a key factors contributing to company's value creation and thus should to be seen as a part of business model (Voelpel et al. 2004; Lund and Nielsen 2014; Nenonen and Storbacka 2010). Table 1. Presents a chronological summary of the established business model definitions.

Furthermore, business model component often referred in the literature is market offering model. Market offering includes value proposition as relation to value that customer obtains via the business model (Lehmann-Ortega and Schoettl, 2005; Johnson, 2010; Demil and Lecocq 2010). Most of the consensus amongst the authors is regarding the relevance of market offering and resources components of business model. On the contrary, there is much less agreement regarding in the areas of strategy, revenue and procurement. (Wirtz et al. 2016)

Table 1. Chronological summary and on the most established business model definitions.

Researcher(s)	Definition of Business Model
Timmers (1998)	"An architecture for the product, service and information flows, including a description of the various business actors and their roles; a description of the potential benefits for the various business actors; and descriptions of sources of revenues."
Jutla, Bodorik, and Wang (1999)	"The business model determines processes and transactions. (i.e.business process- retail [external, internal], procurement, transaction-buy, payment registration etc.)"
Tapscott et al. (2000)	"A business model is about the invention of new value propositions that transform the rules of competition and mobilize people and resources to

	unprecedented levels of performance.”
Applegate (2001)	“A description of a complex business that enables study of its structure, the relationships among structural elements, and how it will respond to the real world.”
Weill and Vitale (2001)	“A description of the roles and relationships among a firm's consumers, customers, allies and suppliers that identifies the major flows of product, information, and money, and the major benefits to participants”
Hawkins (2001)	“A description of the commercial relationship between a business enterprise and the products and/or services it provides in the market. More specifically, it is a way of structuring various, cost and revenue streams such that a business becomes viable, usually in the sense of being able to sustain itself on the basis of the income it generates.”
Osterwalder and Pigneur (2002)	“A description of the value a company offers to one or several segments of customers and the architecture of the firm and its network of partners for creating, marketing and delivering this value and relationship capital, in order to generate profitable and sustainable revenue streams.”
Magretta (2002)	“A story that explains how an enterprise works. Who are your customers, What is their value and How you will you make money in exchange for the given value?”
Hedman and Kalling (2003)	“Business model is a term often used to describe the key components of a given business. That is customers, competitors, offering, activities and organization, resources, supply of factors and production inputs as well as longitudinal process components to cover the dynamics of the business model over time.”
Morris, Schindehutte and Allen (2005)	“A business model is a concise representation of how an interrelated set of decision variables in the areas of venture strategy, architecture, and economics are addressed to create sustainable competitive advantage in defined markets.”
Shafer et al. (2005)	“A representation of a firm’s underlying logic and strategic choices for creating and capturing value within a value network.”
Andersson et al. (2006)	“Business models are created in order to make clear who the business actors are in a business case and how to make their relations explicit. Relations in a business model are formulated in terms of values exchanged between the actors.”
Johnson, Christensen, and Kagermann (2008)	“A business model, from our point of view, consists of four interlocking elements that, taken together, create and deliver value. The most important thing to get right, by far, is the customer value proposition. The other elements are the profit formula, key resources and key processes.”
Demil and Lecocq (2010)	“Generally speaking, the concept refers to the description of the articulation between different BM components or ‘building blocks’ to produce a proposition that can generate value for consumers and thus for the organization.”
Teece (2010)	“In short, a business model defines how the enterprise creates and delivers value to customers, and then converts payments received to profits.”

2.1 Components of Business Model

In addition to holistic definitions at Table 1. some scholars present concise components and frameworks of the business models. Business Model Ontology, a well-known framework that includes nine components: value proposition, target customer, distribution channel, relationship, value configuration, capability, partnership, cost structure, revenue model (Osterwalder 2004); A framework proposed by Johnson et al. (2008) consisting of four interlinked elements: customer value proposition, profit formula, key resources, key processes; Business Model Canvas by Osterwalder and Pigneur (2010), which is extended more practical version of Business Model Ontology that is particularly designed for firms to develop and change business models; Chesbrough (2010) describes a framework with seven functions that business model should execute; Yunus et al. (2010) discuss three components of conventional business model: value proposition, value constellation, profit equation. Gassmann et al. (2014) recognize four components of business model: target customer, value proposition, value chain and revenue model. It should be noted that most of the business model frameworks try to answer following questions: Who is the customer? What is the value proposition? How is revenue created? How this all be funded? As knowing the target customer creates a solid foundation for value proposition - in literature it has somewhat similar definitions demonstrated in Table 2.

Table 2. Overview of target customer definitions

Target customer		
Customer segment	“Different groups of people or organizations an enterprise aims to reach or serve”	Osterwalder and Pigneur (2010)
Target customer	“Who is the target customer (segment)?” (p. 2)	Gassmann et al. (2014)
Market segment	“The users to whom the technology is useful and for what purpose” (p. 533)	Chesbrough and Rosenbloom (2002)
Market factors	“Who do we create value for?” (p. 730)	Morris et al. (2005)

Value proposition has a major role in nearly all business model frameworks and scholars have the most consensus on including it as a component. In Table 3 the value proposition definitions are summarized.

Table 3. Overview of value proposition definitions

Value proposition		
Value proposition	“The value created for user by the offering” (p. 553)	Chesbrough and Rosenbloom (2002)
Factors related to offering	“How will the company create value?”	Morris et al. (2005)
Value proposition	“Describes the bundle of products and services that create value for a specific customer segment” (p. 22)	Osterwalder and Pigneur (2010)
Value proposition	“Represents the unique value a business offers to its customers and needs to be based on the specific geography and customer segments targeted and the intended product and service mix”	Schön (2012)
Value proposition	“What is offered to the target customers” (p. 2)	Gassmann et al. (2014)

Value chain component of business model has the most divergent nature, through the scholars describe analogous aspects across an organization’s activities to create value. Porter (1985) was the first to introduced value chain concept, which he defined as a set of actions that an organization executes to create value for the customers. Coordination of organizations all resources and activities is done through value chain utilizing it for creation and distribution of the product and service offering that was outlined in the value proposition (Chesbrough and Rosenbloom, 2002). Table 4. Demonstrates the differences of value chain definition.

Table 4. Overview of value chain definitions

Value chain		
Value chain	“Value chain divides a firm into the discrete activities it performs in designing, producing, marketing and distributing its product” (p. 26)	Porter (1985)
Architecture	“An architecture for the product, service and information flows, including the description of the various business actors and their roles” (p. 4)	Timmers (1998)
Internal Capability Factors	“What is the company’s internal source of competence?” (p. 730)	Morris et al. (2005)
Key Activities	“The most important things a company must do to make its business model work” (p. 36)	Osterwalder and Pigneur (2010)
Value chain	“How the value proposition is created?” (p. 2)	Gassmann et al. (2014)

As a last component of the business model we discuss value capture, defining how the company’s business model yields revenue. There has been a lot of confusion between the concept of value creation and value capture. Makadok and Coff (1999) emphasize the importance of dividing the processes of value creation and value capture. Table 5. presents the overview on value capture definitions in chronological order.

Table 5. Overview of value capture definitions

Value capture		
Revenue sources	“The sources of revenues” (p. 4)	Timmers (1998)
Economic factors	“How we make money?” (p. 730)	Morris et al. (2005)
Revenue stream	“Represents the cash a company generates from each customer segment” (p. 30)	Osterwalder and Pigneur (2010)

Revenue model	“How company makes revenues?” (p. 74)	Schön (2012)
Revenue model	“How the revenue is created? (p. 2)	Gassmann et al. (2014)

Overview of the literature build our understanding about the similarities in definitions of various business model framework components in comparison with Gassmann et al. (2014) “Magic Triangle”. Since the aforementioned business model consists of both internal and external factors it is well-suited for assessing company’s interplay with environment which is particularly important for this case study analysis. In order to simplify the analysis in this research Gassmann et al. (2014) “Magic Triangle” demonstrated in Figure 2. will be used as a basis for defining business model, because in comparison to three much similar components introduced by Yunus et al. (2010) it includes the target customer. Essentially “Magic Triangle” components are target customer, value proposition, value chain and value capture.

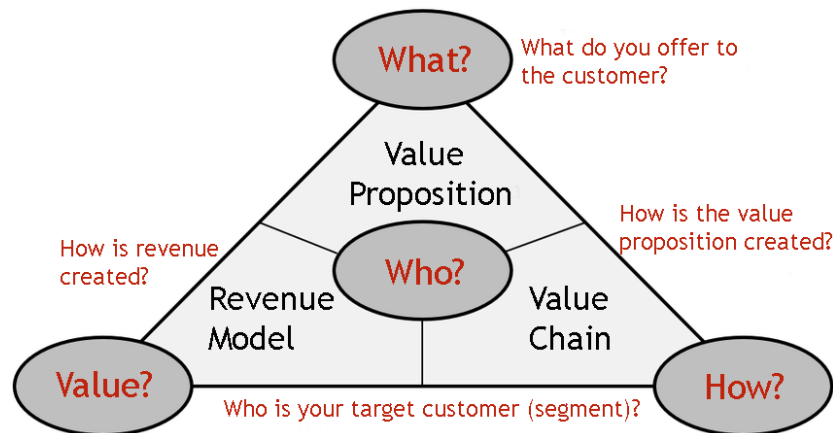


Figure 2. Definition of business model - “Magic Triangle” (Gassmann et al. 2014)

2.2 Business Model Innovation

Business model innovation is an expansion of Business Model, because it integrates numerous topical questions that extend above the limits of business model literature (Foss and Saebi 2017). In recent years business model innovation has gained its popularity as researchers in a variety of research areas identified the potential of new business models in providing companies a competitive edge (Casadesus-Masanell and Zhu, 2013). According Andreini and Bettinelli (2017 p. 55) “*business model innovation is a holistic concept used to deal with issues related to the search for new business logics and new ways for a company to create and capture value for its stakeholders*”.

Thus, the majority of scholars also have consensus that external factors such as technology impact business model innovation; yet these are often not regarded as a part of the business model (Schneider et al. 2013; Heij et al. 2014). In relation to previous, Chesbrough (2010) pointed out that advanced technology doesn't have sizable commercial value till the point it is established in the business model of a company. There has also been discussion about what is the position of strategy in the business models. Some scholars (Chesbrough and Rosenbloom 2002; Voelpel et al. 2004; Shafer et al. 2005; Chesbrough 2010) included strategy inside their conceptualization of business model which sparked the debate and most recent studies argue that strategy should be separated from the business model (Zott and Amit 2008; Casadesus-Masanell and Ricart 2010; DaSilva and Trkman 2013).

In the literature review based on 150 papers Saebi and Foss (2017) recognized four dimensionalities of business model innovation in terms of “scope” and “novelty” (demonstrated in Figure 3).

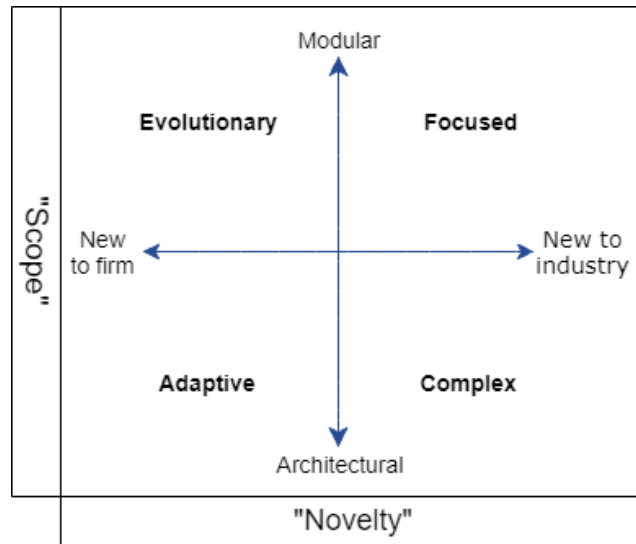


Figure 3. Business model innovation typology matrix (Foss and Saebi, 2017)

Evolutionary business model innovation describes the process that in result brings volunteer and necessary modifications in separate components of the business model, which often take place inevitably over time. **Adaptive** business model innovation describes the modifications in the whole business model, which are novel to the company but aren't certainly novel to the industry in which company operates (Saebi et al., 2017). It occurs occasionally when there are some changes in the external environment and company decides to conform its business model configuration (Teece 2010). **Focused** business model innovation fosters firm's innovation inside one specific component of business model, for example targeting new market segment (Foss and Saebi 2017). **Complex** business model innovation has effect on the entire business model (Foss and Saebi 2017). Amazon is a good example of complex business model innovation, as a company that began as an online bookstore that later became a platform for matching buyers and sellers. In both focused and complex business model innovation management fosters either modular or architectural modifications to reconstruct the market environment (Foss and Saebi 2017).

There has been a discussion in the literature whether business model innovation is a driving factor in the company's performance. According to Porter and Rivkin (1998)

probability of better performance is higher in the business model innovation that includes firmly interconnected components than in the one that has a rather loose structure. Nevertheless, in such complex business model innovation it is challenging to predict the real implications on company's performance (Rivkin 2000). In comparison, loosely coupled organizations have more flexibility to respond to environmental shift, but rather prone to being copied (Rivkin 2000). In the case of tight or loose business model innovation managers are keen on balancing between inflexibility and mimicry.

2.3 Outcomes of Business Model Innovation

The outcomes of business model innovation are a topical theme recently. Especially from the managerial point of view predicting outcomes often play a key role in decision making. Scientific papers published within this theme is mainly concentrated around value, financial performance, industry level outcomes and strategic actions (Andreini 2017 p. 66). Especially value as an outcome has been a rather popular topic. Key value related topics were process of value creation (Chesbrough and Rosenbloom 2002), competitiveness (Liu and Jiang 2013; Michalski 2003), and value capture (Desyllas and Sako 2013). Previously mentioned researchers see value creation and value capture having a connection according their aforementioned papers (Andreini 2017 p. 67).

In financial performance topic, majority of the research examines real economic performance (Demil and Lecoq 2010; Nair et al. 2010). Other research focuses on perceived economic performance (Aspara et al. 2010; Brettel et al. 2012; Huang et al. 2012) as an outcomes of business model innovation (Andreini 2017 p.66). Brettel et al. (2012) recognized that research papers with perceived economic performance as business model innovation outcome usually include measurable components which in regard helps to understand its impact on profitability. In addition to financial perspective, some scholars recognized the potential effects of business model innovation on industry structure (Gambardella and McGahan 2010) and creation of disruptive innovations (Engel 2011).

2.4 Enablers and barriers of Business Model Innovation

The study of factors enabling the business model innovation defined as enablers are constructed from elements that support and facilitate the process of business model innovation. It is important to distinguish business model innovation drivers and business model innovation enablers: Drivers comprise essential conditions for business model innovation while enablers comprise elements that support business model innovation (Andreini 2017 p. 72). Part of the research studying enablers of business model innovation recognized two typologies: technological (Berman et al. 2012) and organizational (Simmons et al. 2013). Additionally, to above-named enablers Christiansen et al. (2012) studied contextual enablers which are in an example characteristic of external environment.

Acknowledging the existence of barriers for business model innovation is as essential when evaluating the transformation from one business model to another. While fostering business model innovation, companies face both internal and external barriers (Birkin et al. 2009; Lange et al. 2015; Rüb et al. 2017). Research related to organizational innovation recognized centralization, formalization and vertical differentiation as structures that have bad effect on innovation (Damanpour 1991) and thus on business model innovation as well (Rüb et al. 2017). The paper that studies 5 main dilemmas that big companies face while pursuing business model innovation (Koen et al. 2010). According Chesbrough (2010) major barriers to business model innovation are managerial understanding and organization's current assets; in addition, business model innovation takes certain time to transform between old and new business model. Massa and Tucci (2013) pointed out that incumbent companies are constrained by existing architecture and dominant logic of the task execution.

3 PLATFORMS

There is no clear consensus between academics about the definition of “platform” or “platform business model”. Because the term is used in many different contexts of meaning and it can be challenging to comprehend (Cusumano 2010). The term has been used often to outline management phenomena at the degree of single products, product systems, markets and industries (Gawer 2009). Most commonly the digital sector provides plenty of examples of industry platforms, such as Google or Facebook (Gawer 2014). These industry platforms act as an orchestrator within a network of companies and individual external developers, which have been commonly identified as platform’s “innovation ecosystem”. (Adner and Kapoor 2010; Nambisan and Sawhney 2011; Gawer 2014). But not only software products can be a platform, but basically any products (Sviokla and Paoni 2005) and due to this nature, platform technology can be utilized in a variety of industries (Evans et al. 2008).

Economic theory and engineering design are two separately evolved and dominating perspectives in the research related to platforms (Gawer 2014). Rochet and Tirole (2003) introduced the conceptualization of the platforms as a two-sided market, which is a well-known economic perspective. The focal point of economics perspective is on how platforms as market convey transactions over various customer units and how network effects foster platform competition. On the opposite from engineering design viewpoint product platforms as technological designs support firms in creating modularized product innovation. (Gawer 2014)

Porch et al. (2015) analyzed platform business model in the systematic literature review using algorithmic historiography, which demonstrated that platform literature is separated in two streams that don’t cross reference each other. One literature stream is particularly focused on interior based platforms while another on the exterior based platforms. Thomas et al. (2014) extended their research of platforms from previous platform typologies by Gawer (2009) and recognized four literature streams:

organizational platforms, product family platforms, market intermediary platforms and platform ecosystems. Figure 4. illustrates the upswing of platform literature, which began in the past two decades.

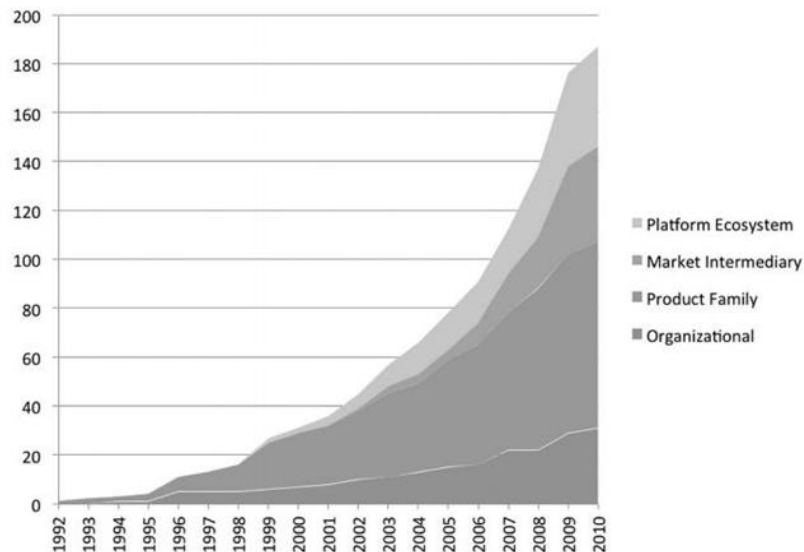


Figure 4. Volume of the platform papers sorted by four literature streams. (Thomas et al. 2014)

According Gawer and Cusumano (2014) platforms can be split into two major categories: company focused internal platforms and industry wide external platforms. Internal platforms are a set of assets organized in common structure from which company can develop and produce a range of differential products with efficiency. External platforms relate to products, technologies or services that create a foundation upon which outside firms can develop their complementary products, services or technologies. The external platforms are open to extrinsic innovation whereas internal platforms are rather closed from extrinsic innovation. (Gawer and Cusumano 2014) Company that has established exterior platform focuses extend their business logic above the company's internal capabilities by enabling complementary product development by complementors and interact between different participant groups to create multi-sided markets (Porch et al. 2015). The unique characteristics of exterior platforms is non-linearity of value chain and company orchestrating the platform rely on

complementors to drive value (Eisenmann et al. 2006; Porch et al. 2015). In the literature exterior platforms has been studied from the engineering perspective, where platforms defined as technological architectures and in economics perspective where platforms are defined as markets (Gawer 2014).

According to Gupta (2017) decentralization enabled by blockchain technology enables seamless operation between members of complicated networks without the need for intermediaries such as platforms. Supposedly cutting transaction or membership fees with novel blockchain enabled platforms could significantly affect the underlying business logic of industry platforms. Similarly, Gupta (2017) stated that current processes also include friction which motivates to keep smaller group of partners. This study's main focus is in industry platforms that can vary from exterior to interior platforms. Both exterior and interior platform perspective were chosen to gain flexibility in the research.

3.1 Multi-Sided platforms and Multi-sided markets

Before explaining multi-sided markets understanding the transition to that point from two-sided markets is crucial. Eisenmann et al. (2006) state that products and services which connect groups of users in two-sided market are platforms. Platform business model foreseeably involve a transaction that is taking place in “two-sided market” (Rochet and Tirole 2006) where different stakeholders are unrestricted to participate in the platform on the demand and supply side (Rochet and Tirole 2003; Rochet and Tirole 2006; Armstrong and Wright 2007). Rysman (2009) on the other hand defines two-sided market a concept where two agent groups interact through intermediary platform and decisions of both agent groups has an effect on other group of agents.

However, in the recent years, two-sided markets became rather anterior and multi-sided platforms perspective has established its popularity. Hagiu and Wright (2013) discusses

that this may be since major fastest growing businesses of the past decade are multi-sided platforms. In some fields of commerce multi-sidedness has been seen as a given characteristic (Hagiu and Wright, 2015). Nevertheless, companies mostly aim to determine themselves the level of “multisidedness” which have vast effect on profitability. From multi-sided market point of view platforms are multi-sided when they act as intermediaries or marketplaces that facilitate exchange of interactions between two or more participant groups (Boudreau and Hagiu 2008; Hagiu and Yoffie 2009; Gawer and Cusumano 2014; Hagiu 2014; Seppälä et al. 2015).

According Hagiu and Wright (2015) multi-sided platforms have two main characteristics; they enable direct interactions between two or more separate counterparts and all counterparts are affiliated with the platform itself. Hagiu (2014) explained “affiliation” that users on each counterpart purposefully make platform specific investments which are required to enable direct collaboration with one another. Specific “investments” are either investment of time or money, for example fixed fees for the monthly access to the platform or time required to spend on learning how to participate in the platform.

Seppälä et al. (2015) in contrast to previous definition integrated a network-based view by recognizing three multi-sided platform characteristics: it serves two or more different customers; connection between different kind of customer group creates direct and indirect network effects; the third party is needed to forward effects between distinct parties. This view aligns with Rochet and Tirole (2006) which state if there is no network effects, the platform isn't multi-sided.

3.2 Variations of Multi-Sided Platform

According Sanchez-Cartas and Leon (2019) there are 80 various multi-sided platform models in the literature that are sorted in many ways: the hypothesis of being in one or various platforms at once (singlehoming vs. multihoming), the nature of fees, the amount of competing platforms in the market.

Evans (2003) introduced the three categories: market-makers, audience-markets, demand-coordinators. Market makers allow the members of groups to make transactions with one another. Audience-makers on the other hand are defined as a market where platforms couple advertisers to audiences. Demand-coordinators are the ones that don't fit in two previously mentioned categories. This categorization is sort of restrictive because quite many contemporary businesses end up being categorized as a demand-coordinators.

Flistrucci (2008) introduced more relevant classification for current situation by putting two-sided models in two categories: two-sided non-transaction markets (there is no transaction between end-users) and two-sided transaction markets (there is a transaction between end-users, and it is discernible by the platform).

3.3 Network effects

As discussed in the chapter about multi-sided platforms, network effects have important role in them. A lot of empirical work related to multisided platforms has a strong interest in measuring network effects and their impact on the acceptance of the platform by the users (e. g. Rysman 2004; Clements and Ohashi 2005, Lee 2008). Often network effects delineate what characteristics do the multisided platforms receive and create entry barriers for competitors due to enhanced value of the platform (Rochet and Tirole 2003). In brief, when a product becomes more valuable as the user base expands - the situation can be seen as a network effect (Parker and Van Alstyne 2005). As an example, when comparing video-platforms Vimeo and Youtube; the user have more potential to receive more value from Youtube, since there is considerably more people using the platform on a daily basis. Bigger network means that the supply and demand meet better and there is enough data to orchestrate even more efficient interactions between users. As from example usually the platform provider that has more users tend to dominate the market.

Katz and Shapiro (1985) introduces two types of network effects - direct and indirect network effects. Direct network effects are most often formed through demand side of the network (Lin and Lu 2011) and they occur linearly with the increase of the number of users, this is why they are especially important to the communications networks (Veljanovski 2007). Indirect network effects happen in situations when value that consumer descends from the product and grows together with the number of additional users of interoperable complementary goods (Veljanovski 2007; Hagiu, 2014). Platforms with strong indirect network effects tend to embed themselves strongly in the market and therefore creating high entry barriers for competitors. However, multi-sided platforms face most often difficulties in growing one side of the platform to attract another side (Hagiu 2014), which is referred as “the chicken and egg problem (Cillaud and Jullien 2001).

Network effects can also have positive and negative nature, which also determines whether the product gains success or fails. According Gawer (2009) most oftenly network effects are positive. In the situation, where a customer appreciate product more if a similar customer utilizes it as well - the network effect is positive. On the contrary, if the situation is such that customer value product less due to the fact that it is used by others - the network effect is negative.

3.4 Governance of Multisided Platform

Since multi-sided platforms are responsible for facilitating interactions between third parties and create value through that, governance has an important role in the strategic decisions (Boudreau and Hagiu 2010). Before transforming into multisided platform, it is crucial to understand how it will be governed, who are granted access and what is the level of openness. There are two contradictory goals in governance: on the one hand platform requires keeping control and at the same time it should allow 3rd party developers to build more features (Ghazawneh 2012; Tiwana 2010).

When designing the governance, we need to take leadership in account, where decision making about intellectual property and right architecture counts (Gawer and Cusumano, 2008). Bourdeau and Hagi (2009) recognized that governance of multi-sided platforms also is related to having platform rules, which are either derived from regulations or implemented by the strategic leadership decisions. Commonly these platform rules apply to ownership of information and data or transactions. Governance models can also be rather loose and have more distributed nature, such as Linux relying on full open source development.

According Tiwana et al. (2010) platform governance can be explored from three separate perspectives: decision rights partitioning (how decision making rights are split between the platform owner and third parties), control (perfunctory and informal systems enforced by the platform owner to incentivize desired behaviors by third parties) and proprietary versus shared ownerships (whether there are multiple platform owners or a single owner). When designing a decision rights partitioning three questions need to be answered: what are the features of the subsystem? How it should be done? Who has the control over the ecosystem's internal interfaces? Designing control requires understanding the control of the output, process and clan control. Clan control refers to shared beliefs and norms used to guide behavior of third parties. (Tiwana et al. 2010)

Literature has introduced three information technology governance regimes: centralized, decentralized and hybrid (Brown and Magill 1994; Fiedler et al. 1996; Kazan et al. 2014). According to Zhu et al. (2017) platform governance design choices should be done chosen according to the context and needs of the company.

Centrally governed platform design implies a system that stores in a cloud or server which is under the control of one organization acting as platform provider. There may be some trusted counterparts with access, but most often the platform is rather unevenly shared across participants. (Mattila et al. 2016) Centrally controlled platform is usually easier to implement because of their simplified structure and companies tend to prefer it

because of reluctance of participation in a platform provided by another company. Reluctance is rooted in the issue of limited capability of value capturing potential (Mattila et al. 2016)

Decentralized platform governance refers to sharing of control and responsibilities between platform owner and user (Lee et al. 2017) and the layers such as content, service, network, system and device layers of the platform are linked loosely (Kazan et al. 2014).

3.5 Platform Design Toolkit

While Business Model Canvas by Osterwalder and Pigneur (2010) is well suited tool for pipeline business models - it isn't practical for shaping and analyzing multi-sided platforms. Platform Design Toolkit is a framework Cicero (2019) developed for ideating, initiating and deploying platform strategies that helps ecosystem to create and capture value. Cicero (2019) separates platform ecosystem entities into three groups: impact entities, demand entities and supply entities. Impact entities are engaged in constant interactions occurring in the ecosystem. Demand entities are focused on consuming the value which the ecosystem generates, and they are loosely linked to the ecosystem, since they can leave easily. Supply entities are focused on generating the value consumed in the ecosystem. Table 6. represents the subgroups and influence capabilities of entities

Table 6. Platform ecosystem entities, entity subgroups and their influence capabilities

Entity type	Subgroup	Influence capabilities
Impact Entities	Platform Owners (PO) Platform Stakeholders (PS)	Sizable entities influenced by whole system dynamics
Demand Entities	Peer Consumers (PC)	Individuals, SME organizations that have specific interest and identifiable objectives. Involved in constant interactions
Supply Entities	Partners (PA) Peer Producers (PP)	

According to Cicero (2019) value is produced in the platform by platform owner using transaction and learning engine. Transaction engine is a combination of channels and context specifically designed to facilitate interactions and exchanges between entity-roles. The aim is to optimize channels for reduction of transaction/transaction costs. Learning engine are combination of support services that Platform Owner generates for the participants so they can learn, improve and evolve.

Platform Design Toolkit includes eight steps from mapping the ecosystem to setting up the minimum viable platform. Each of the steps include tools for designing the platform. Out of selection of tools this thesis will utilize Ecosystem Canvas and Ecosystem’s Motivation Matrix.

Ecosystem Canvas (Figure 5.) is a map of impact, supply and demand entities that have specific context, motivations and expectations. Aim is to rather generalize in order to have room for scaling up, you’ll want to keep as much potential as possible inside the reach of your strategy. Clustering entities together is recommended. (Cicero 2019)

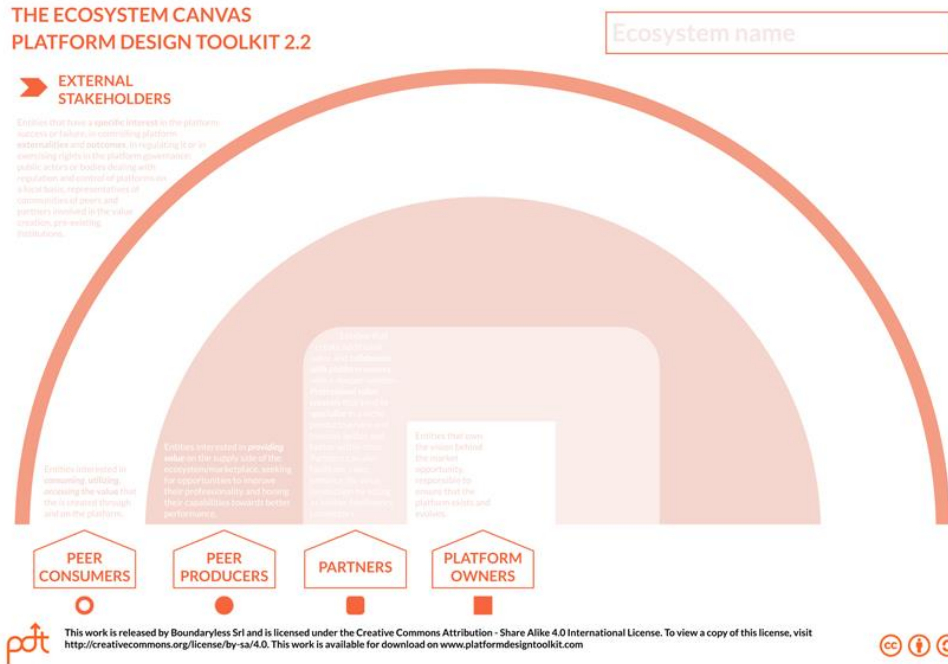


Figure 5. Ecosystem canvas (Cicero 2019)

Motivation Matrix (Figure 6.) assists in mapping the current and future value exchanges that could happen between entities. After completing motivation matrix there should be clear understanding which relationships are the strongest. (Cicero 2019)

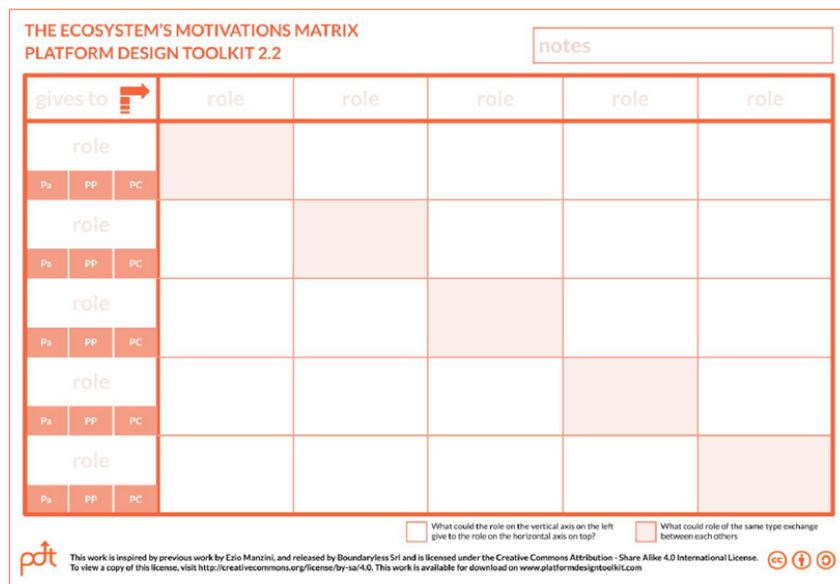


Figure 6. Motivations Matrix (Cicero 2019)

4 BLOCKCHAIN TECHNOLOGY

In this chapter blockchain technology and its technological aspects are defined and as well as pros and cons of the technology are evaluated. We will begin by giving a general overview of the blockchain and its applicability. In the following parts of this chapter we will present components possible architectures that the technology consists of. This all need to be understood before proceeding into empirical part. Last part will also discuss the current applications of blockchain technology in the energy sector.

4.1 Principles of blockchain technology

Blockchain technology is a completely distributed system for cryptographically archiving a consistent, immutable and linear event log of transactions between actors in the same network (Risus and Sphorer 2017). The technology itself was derived from the well-known and widely used digital currency Bitcoin, that is based on it (Morabito 2017 p. 5). Bitcoin blockchain system aims to eliminate the centralized control, providing an ability of any entity to write on the blockchain and performing in the similar manner such as network system of computer-generated databases (Morabito 2017 p. 7).

Iansiti and Lakhani (2017) lists distributed database, peer-to-peer transmission, transparency, irreversibility of records and computational logic as five core principles of blockchain technology. **Distributed database** means that no single entity is controlling the data on the blockchain but instead each participant of the network has access to whole blockchain database and its full history. Verification the records of transactions doesn't require trusted third party. **Peer-to-peer transmission** means that communication happens directly between peers without the central node. **Transparency** means that all actions and values related to nodes of the network are visible to anyone who has access to the network. Each node, or participant is signed digitally by a specific 30-character alphanumeric address that identifies it. **Irreversibility** means that transaction can't be altered after it has been entered in the database, since this transaction is linked to each transaction that occurred earlier. **Computational logic**

stands for the fact that all the transactions on blockchain can be programmed, network participants can create rules and algorithms that trigger transactions automatically between participants. (Iansiti and Lakhani 2017)

According to a more simplified definition of Lewis (2015) blockchain is a data coupled together in a logical order creating a data structure. Table 7. demonstrates a brief comparison of Bitcoin approach and mainstream methods adapted from Lewis (2015).

Table 7. Comparison of Bitcoin approach and mainstream approach adapted from Lewis (2015)

Category	Mainstream methods	Bitcoin's approach
Consensus mechanism	Trusted or super node (No need for a trusted networks)	Longest chain rule
Upgrade mechanism	Centralized upgrade, contractual obligations	The rules change via; BIPs (for writing the rules) Vote by hashing power (for the implementation of the rules)
Data storage	A database	Data should be stored via the blockchain technology
Data distribution	Hierarchical, Client-server	The distribution of new data should be in a peer-to-peer format
Criteria for participation	Trusted, pre-vetted participants	Transaction submission, reading and authentication are anonymous and open
Defence mechanism	Not needed in trusted networks	Proof-of-work
Incentivisation	Contractual obligations or 3rd party funding	Bitcoin block mining reward

4.1.1 Blockchain typology

Contemporary blockchain systems are split into three variations: public (permissionless), private (permissioned) and consortium (hybrid) blockchains (Buterin 2015). Table 8. represents the comparison between the characteristics of public, private and consortium blockchains.

Table 8. Comparison between the characteristics of public, private and consortium blockchains. (Zheng et al. 2017)

Characteristics	Public	Private	Consortium
Consensus	All miners	One organization	Selected set of nodes
Consensus process	Permissionless	Permissioned	Permissioned
Read permission	Public	Can be restricted	Can be restricted
Immutability	Nearly impossible to tamper	Could be tampered	Could be tampered
Efficiency	Low	High	High
Centralized	No	Yes	Partially

Public decentralized blockchain are the ones that are available for everyone who has access to the internet (Pilkington 2015). Public blockchains don't have central authority and they frequently use consensus method that requires a lot of effort to foreclose harmful users from hacking the system. Most often they utilize proof-of-work (PoW) or proof-of-stake (PoS) consensus mechanisms to validate transactions (Swanson 2015).

Private blockchains face criticism because the ledger of is not public and everyone cannot read and write on it. Companies that want to work together although don't trust

each other completely can establish a permissioned blockchain and invite their counterparts to record their transactions on a shared distributed ledger. In case of private blockchain participants that are establishing it decide themselves what type of consensus mechanism is going to be utilized and what is the level of trust. (Yaga et al. 2018)

Consortium (hybrid) blockchains fall somewhere in between public and private blockchains. It is a situation where a group of companies are consensus and decision making is evenly distributed among them. Problem often lies exactly in governance, if it gets neglected the consortium chain becomes a private chain. This can be avoided if from the start companies set standards for communication and execute them on the blockchain. (Mueller 2018)

As an example, let's assume that there are 20 companies in the consortium. These companies are free to agree using the smart contracts as long as minimum 15 companies agree on verification or something need to be added to blockchain (Ray 2018). According Virmani (2018) current consortium blockchains are mainly related to payment networks (Ripple, Corda, BankChain, FISCO), shipping (Global Shipping Business Network).

4.1.2 Cryptographic hash functions

Blockchain systems rely widely on cryptographic hashes, which are an output of transformed from the original information (Pilkington 2016). Cryptographic hash function is an algorithm that maps data of arbitrary size to a bit string of a fixed size and is designed to be an infeasible to revert (Halewi and Krawczyk 2006).

There are three properties that cryptographic hash function fulfills: preimage resistance (its computationally hard to reverse a hash function), second pre-image resistance (its computationally hard to find a different input with the same hash) and collision

resistance (its computationally hard to find two different inputs of any length that result in the same hash) (Rjaško 2008).

Public key cryptography that was invented as early as 1970s has a foundational role in information security. In bitcoin payment system public key cryptography is utilized to create pair of public and private key. The private key is a randomly picked number using elliptic curve multiplication to generate a public key. Afterwards, one-way cryptographic hash function is applied to generate a bitcoin address. (Antonopoulos 2017 p. 57)

Figure 7. demonstrates how hashing function is applied for generating the bitcoin address using private key.

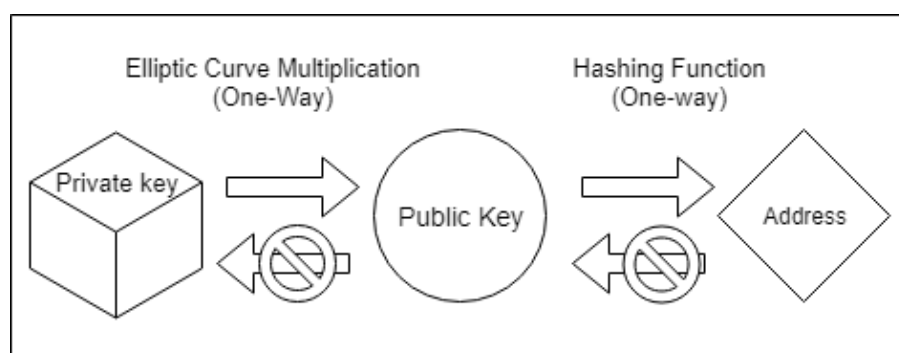


Figure 7. Private key, public key and bitcoin address (Antonopoulos 2017 p. 58)

The one who has control over a private key has access to the all bitcoins that are in that address. For the sake of safety private key must remain secret, backed up and protected from potential loss. In the case that it gets lost it cannot be recovered. (Antonopoulos 2017)

4.2 Consensus Mechanisms

The role of consensus mechanism (protocol) in a blockchain network is that all nodes in the network approve upon a coherent state of the blockchain (Baliga 2017). In case that individual copies of blockchain deviate, blockchain forking will happen and some nodes that have different view and won't be able to maintain the unique authoritative chronology. (Greenspan 2015; Christidis and Devetsikiotis 2017). It is a big challenge to

achieve consensus in a distributed system, because consensus algorithms must be resilient to failures of nodes, message delays, messages reaching out-of-order and corrupted messages (Baliga 2017).

Fischer et al. (1985) introduced FLP impossibility concept stating that asynchronous fault tolerant systems can't simultaneously satisfy three properties: liveness, safety and fault tolerance. In a blockchain system where our aim is consensus a liveness is represented as a property guaranteeing that each node will eventually decide on a value (Tran 2017). Safety property on the other hand is guaranteeing that different components will never decide on different values (Tran 2017). Fault-tolerance property represents the recovery from situation where the malicious node that participated in consensus (Baliga 2017).

There are mainly two types of faults that occur in distributed systems: Fail-stop faults and Byzantine faults. Fail stop fault occurs most often due to software or hardware crashes which makes nodes to discontinue engaging in the consensus. Byzantine faults occur when a node is being altered by someone or there are some issues in the software. (Baliga 2017)

Byzantine's fault stems from The Byzantine Generals' Problem (BGP), described by Lamport et al. (1982). Assuming that there are four generals each leading own troop surrounding a walled city. In order to capture the city, they all need to attack at the same time. If one or more generals decide to retreat their troops, the city will be able to fight off the attack. Generals are able to communicate only through messengers and there is a risk that they are corrupt, or they lie. Generals can lie as well if they want to make their own troop stronger by letting others attack and get killed. (Lamport et al. 1982)

4.2.1 Proof-of-Work (PoW)

Vast majority of the blockchains are based on Proof-of-Work (PoW) consensus mechanisms and it was first introduced in Bitcoin whitepaper (Gervais et al. 2016) and

in simple terms it is a proof of that a scarce resource was consumed (Poelstra 2015). PoW works the way that complex computational process authenticates the blocks. In the Proof-of-Work consensus mechanism miners compete for the block reward by trying to guess nonce (number only used once) value in the block till the moment that value is found and gives the block's hash the requisite zero bits. Predominant amount of decisions is described by the longest chain, because it has most computational effort put in it. To make a modification in one block the chain the attacker would have to redo all the blocks plus catch up and surpass the PoW-process of honest miners. (Nakamoto 2008) Aforementioned situation is called Majority attack where one entity is controlling the majority (minimum 51%) of hashing power (Binance 2018). Security of the PoW lays in principle that no counterpart should input more than 50% of the processing power, because in such situation could control the whole blockchain (Gervais et al. 2016). The more nodes there are mining the bitcoin the more secure it becomes as there is more miners (Binance 2018)

Calculating hashes using Proof-of-Work consensus mechanism requires a lot of energy and thus is a rather unecological process (Tschorsch and Schauer, 2016). However, it also works as an important element for incentivization which is according Nakamoto (2008) similar to gold mining that devote resources and energy to bring new gold to circulation. De Vries (2018) estimates that Bitcoin mining equipment consumes 8.92 Gigawatts of electricity for both the mining process and cooling and the consumption is expected to rise even further.

4.2.2 Proof-of-Stake (PoS)

Because of the energy issues of the PoW consensus mechanism, the most often discussed replacement for would be Proof-of-Stake (PoS) consensus mechanism. In PoS, Stake is a security deposit that Proof-of-Stake miners must put in before the consensus mechanism allows them to propose and validate blocks (Martinez 2018). The earliest versions of PoS consensus mechanism didn't require security deposit (Martinez 2018). Alternatively, to PoW it offers randomly selected stakeholder right to

update the blockchain and therefore creates an incentive for stakeholders to participate in computational arms race. The validators receive a monetary reward, but it doesn't require explicit cost from stakeholders to receive the right for validating the blocks. (Saleh 2018)

However, Proof-of-Stake consensus mechanism meets a Nothing at Stake problem which is an assumption that because it is computationally cheap to validate any block the miners will validate multiple forks. This way the network becomes more vulnerable to double-spend attacks. The Nothing at Stake problem is built on assumptions that there are zero miners wanting to mine only one chain at a time; Miners seek to profit anytime there is an opportunity, neglecting the security of the network; Miners are using a modified software that brings the ability to mine several forks at a time. (Martinez 2018)

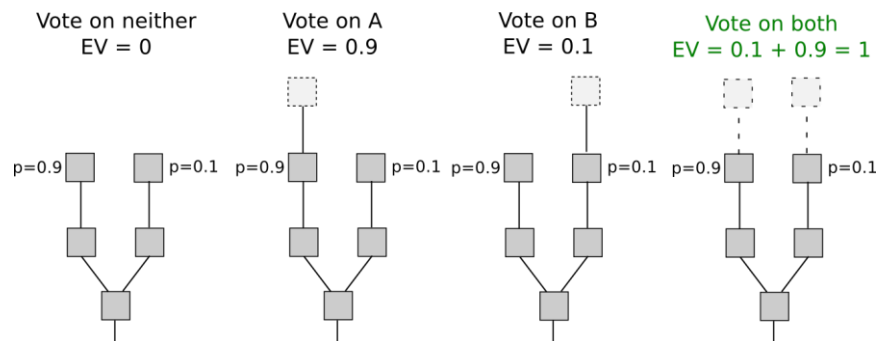


Figure 8. Nothing at Stake problem (Buterin 2016)

Ethereum blockchain introduced approach for solving Nothing at Stake problem (Figure 8.) by penalizing the miners that create blocks on multiple chains (Buterin 2016).

4.2.3 Proof-of-Authority (PoA)

Proof-of-Authority consensus algorithm relies on trusted nodes which are recognized as authorities (De Angelis et al. 2018). These authorities have unique id and more than half are assumed to be honest. Consensus of transactions is reached by mining rotation schema, approach that is utilized to split fairly the responsibility of block creation

between authorities (Gaetani et al. 2017; De Angelis et al. 2018). In comparison to PoW it doesn't require a lot of computational power, has high throughput of transactions as well as can be applied for both public and private blockchain networks (Walter 2018).

4.2.4 Proof-of-Activity (POA)

Proof-of-Activity is a hybrid consensus mechanism that combines Proof-of-Work and Proof-of-Stake consensus mechanisms into single process. The role of miners is to race for guessing the nonce and finding the block in order to gain the monetary reward, the more computational power a single miner has the bigger chances there are for finding a block. In comparison to PoW mining, blocks don't contain transactions. PoS takes the leading role after by validating the transactions using signatures. (Dhariwal 2018) This way Proof-of-Activity creates two-layer security on the network because attacker need to have both 51% of mining power in the network and 51% of coins staked in the network which would be a very costly operation (Dean et al. 2018).

4.3 Smart contracts

As mentioned in Swan (2015) categorization of blockchain development stages, smart contracts bring more functionality beyond the currency. Szabo (1997) was the first to introduce the "smart contract" concept which according to his definition combination of protocols and user interfaces to validate and secure relationships via computer networks. Thus, when concept is applied the transaction fees get radically lower in comparison with traditional process requiring a trusted third party (Alharby and van Moorsel 2017). However, back in 1990s technological level was not advanced enough to create smart contracts.

Essentially, smart contracts are quotable and modular pieces of code that runs on blockchain demonstrating unilateral promises in order to create a determined

computation. Code pieces are kept on a blockchain in certain address and this address is determined when smart contracts get assigned on the blockchain. As the event that was described in the contract takes place, a transaction is executed. (Tuesta et al. 2015) Once the smart contract is deployed and registered on the blockchain it is immutable, unstoppable and incontrovertible (Wall 2016). Verification of smart contracts happens in the similar way as in Bitcoin network, so every node participates in the verification process (Wall 2016). Smart contracts be made even more complex by adding sub-contracts or storage to them (Anderson et al. 2016). Therefore, it's important for smart contract code to proclaim what will happen with contract in difference occasions of its lifetime (Wall 2016). The Figure 9. shows how decentralized cryptocurrency system based on the smart contract works in practice.

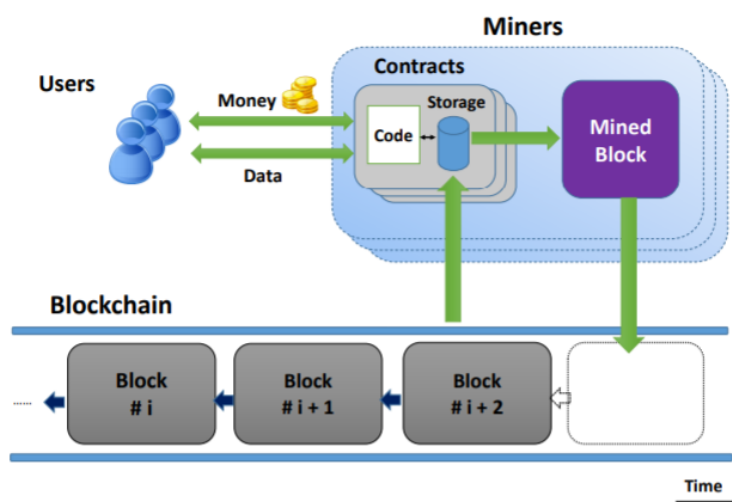


Figure 9. Decentralized cryptocurrency system with smart contracts (Delmolino et al. 2015)

There are a variety of blockchain platforms that can be used for smart contract development, but Ethereum he most commonly used (Alharby and van Moorsel 2017). Buterin (2014) is the creator of Ethereum and he released the original whitepaper explaining the solution. Ethereum platform incorporates Turing complete programming language and decentralized computer named Ethereum Virtual Machine (EVM). Solidity, Serpent and LLL are languages that can be used for scripting Ethereum smart contracts (Buterin 2014). The popularity of the Ethereum platform can be explained by

Turing-completeness of the programming language, which enables its users to create more complex and tailored contracts (Alharby and van Moorsel 2017).

4.4 Evolution of blockchain technology

No matter the young age of blockchain technology, there is already some evolution happening. Apart from the use case of Bitcoin cryptocurrency contemporary blockchain technology can also guarantee that transactions conform with programmable rules by utilizing smart contracts (Risus and Spohrer 2017; Tschorch and Scheuermann 2016). According Swan (2015) contemporary technological advancements in blockchain technology are categorized into blockchain 1.0 (cryptocurrency), blockchain 2.0 (smart contracts) and blockchain 3.0 (applications) demonstrated in Table 9.

Table 9. Evolution of blockchain technology

Type	Description	Introduced	Examples
Blockchain 1.0	Currency	2009 Bitcoin	Bitcoin and other cryptocurrencies.
Blockchain 2.0	Contracts	2013 NXT platform	Financial services, Smart Contracts, Smart Property, Crowdfunding
Blockchain 3.0	Justice, efficiency, applications beyond currency, economics and markets	2015 approximately	Digital Identity, Governance Services, Elections, Intellectual Property Protection

4.5 Blockchain as a decentralized platform

Blockchain platform term was first introduced by Mougayar (2016) who defined it as underlying two-layer system of applications and services. Glaser (2017) on the other hand sees blockchain platform as distributed database, where nodes are connected

through peer-to-peer network enabling the transactions between them and permission mechanism is utilized to provide a network access and execute transactions which are validated by consensus mechanism. Mattila (2016) defines blockchain platforms as digital platforms of distributed trust that enable censorship resistance, robust security and disintermediation - making it possible for entities to transact valuable assets directly. Mattila et al. (2016) sees blockchain technology as enabler of cross-industry collaboration on a wider range than ever before, which has potential to scale two-sided market into multi-sided market and significantly grow network effects (Figure 10.). In line the platform control becomes decentralized, which exempts entities that collaborate from attempts to dominate the platform governance (Mattila et al. 2016).

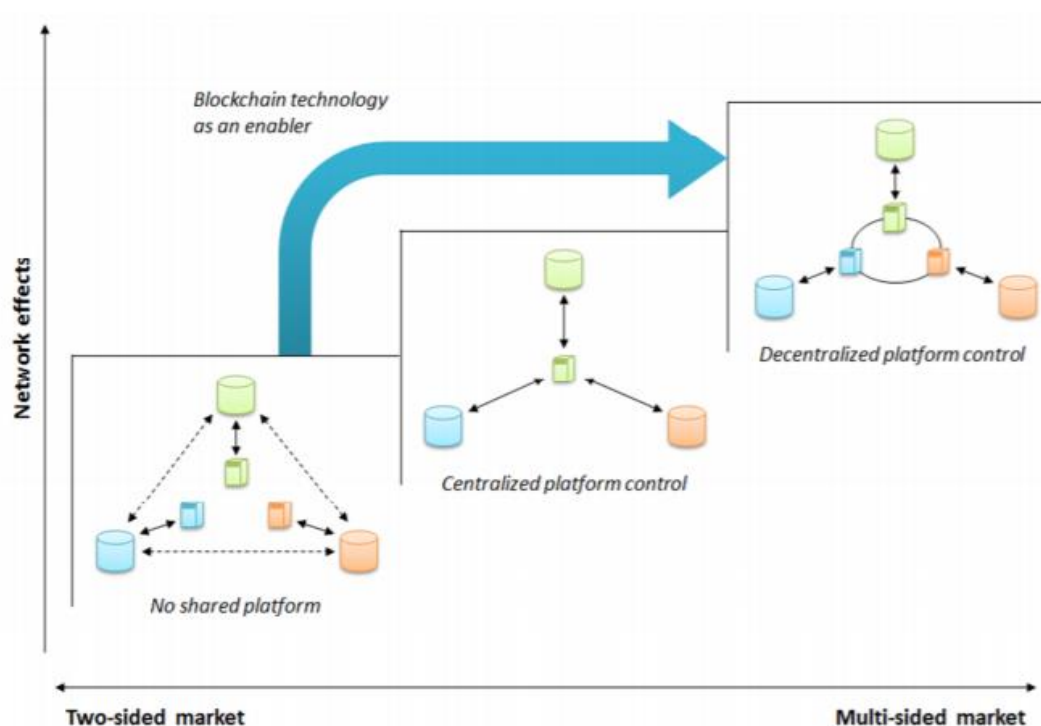


Figure 10. Blockchain technology as an enabler in the markets for durable and capital goods (Mattila et al. 2016)

Decentralized platform requires completely distributed technology stack that is built on the blockchain technology and thus would exclude the need for central authority (Mattila et al. 2016). Decentralized platform based on public distributed ledger enable

decentralized markets that bring a lot of efficiency and flexibility in comparison with existing centralized solutions (Evans 2014).

Blockchain systems can be explored abstractly from fabric layer and decentralized layer perspective (Glaser 2017). While fabric layer is configured from database management, consensus and P2P communication; application layer consists of services and features executed with smart contracts that rely on functionalities of fabric layer. Glaser et al. (2019) stated that blockchain can be seen as a potential infrastructure for new business models in contemporary platform economy, with examples of P2P sharing, autonomous asset registry or crowdfunding. Major difference in the public blockchain platform in comparison to present digital platforms is that blockchains main functions are developed and operated by a group of self-coordinated open-source developers and transaction validators (Glaser et al. 2019).

4.6 The Scalability Trilemma

Because the implementation of the blockchain in the early phase, naturally it faces challenges. Buterin (2016) introduced The Scalability Trilemma (Blockchain Trilemma) based on the Mundell-Fleming framework of impossible trinity referring to tradeoff that has to be made when deciding on how to structure an architecture of the blockchain. The Scalability Trilemma including following elements: decentralization, security and scalability.

1. **Decentralization** relates to distribution of ownership, influence and value in the blockchain. This element has also an ideological perspective of giving power back to the community. (Viswanathan and Shah 2018)
2. **Security** represents the how strongly can blockchain defend itself against the internal or external attacks. Decentralization and security are corresponding elements, because the more nodes there are in the network the less risk is for having a central point of failure. (Viswanathan and Shah 2018)

3. **Scalability** is considered as the most important of the three, because it sets the limits for the size of the network. Speed and volume of transactions play a major role in scalability (Viswanathan and Shah 2018)

The topic has been discussed by Abadi and Brunnermeier (2018) introduced their three elements: Cost efficiency, Correctness, Decentralization; which cannot be satisfied simultaneously. This master's thesis will focus on the Scalability Trilemma introduced by (Buterin 2016).

5 ELECTRICITY POWER SYSTEM

Main role of electricity system is to transmit and distribute power from the source of power (most often power plants) to consumers. At the current state electricity systems have rather hierarchical design including transmission grid, sub-transmission grid and distribution grid. Power plants connect are connected to transmission grid which is designed to transmit large volume of energy through long range distances. The role of sub-transmission is to transmit energy from high to low voltage, acting as a mediator between transmission grid and distribution grid. Distribution grid is the last counterpart of the electricity system, before the customer gets the electricity. Distribution grid delivers energy in high voltage to industrial customers and low voltage to residential customers.

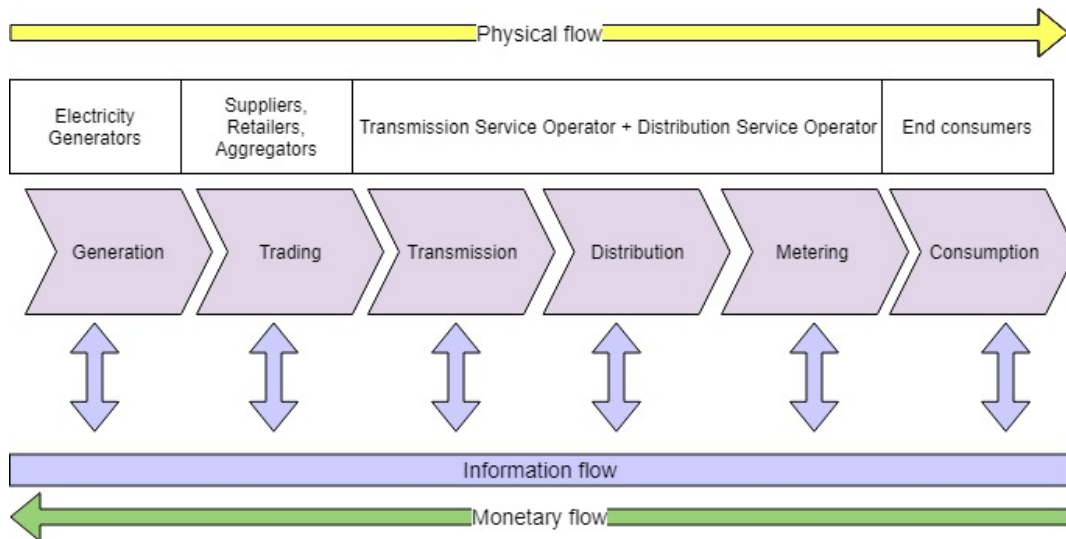


Figure 11. Traditional electricity power system, adopted from (Fens 2005)

Traditionally electricity system incorporates six actions related to electricity: generation, trading, transmission, distribution, metering and consumption. There are three key flow exchanges in the system: physical flow of electricity, information flow and monetary flow. Supply of electricity to consumers comes by the means of two counterparties Transmission System Operator (TSO) and Distribution System Operator (DSO). TSOs and DSOs have their businesses strictly regulated, because they are operating as a natural monopoly. In contrast, in 1990s both energy trading and generation were

opened for competition in Europe. Electricity Generators add power to the grid mainly via power plant and increasingly on a smaller scale on distribution level. Transmission Service Operator always ensures the stability and supply of the grid . Distribution System Operator on forwards electricity from the transmission grid to the end customers, while operation on the regional grid level. DSO and TSO are responsible for metering entire energy production and consumption of all entities linked to their grid.

5.1 Distribution System Operator (DSO) in Finland

Because the cost-efficiency and avoiding complexity electricity networks are natural monopolies. Electricity distribution networks are also seen as enablers of the marketplace and DSO have an important role in keeping the market up and running. DSOs are responsible for developing electricity network and tying contracts with the customers. The distribution networks have to be supervised 24/7 for power outages to ensure the safety of the customers. Metering the energy consumption and gathering the data to forward it to electricity suppliers is one of the major duties of DSO as well. (Annala and Viljanen 2009)

Distribution network activities can be divided in network ownership, network operation and ancillary services (Lakervi and Partanen 2008). Asset owner monitors the return on investment, especially asset return, while asset manager takes care of network operation, nurtures customer relationships. Outsourcing business functions and establishing partnerships with external stakeholders is a growing in electricity distribution networks business. Hence, aforementioned outsourcing trend is helping distribution network operators to simplify their business and focus on their main tasks such as monitoring and taking care of their grid. (Lakervi and Partanen 2008)

In the upcoming years DSOs will have an even bigger role in electricity market by empowering marketplace for electricity and adding demand response services. At the current state of Finland has 77 Distribution System Operators and the country has nearly 100 % coverage in Smart Metering. Finnish electricity distribution networks are

robust and due to that no restrictions need to be implemented in the market and the growing adoption of EVs and renewable energy sources won't create bottlenecks. (Lehto 2018)

Growing adoption of DERs (Distributed Energy Resources) and EVs (Electrical Vehicles) will lead the path to meeting this goal. As regulation and technological development related to EVs will get to more mature phase we could see millions of EVs in daily use which to some distinct could also be utilized as short-term energy storages. Particularly for DSOs flexibility would guarantee stronger ties to the customer, providing good economic value and improved interplay with local flexibility resources. This would necessitate regulatory frameworks due to modifications in business structures and pricing. (Colle et al. 2018)

The energy industry is aware that a single the winning structure for future DSO doesn't exist due to differences in regulatory frameworks and dynamics across the EU region.

5.2 Blockchain-enabled opportunities for energy sector

According recent Infoholic Research (2019) blockchain report forecast blockchain energy utilities market is expected to reach 3 trillion dollars by 2024. According the report blockchain technology supports grid management, energy trading, payment solutions, supply chain and others. When searching for a solution to achieve better reliability, efficiency and flexibility - blockchain technology is an answer to that.

Blockchain has potential throughout the whole electricity power system and variety of operations as well as completely new business models. According Andoni et al. (2019) it is extremely hard to shift the whole current structure of the energy market into decentralized in a limited period of time, therefore the companies studying blockchain technology have rather focused on a single part of the energy market at the time. Andoni

et al. (2019) studied 140 blockchain innovation projects and research initiatives in energy sector and clustered them into 8 clusters:

- metering, billing and security
- decentralized energy trading
- grid management
- green certificates and carbon trading
- IoT, smart devices, automation and asset management
- electric e-mobility
- general purpose initiatives and consortia
- cryptocurrencies, tokens and investments

Aside from the novel business models blockchain technology could also be applied in the selection of business processes of utility companies. The use cases that (Andoni et al. 2019) spotted were related to billing, sales and marketing, trading and markets, automation, smart grid applications and data transfer, grid management, security and identity management, sharing of resources, competition, transparency.

Burger et al. (2016) conducted a study among German energy sector executives, and wide range of potential application for blockchain technology were recognized. In the study executives agreed that the technology has potential for enabling novel business models via platforms and optimize processes. However, at the current situation where blockchain is in development phase, competitive advantage is yet relatively small. Thus desirability of blockchain technology is based on improved efficiency of a single transaction, volume of performed transactions and customer adoption. Henderson et al. (2018) pointed out that some of the business models might even become obsolete or radically change.

Mylrea et al. (2017) listed exhaustive list of benefits that blockchain technology brings to energy companies which are mainly related to efficiency, cost reduction and improved security.

- Provides increased trustworthiness and protects data integrity

- Securing integrity of data
- Removes intermediaries and thus trims cost of energy exchange
- Supports multifactor verification through distributed ledger
- Smart contracts can facilitate the exchange of surplus generation from DERs and EVs on consumer level.
- Unlocks quick detection of data anomalies thus better resilience to cyber attacks
- Helps to bring down transaction costs in energy sector
- DSOs can receive more accurate transaction data that is needed for charging the network costs
- TSOs can lessen their data constraints and requirements which are now used for clearing purposes.

Out of clusters Andoni et al. (2019) proposed, we picked the blockchain innovation projects that relates to business of Distribution Service Operator the most.

5.3.1 Peer-to-Peer (P2P) energy trade

According Zhang et al. (2018) underlying business layer in energy trading defines how electricity is traded between peers and third parties. This business layer includes peers, suppliers, distribution system operators and energy market regulators. Therefore, broad spectre of business models could be developed while enabling P2P trading. (Zhang et al. 2018)

As Peer-to-peer electricity trade sets direct connection between prosumers and customers, there is no need for power aggregator (Zhang et al. 2018). Thus, this could serve customers via savings and incentivize producers and prosumers with revenue, as well as reduce electricity distribution losses (Wang et al. 2015). According Long et al. (2018) in the distributed energy market there will be a strong variation of price requiring constant settlement of electricity fees - therefore resilient, secure and streamlined system

for information and value exchange need to be established. Noor et al. (2018) points out that energy storage plays an important role in the peer-to-peer energy trading.

Since blockchain enables automated smart contract in P2P (peer-to-peer) networks, it has been recognized as an enabler for P2P energy trading. There is a need for blockchain in the microgrid level P2P energy trade, since it is important preclude market from double spending and simultaneously enabling self-balancing capability. Blockchain based microgrid can foster P2P energy trade between all the market actors. As the physical structure of the grid is owned by the Distribution System Operator, the distribution fees must be paid. In the blockchain based microgrid distribution fees can be charged from each transaction through smart contracts. (Özlem 2018)

The Brooklyn Microgrid pilot project was among the first to succeed in realization of blockchain-based P2P electricity transaction. In the scientific research Mihaylov et al. (2014) were among the first to study the use of cryptocurrencies in peer-to-peer energy trading. In the solution Mihaylov et al. (2014) proposed energy that is infused into grid by prosumers is transformed into cryptocurrency coins, whose rates are dependent on the supply and demand conditions during the time of infusion.

5.3.2 Billing, metering and security

There have been few studies related to use of blockchain technology in smart metering and processes related to billing. Even though smart meters smart meter might show the production of certain entity, it is still complicated to prove that the smart meter itself hasn't been altered physically. Blockchain technology can enable a automating billing in energy services for consumers, proposing a cost cuts to administrative tasks. The traceability of energy production and consumption throughout the process may bring enhanced transparency to the billing. Also, as in the billing process the customer related data is being used, blockchain could play an important role in safeguarding it from cyberthreats. (Andoni et al. 2019)

Among the earliest use cases in billing was acceptance of cryptocurrency for electricity payments were recognized in the Netherlands and Japan, where customers would benefit from reduced bill when paying with cryptocurrencies (Andoni et al. 2019). In South Africa, Bankymoon startup linked smart meters with unique bitcoin addresses and as smart meter gets a payment, the system computes the tariff and tops up the meter for the user (Njeri 2017). Solution helps the unbanked to avoid hefty transaction fees paid to banks when using the traditional payment method for electricity. Pylon Network (2017) is working on a neutral data hub that is based on blockchain technology where both consumption and production data of energy market users is stored. This way the consumer is in the control of the data and thus can share it with third parties that provide personalized ancillary services for saving on the electricity bill. Pylon also created a blockchain integrated smart meter that can automatically track produced and consumed energy.

In addition to electricity, some companies are exploring blockchain technology for other metering solutions. As an example, CGI and Enerco ran a pilot project for exploring blockchain technology in meter data collection and billing. The solution has removed the need to cross validation as data stored in the blockchain was set to be accessible for selection of parties. As a result, up to 50% savings on administrative costs might be achieved with the implementation. (Andoni et al. 2019)

There have been several studies on how blockchain might enhance the security of the processes related to electricity distribution. If the smart grid is attacked by the hackers, the significant damage can be caused by power outages. For example, there are complications with prediction of electricity use, and prepayment scheme is often based on a centralized server, thus being vulnerable to data breaches. Electricity meter has a key role in measuring electricity consumption for each user to be shown to the supplier (Aiman et al. 2018).

For energy sector blockchain technology offers novel way to distribute trust which has evident value proposition in cybersecurity. According Mylrea et al. (2017) there are two main challenges that endanger security in today's electricity infrastructure - trustworthiness and integrity of the data, both of which can be solved with blockchain technology. Keyless Signature Infrastructure (KSI) introduced by Guardtime, stores only hash values on the blockchain which makes it lightweight and scalable. KSI can be run on top of current security products bringing proof of data integrity and reducing the operational cost by removing single point of trust. Guardtime tries connecting cloud solutions and distributed architecture with blockchain - which has the potential to enable near real-time energy exchange on the microgrid level (Mylrea et al. 2017).

5.3.3 Decentralized Grid Management

There are a group of companies combining automation and decentralized grid management. In research related to decentralized grid management it has been concluded that it is possible to satisfy all actors to provide necessary balancing power by means of decentralized assets in the possible less costly way than current centralized system (Lehnhoff et al. 2011; Lehnhoff 2010; Schlund and German 2019). The benefits lie in the improved balance of supply and demand, paired with better coordination between TSOs and DSOs, automatically verified grid assets and enhanced visibility of DERs (Andoni et al. 2019). With the assumption that blockchain technology will be able to scale up the number transactions without compromising on security and speed, it would simplify the network operation. DSOs or TSOs could be operating own private blockchain to which all devices are connected, thus unlocking the transaction tracking and efficient intervening (IRENA 2019). Belgian TSO Elia is running a pilot project on blockchain technology aiming to optimize processes related to demand response such as financial settlement, registering, measuring and confirmation (Bronski 2018)

One of the profound initiatives is Gridchain presented by PONTON, where group of Austrian DSOs explored a blockchain for integration of processes like requesting balancing power and congestion management. As a result of the pilot project balance

settlement time shortened significantly. Company points out the fragmentation of generation assets and acceleration of the process will need an enhanced communication to ensure reliable and secure exchange (PONTON 2019).

5.3.4 Wholesale energy trading

Blockchain has a potential to make wholesale trading more autonomous. At the current state wholesale energy markets include hard processes which need trusted third parties such as exchanges, brokers, price reporters, banks and regulators. There is still manual work being done in the process, transactions need to be verified many times and aligned many times throughout the process. Slow transaction speed lead to too much friction that makes it too expensive for small-scale producers to participate in the wholesale market. Blockchain and smart contracts unlock the possibility for any electricity producer to trade with end customer or energy supplier through autonomous trading agent that searches for the best option in the marketplace. Agreement is registered on the blockchain and self-executed when delivery occurs. In parallel payment is executed automatically at the time that is specified in the contract. (Grewal-Carr and Marshall 2016; Andoni et al. 2019)

There has been pilot projects related to the wholesale energy marketplaces. The 12-week trial for gas trading on blockchain ran by Wien Energie in partnership with BTL showed that blockchain can bring clear benefits to trading through automation, confirmation, invoice generation, audit, reporting and compliance with regulation. Another notable wholesale energy trade project Enerchain was launched in May 2019 by PONTON, which enables decentralised energy trading where prosumers, consumers and suppliers can directly trade regionally or cross regionally (Enerchain 2019).

5.3.5 Imbalance settlement and demand response

Similarly, to wholesale energy market, imbalance settlement in the power markets has room for improvement due to operational inefficiencies. Blockchain gives a multitude of opportunities for balance responsible parties to eliminate divergence from notified trade schedules and convert this deviance into profit and keep commitment in such conditions above control (Gladikov 2019).

In the imbalance settlement, blockchain enabled smart contracts can unlock possibility of tracking which producer or consumer created the imbalance and do a real-time billing (Andoni et al. 2019). Main benefits come from improving efficiency by reducing back office processes and improved payment flow for provided services (Dütsch and Steinecke 2017).

As integration of renewable energy brought uncertainty because of its unpredictability, either surplus or deficit of electricity is a threat for energy supply, which may lead to energy components congestion and peaking with outages or service disturbance. Best approach to this problem by demand side management with incentivization of distributed energy producers to deal with peak load periods. In demand response related challenges, the benefits of implementing blockchain technology lies in distributed management of energy demand, almost real-time automated demand response event programs, almost near real-time financial settlement, secure transactions of energy. From DSO perspective unlocks balancing without centralized control and supervision. (Pop et al. 2018)

5.3.6 Cryptocurrencies, tokens and investment

Cryptocurrencies and tokens are maybe one of the most well-known applications for blockchain technology. Cryptocurrencies can be used as a reward system or for tokenization of assets that would enable better shared ownership of the assets as it can be split in thousands or millions of pieces. Tokenization can be digital representation of a

physical or non-physical asset or commodity. Reward system can be used to incentivize certain behavior or foster green energy adoption. (Andoni et al. 2019)

WePower ran a successful pilot project with Estonia's TSO Elering for tokenization of energy production and consumption data. As a result of project 26 000 hours of data were turned into 39 billion smart energy tokens on the Ethereum blockchain (Martyniuk 2018). Tokenization enhances liquidity in energy trading and allows energy producers sell directly to consumers. Another use of tokenization has been introduced by Sun Exchange, a blockchain startup located in South Africa. Sun Exchange is a platform that enables crowd ownership of the solar panels which also yields dividends in bitcoin for the investors for 20 years. In the solution blockchain automatically tracking the ownership and revenue streams thus creating the transparency which is required by the regulators. (Sun Exchange 2019)

Even though there are lots of use cases that can be solved with cryptocurrency, it is still challenging to build a system that will keep the value in the long term. This is still due to rather high volatility of the cryptocurrencies.

5.3.7 Carbon credits

Kruger et al. (2007) pointed out that carbon emission trading in the future should concentrate around simplicity, cost effectiveness, fairness and obedience. The current market structure of the carbon credits and renewable energy certificates are quite scattered and complex which according Kempener et al. (2009) discourages individuals from engaging in trading process. Thus, especially small-scale energy production is excluded from obtaining carbon credits, because of the high costs related to this procedure. The current auditing process related to is conducted by central authority, so naturally there might be a risk for fraud or errors (Andoni et al. 2019).

Carbon credits and green certificates are quite illiquid have high transaction costs in the current market. Therefore, blockchain based products such as C6 were introduced. C6 enables owners of solar or wind farm to sell renewable energy credits rapidly with low transactions and petrochemical plants can buy them at the most suitable price. The system works by linking the platform to smart meters, this way the system autonomously finds a buyer and send you the funds. (Power Ledger 2019)

Chinese Energy-Blockchain Lab teamed up with IBM to build a platform for managing carbon credits on blockchain, with the aim of reducing expenses related to trading by 30 percent. (Göß 2017) The issues with blockchain based system are related to certification and verification of the services.

5.3.8 Supply chain management and procurement

Distribution System Operators have tight requirements for upgrading the grid so that it delivers electricity stably. In addition, this grid needs to be constantly serviced and maintained. Therefore, DSOs have to deal with suppliers delivering the components and materials as well as contractors that do the work. Blockchain has potential drastically streamline the integration and automation of various procurement processes (Forger 2018). As the procurement process involves many stakeholders there is true benefit from transparent blockchain based solution, where supplier portfolio management and administration as well as complaints management can be done more effectively (Nicoletti 2018).

Shared and transparent view removes the need for manual transfer of information between partners via files, spreadsheets, emails and phone calls. As an example, blockchain can be utilized for selection of steps: quality certificates of supplier, proof of ownership, supplier quotes, purchase orders and contracts. Resolving contradictions between organization are thus much quicker and providing proof of sustainably sourced material can be easier. (Nicoletti 2018)

Nicoletti (2018) emphasizes that blockchain technology is relevant for the entire process of procurement. Starting from the tendering process where blockchain can be used for identity verification of the supplier or restriction of the risk related to purchasing from that supplier. All the information received from suppliers can be stored on a blockchain where it will be immutable, helping to handle suppliers' complaints. When managing the inventory, it is crucial to ascertain the accuracy of the inventory, thus products can be registered on the blockchain with a unique ID. Blockchain has potential to disrupt trade finance with tracking and processing speedy transactions with no paperwork involved. As procurement seldomly involves cross-border payments, application of blockchain would simplify the commercial transactions between parties, which would especially benefit SMEs. (Nicoletti 2018)

6 RESEARCH METHOD

In the next chapter the research method used in this master thesis will be elaborated, starting with the research design, adhered by the research process and ended with the description of validity, reliability and generalizability of the study. Research design part delineate the aware choices which set the basis of how the study is led. In the research process the real execution of the thesis is described. The literature study and the interview process are explained in detail, proceeded by the research analysis, further clarifying how the collected data is analyzed. The chapter concludes with a brief evaluation of the validity, reliability and generalizability of the study.

6.1 Research paradigm

When shaping the research design, it is crucial to decide what paradigm the study will be taking. According Schwandt (2001, p. 183-4) definition “paradigm is a shared world view that represents the beliefs and values in a discipline and guides how problems are solved”. Some paradigms are bound to certain methodologies, as an example positivist paradigm is often used with quantitative methodology, while constructivist paradigm is used with qualitative methodology (Chilisa and Kawulich 2012). Mackenzie and Knipe (2006) categorized 6 variations of theoretical paradigms: positivist, constructivist, interpretivist, transformative, emancipatory, critical, pragmatism and deconstructivist, postpositivist or interpretivist. This thesis follows the assumptions of interpretivism because it aims to deliver understanding of a phenomenon within a certain context.

6.2 Methodology

The research methodology used in this thesis is qualitative research, which is also commonly seen in pair with interpretivist paradigm (Chilisa and Kawulich 2012). In comparison to quantitative method it the small details and random events matter. As an example, if interview respondent brings something unexpected in the interview, this may cause a need to broaden the literature review. In this particular study blockchain applications for Distribution System Operator need an evaluation from a holistic approach, thus making the selection of qualitative research method appropriate (Creswell 2017). The important criteria for this research approach is flexibility and room for innovation.

The purpose of this master thesis is exploratory because it will study the area that hasn't antecedently been studied and aims to research uncharted dimensions of the issue. It is rather useful when the exact nature of a phenomenon is not well known, while the aim of the study is to clarify a wide understanding of it. These studies are not aiming for conclusive answers but instead be seen as preliminary research carried out for creation of the groundwork for more definitive research in the future. Exploratory studies have adaptable nature since the direction of the study can shift as new insights get discovered. The research design is thus formulated in the way that in the first phase the focus is broad but in the latter parts in gets more specific. (Dudovskiy 2018)

Because there are scarce resources about blockchain technology affecting the business models of Distribution System Operator, it is encouraging reason to adapt an exploratory approach as both study purpose and research questions can be adjusted after further findings. Occasionally, when exploratory study is carried out many alternative options for solution to a certain problem are found.

6.3 Research approach

Research approaches require reasoning which is a process of utilizing present knowledge for making predictions, outlining conclusions or developing explanations; there are three types - abductive, deductive and inductive (Butte 2010). Since qualitative research incorporates evolving questions and procedures, data is gathered in the participant setting and researcher interprets the meaning of data - the reasoning is occasionally inductive (Creswell 2017). However, for this thesis the abductive approach that combines both inductive and deductive approach is being used. Due to this pick, there is room for shifting between literature and research material studied - and therefore both will be affecting each other. We can conclude that the research approach is ideal for the grounded theory.

6.4 Data collection

What comes to qualitative case study - data can be collected in many different ways, by combining data sources and methods. It ensures that phenomenon is not examined only through a single lens but multiple lenses. These data sources could be for example interviews, documentation, direct observations, physical artefacts and participant observations. Collecting overwhelming amounts of data can however be a risk, since organizing and managing it might become too difficult. (Baxter and Jack 2008)

Interviews are optimal data collection method for this research, as they help in understanding the opinions of people on the matter and thus reply to the research questions. In this study semi-structured interviews are utilized as the main data collection method, since more broad information is possible to extract from the people who understand how current business model of DSO operates.

Essentially, interview is a discussion between two people and depending on the duration the amounts of data generated can be sizable. There are three types of interviews structured, unstructured and semi-structured. Benefits of structured interview

lies in the fact that it enables short answers, simplifying the analysis part. Structured interviews enable standardization and are particularly useful for research of bigger scale. Interviews can be defined as unstructured, if it is more like an open discussion about particular theme where researcher allows interviewees to come up with own ideas. In case of semi-structured interview, there is a clear list of questions that need to be addressed by interviewee, but placement, phrasing and structure are adjustable. (Draper and Swift 2011)

Semi-structured interview method was chosen as the most suitable, since it gives the opportunity to ask clarifying questions, which other methods don't allow. Occasionally semi-structured interviews carried out as theme interviews, meaning that researcher decided the themes beforehand for interviewee, but can also introduce new questions in the interview process (Hirsjärvi et al. 2004). In theme interviews it is possible to combine open discussion with the pre-planned research questions. However, it's crucial for the researcher to keep the discussion on the right path in case its going out of the theme.

Regarding the data collection, there were 15 case company employee interviews conducted, all of which were audio-recorded. First interviewees were picked by random and latter part on referral basis. Employees were each sent an email with the proposed meeting invitation and open-ended questions with the proposed theme for the discussion. Each of the interviews were booked for duration of one hour, but all of them lasted less than one hour. 9 interviews were conducted face-to-face at the company office premises and 5 were conducted via Skype. To relieve the tension of formality, occasionally interviewees were asked about their position and discussion was kept informal, particularly in the beginning of the interview.

Regarding benchmarking analysis, the blockchain innovation projects were collected from secondary sources such as existing research Andoni et al. (2019). Also, non-scientific literature such as Comprehensive Guide to Companies involved in Blockchain and Energy (Montemayor et al. 2017). Additionally, list of blockchain energy startups attending Event Horizon Summit was used as a reliable secondary source

(EventHorizon 2019). As not all interview themes pointed out specifically towards companies that implement blockchain in energy sector, DuckDuckGo and Google search engines were utilized to find blockchain startups that are specifically corresponding to the challenges recognized in the employee interviews. Two distinct search engines were utilized because they give different outputs for the same inputs, thus balancing the bias.

6.5 Data Analysis

The underlying basis is that the researcher should be able to understand the collected data to conduct high standard qualitative analysis. In this study thematic analysis is utilized which according Braun and Clarke (2006) is the fundamental method for qualitative analysis. Essentially thematic analysis aims to recognize all data that can be connected to the classified patterns, thus all discussions that fit under particular pattern are positioned with analogous pattern (Aronson 1992). Furthermore, in thematic analysis approach themes are also divided in the sub-themes. Leininger (1985, p.60) states that themes are found by combining elements or particles of ideas or experiences, which are often meaningless when looked at separately.

Therefore, data analysis began with transcribing audio material into text which resulted cumulatively in 39 pages of text which was summarized into 26 pages of text which are shown in case company interviews chapter. Out of 26 pages thematic analysis was completed to derive the main theme and sub-themes of the interviews. Summarized text was simplified further by titling chapters of discussions. Further, themes were compared and the ones having similarities were grouped by naming similarly. Followingly, themes discussed by each interviewee were added to the table and quantification of the frequency was counted. Themes received from thematic analysis gives study the direction for benchmarking analysis. Benchmarking is created to enable managers to comprehend how their company's performance measures against the other companies (Pryor 1989). According Pryor (1989) benchmarking is function agnostic approach and

therefore can be applied to any area of the company. Thus, this method helps to recognize how blockchain based companies tackle the issues of Distribution System Operator and furthermore assist in generating a blockchain based business model scenario tailored for Distribution System Operator. In the following chapter, the typologies of the business model innovation of aforementioned business models are defined using definitions (Foss and Saebi 2017) introduced. According Foss and Saebi (2017) business models are categorized into four types: evolutionary, adaptive, focused and complex business models in terms of “scope” and “novelty” scale. In the last part of the empirical part the Platform Design Toolkit Cicero (2019) introduced is utilized and only business models that are platforms are included in the analysis. Particular two tools utilized in the scenario building are Ecosystem Canvas and Motivations Matrix.

6.6 Evaluating tools for blockchain technology need

There has been developed a variety of tools helping the organizations in their blockchain implementation process. Tools have been proposed because after blockchain hype in 2017, it became clear that Bitcoin and Ethereum is not a silver bullet for problems and alternative blockchain methods need to be introduced (Koens and Poll 2018). Therefore, it is crucial to study conditions that need to be fulfilled before going any further in the implementation process. Systematically, before choosing the right framework we need to assess the ones introduced in the literature.

6.6.1 Database approach

Majority of the assessment tools found have rather technical approach to evaluating suitability of blockchain where it is benchmarked to the conventional database. But the problem with the database perspective assessment tools that they vary so much from each other that the outcomes are different (Koens and Poll 2018).

Wibowo and Ery (2018) introduced two level general purpose Blockchain Implementation Assessment Framework (BIAF) having 8 checkpoints on first level, which help to elaborate that use case is appropriate for blockchain technology. Blockchain is seen as a sizable database with each stakeholder being a node and sharing the database ownership with others. Therefore, Wibowo and Ery (2018) emphasizes that most important checkpoints are related to asset and multi-stakeholders.

Level 1. of Blockchain Implementation Assessment Framework Wibowo and Ery (2018)

1. Centralized database solution is considered as deficient, potentially because of its security or complexity of tracking data.
2. The data or asset that moves throughout the system is historical asset and its history needs to be registered
3. The systems needs single database with excess dataset so that all stakeholders together can amend performance.
4. Multi-stakeholders store different datasets but complement each other to enrich the asset
5. The placement of each data source is distributed over many locations
6. Many participants who need to change the data but only certain participants can change basic application
7. There are standards for the protection of personal data

Alternatively, Lo et al. (2017) introduced widely popular tool Suitability Evaluation Framework for architecting blockchain based applications. Framework was constructed based on research conducted for Australian government and implementing proof-of-concept blockchain-based systems (Staples et al. 2017). It was used for evaluating supply chain, electronic health records, identity and stock market (Lo et al. 2017). Suitability Evaluation Framework consists of flowcharts, including yes/no questions and it demonstrated in Figure12.

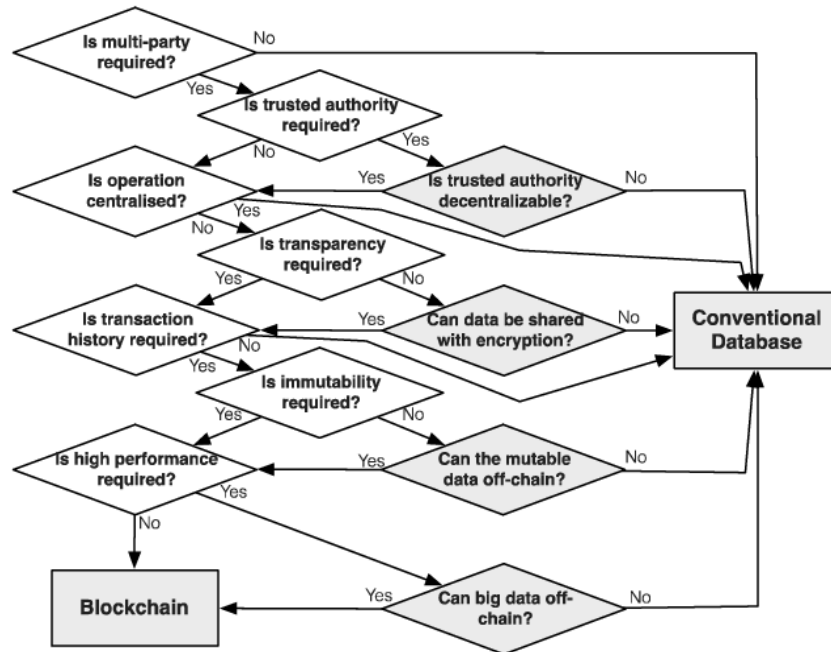


Figure 12. Suitability Evaluation Framework (Lo et al. 2017)

Koens and Poll (2018) made an extensive analysis of 30 schemes for blockchain technology implementation and recognized a fundamental issue in them - mainly because the schemes don't introduce alternative. They stated that none of the earlier proposed schemes were complete and thus derived their own scheme which can be utilized for checking the suitability of the blockchain technology. In the research they pointed out that analyzed schemes use different terms for blockchain and aren't always correct. As an example, Wüst and Gervais (2017) distinguish permissioned and permissionless blockchains, but their example Corda is more defined as a decentralized database. Other terms actively used in the schemes are central databases, central ledgers, shared ledgers, distributed databases, distributed ledgers, blockchain. Central ledger is defined as a central database that enables transaction interaction, which refers to interrelatedness of transactions of various participants (Greenspan 2015). The questions asked in the schemes were analyzed as well and similarities were recognized. Typology of questions can be split in the ones determining need for database, the ones addressing limitations of blockchain, the ones focusing on system design, the ones asking about the process. (Koens and Poll 2018)

Koens and Poll (2018) classified schemes into three clusters that have separate goals:

Cluster 1. Trying to determine if blockchain should be used.

Cluster 2. Aiming to determine which blockchain type should be used.

Cluster 3. Suggesting an alternative technology that can be used, such as traditional databases.

They propose own scheme built based on these three clusters, the aim of which is to make all 30 analyzed schemes obsolete. Koens and Poll (2018) state that blockchain is needed only in situations where unidentified participants want to reach consensus. It is possible to use blockchain in any situation where the database is required, because alternative and already mature technologies can be easier to implement. The scheme of Koens and Poll (2018) is demonstrated in the Figure 13. Koens and Poll (2018) scheme can be better understood by tech savvy people.

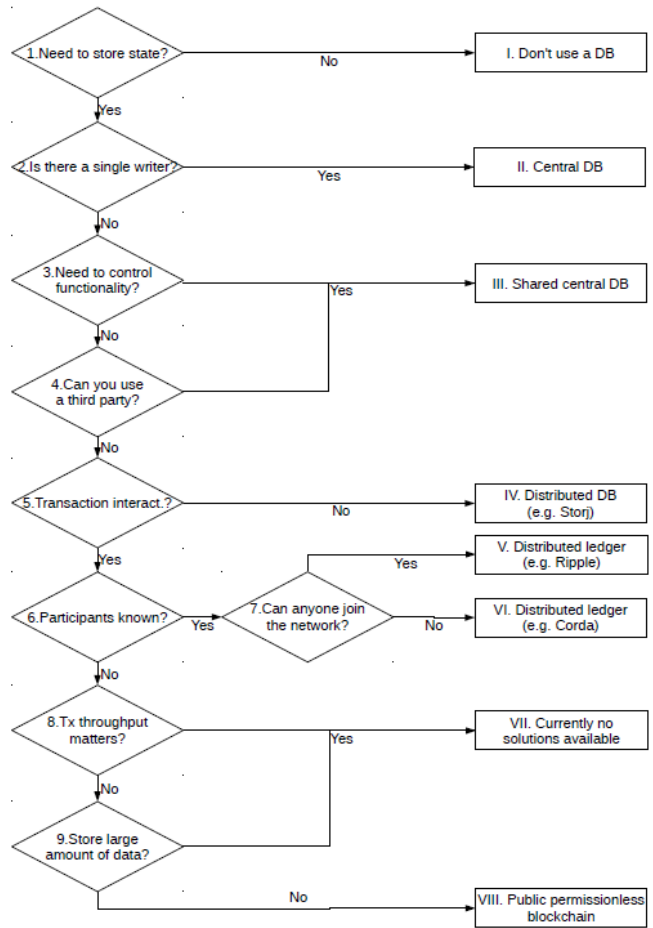


Figure 13. Scheme for determining which type of database is appropriate (Koens and Poll 2018)

6.6.2 Quantitative approach

Schreiber (2018) introduced a quantitative based framework (Table 10.) for evaluating blockchain level of fit. Framework is based on evaluation of 23 blockchain implementation projects and findings in that field led to identification of questions that need to be answered. Network management use case was among the implementation projects as well. Out of 23 projects only four survived to the testing stage and majority of the abandonment emerged in planning or analysis stage. (Schreiber 2018)

Table 10. Quantitative framework for blockchain evaluation (Schreiber 2018).

Architecture or blockchain characteristic	Example subjective suggested weighting	Weight (this column must add up to 100)	Subjective percentage of affirmation	Weight × affirmation
<i>Immutability</i> : Will the architecture ever need the ability to execute a command with update or delete semantics?	12			
<i>Transparency</i> : Does the architecture require transparency between actors?	12			
<i>Trust</i> : Does the ecosystem currently lack trust between participants?	16			
<i>Identity</i> : Must participants and actors be mapped to their transactions, or do those transactions have a value to be claimed by a participant?	5			
<i>Distribution</i> : Can the implementation manage and afford distribution of nodes and participants? Does the system have multiple writers?	10			
<i>Workflow</i> : Would the addition of a distributed ledger simplify workflow?	5			
<i>Transactions</i> : Does the system follow a transactional model, or is the data transactional?	12			
<i>Historical record</i> : Is the project ready to assume the fiscal, legal, distributive, and cryptographic responsibilities of running this chain for an indeterminate time period?	8			
<i>Ecosystem</i> : Does the architecture support an ecosystem as opposed to a single company?	15			
<i>Inefficiency</i> : Will the architecture support a blockchain's security overhead, search limitations, and transactional verification model?	5			
Total percentage of fit:				

Using quantitative approach requires deeper technical understanding of the system architecture used in the company as well as requires some level of understanding about blockchain technology functionalities. This framework is an adequate tool for technical consultant who aims to study the specifications of the blockchain technology, but not that suitable tool for studying the actual need of implementation.

6.6.3 Business process approach

In comparison to database approach, business process approach rather asks more general questions to determine whether blockchain can be applied. Therefore, business process approach evaluation tools can be more understood by a broader range of

people. This approach offers more flexibility but neglecting the technology aspect might be a risk in proceeding with actual implementation. As this study is focused on figuring out the impact of blockchain technology on business models, interview questions built upon business process approach might be more suitable.

Gupta (2017b) says that in order to evaluate the need for blockchain technology there at minimum one of the questions need to be answered with yes. These questions are formulated on rather industry level than the process level and they are shown in Table 11.

Table 11. Business process approach to blockchain need

Number	Determining How Blockchain Fits in Your Industry. Gupta (2017b)
1	Does business network manage contractual relationships?
2	Do process involve tracking transactions executed between more than two parties?
3	Is the current system overly complicated or pricey, possibly due to the need for intermediaries or a central point of control?
4	Can the network benefit from increased trust, transparency, and accountability in recordkeeping?
5	Is the current system prone to errors due to manual processes or duplication of effort?
6	Is the current transaction system vulnerable to fraud, cyber-attack, and human error?

In this master’s thesis we will utilize question proposed by Gupta (2017b) because it simplifies the questions so that they could be understood by people with technical and non-technical background thus getting more exhaustive answers.

7 EMPIRICAL RESEARCH

This chapter contains the major analysis and discoveries of empirical part of the study, linking the discoveries to theory. First sub-chapter demonstrates summarized data collected in the interviews and shows what challenges DSOs business model and business processes currently confront.

7.1 Case company interviews

The case company where interviews were conducted is a Distribution Services Operator operating in Finland. In order to receive a maximally broad picture of the company with various scopes on the electricity distribution and functions related to Distributions Service Operator, diverse set of employees were interviewed. Main aim of the interviews is to answer first subquestion of the study: *“What are the major challenges in DSOs current business model and related processes that can be addressed with blockchain technology?”*. Interviews help the study to understand the pain points in the current business model and processes and derive development ideas related to them. Results of the case company interviews guide the direction of for analyzing existing blockchain enabled business models found from secondary sources and thus answering *“How blockchain technology could impact Business Model Innovation of DSOs?”* Table 12. demonstrates anonymized persons that were interviewed for this research. Interview questions are demonstrated in Appendix 3.

Table 12. Case company interviews data

Case company internal interviews				
Interview	Code	Position at the company	Duration	Interview type
1	A	Development Project Manager	31 min	Live
2	B	Asset Manager	43 min	Live
3	C	Purchasing Manager	41 min	Live
4	D	Invoicing Manager	38 min	Live
5	E	Regulation and Revenue Manager	30 min	Skype
6	F	Business development specialist, metering	39 min	Skype
7	G	Data Scientist	34 min	Live
8	H	Business development specialist, microgrids	51 min	Skype
9	I	Sustainability manager	23 min	Skype
10	J	Procurement manager	27 min	Live
11	K	Land use specialist	30 min	Skype
12	L	Privacy expert	24 min	Live
13	M	Head Development Manager	32 min	Skype
14	N	Supply Chain Manager	35 min	Live
15	O	ICT-service manager	43 min	Live

	Average duration 34 min	60% Live 40% Skype
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Employee interview 1

Development Project Manager (A) has a track record of participating in the development of novel digital services to the offering of DSO. In the previous position (A) was involved in connecting the solar panel prosumers to the DSOs network.

Main topics that arose in this interview were related to **prosumers selling the excess electricity and crowdfunding of solar plants**. In selling excess electricity DSO is granting the permission to connect the solar panel to the network. At the current situation prosumers are eligible to make a contract with electricity supplier and sell the excess electricity to receive Nordic electricity spot market price (**3-4 cents/Kwh**). When contract between company and electricity supplier is created, DSO begins delivering metering information to the electricity supplier. In the interview (A) pointed out that **prosumers were complaining that the price is too low** and they are **frustrated of not having an impact** on the current way of doing things. Because of this, for prosumers it is rather important to choose the solar panels of the right size to **minimize the overproduction**.

“Even if we remind the prosumers to make the contract with the electricity supplier some don't remember or just don't care less and that's a problem for the market.”

According to the discussion DSO has a rather **passive** role in the process related to solar panel producers. According to (A) DSO connects solar panel to the network and reminds customer to make an agreement with electricity supplier. In order to start selling excess electricity customer **has to be proactive**.

(A) believes that **price level** would be the main motive for prosumers engaging in P2P energy trading. In addition (A) mentioned that P2P energy trading has to be **maximally convenient** for prosumers. Prosumers are aware that electricity flows through the neighborhood to the closest point it is where it is consumed.

“There have been questions - why can't I sell it directly to my neighbor? It might be so that the neighbor doesn't want to buy his own solar panels, but he would like to buy some solar energy.”

In the conversation with (A) it was recognized that the process of selling electricity overproduction involves **4 key stakeholders** - Electricity Supplier, DSO, prosumer and bank. Bills for distribution and electricity consumption are sent separately. Information about the production is mainly demonstrated in the electricity bill, also some inverter producers have online software that allows customers to track the information.

According to (A) prosumers do trust the current processes but would **prefer more precise way to measure data**. Now measurement data is seen only a day after the production occurs and (A) pointed out that quite often both prosumers and consumers would prefer seeing the measurement data in real-time. What comes to cybersecurity (A) sees that **alteration of measurement data is a risk**.

At the interview we also had a discussion about the crowdfunding and co-ownership of solar panels. (A) mentioned other Finnish utility companies doing something related to this, but said that case company is not involved in such activity. However, case company **enables** a case for entities to **offer their rooftop to company for installing and maintaining the solar plants on the roof**. In the discussion tokenization of solar panel ownership arose. (A) **agreed** that there would be some sense in **owning a small fraction of a solar power production plant**, since people are worried about the damage which can happen to the roof or else - so it would be a great option for those

who don't have thousands of euros to invest in solar panels. (A) believes that it would **lower barriers for customers to join sustainable energy production** and **earn** extra income via dividends that are paid out on a scheduled basis. (A) **hesitates that Finnish people are familiar with tokens** and blockchain technology and what is their attitude towards it. (A) pointed out that as Southern Finland is the sunniest region, thus it is the best area for running solar panel crowdfunding. Also, it was discussed that these projects might be located **outside Finland as well**, thus bringing even better dividends.

Employee interview 2

Asset Manager (B) has extensive experience in maintenance related processes on distribution, investments and management level. Asset Manager is responsible for all the assets excluding the company office related assets and reports to CEO. Discussion with (B) was dominated by following topics: **metering information, distribution line safety and cybersecurity, measurement data accuracy, maintenance related crowdsourcing.**

(B) was wondering what type of electricity meters might be in the future and if 4G or 5G would be utilized for communication, how it will be **secured and safely stored** in the DSOs systems. **Protecting the distribution network** from external parties that would want to intrude the system and change values there is very important (B) pointed out. Even a minor change in some metering parameters might cause a considerable loss of revenue counted in millions of euros. (B) agrees that it is important to have verified and well secured information.

(B) emphasized that **metering information is the foundation of invoicing**, thus accuracy and safety of that information is very important. It is the information that is sent from primary substation to network control room of the DSO. We also discussed how information collected from our IOT devices could be registered safely.

What comes to transactions, there are hundreds of thousands of transactions happening in the network according (B). IoT systems are data-driven thus they are constantly predicting the network health before fault occurrence, so the throughput is high. (B) indicated that part of the systems is **observing the network stages** (whether it is electrified or not) and another part is aimed to **forecast maintenance**. According (B) there might be **use for blockchain in the registration and storage of network related information**. Another part of the interview was highly focused on the **network maintenance related work** that DSOs contractors are doing. (B) said that the company's commercial points such as substations and cabinets are now 300-500 meters between each other - but **this distance will increase in future**. DSOs contractors are reducing the amount of network components so they will have to **drive longer distances for inspection or repair or removal of asset**, thus cost and time used to complete work will increase per each asset. (B) brought up **crowdsourcing as a solution**, by sharing the information related to the maintenance with larger crowd. The company launched a pilot project with Postal office, where employees gather network related information as they pass by our assets, but there is an interest to **open it to public** so that people who live in the neighborhood can earn extra money and keep the area safe. (B) said that this could be a **gamified application** where our assets would be put on the map with **rewards for each type of information**. Off course there would need a tool to verify the information. Payments are linked to this solution as well, because (B) indicated that paying rewards in **tokens** is more feasible than having slow and expensive transaction process via banking system. (B) believes that application should be designed in such a way that it **won't store any personal data or banking information**. (B) said that value from such application would be in the fact that as the network maintenance is up and running 24/7 with significantly lower costs.

We also discussed about how DSO could bring more work to **independent electricians** that complete small jobs, because over time the amount of work needed will reduce and thus contractors will have to lay off people. (B) had an idea that the **repairing's of our assets could be crowdsourced** as well, because DSO has the contact information of the electricians. But instead, because DSO has pre-agreed contractors it needs to order

from them and they sometimes to drive 50 km or more, which creates extra costs. (B) said that DSO could **introduce a marketplace** where we would introduce small jobs for completion. (B) was aware that in this kind of system it is crucial to verify that the person is eligible/have certification for taking this task. Creating this marketplace would ensure low cost in the future network maintenance and it could be later opened for other companies as well.

Employee interview 3

Third interview was with the purchasing manager (C) of the company, whose responsibilities are regarding purchasing related business processes and procurement software. In discussion we mainly discussed the **purchasing process** which is highly important for the case company that does a lot of network upgrade.

(C) emphasized that the most important part of the purchasing process is that the ERP system has **up-to-date information** such as **business information, business identity codes and right bank accounts**. This is because when DSO received an invoice it should be matched correctly with an order information. In discussion with (C) key internal stakeholders recognized were procurement department, project managers, finance department. The ERP system users have rights in hierarchical manner.

What comes to **external stakeholders**, there are **suppliers** and **contractors**. According (C) **97% of the purchasing orders** are sent via EDI (Electronic Data Interchange) connection to the supplier's ERP system or some other system where orders are received. Suppliers can provide DSO with information of the state related and confirm that goods are delivered for example. If some changes have been made to order, we always inform the suppliers. Most communication is done via email or phone. **Project management** department of DSO has a **connection** through system to **contractors**, which still hasn't made phone irrelevant. There is no such system established with suppliers - instead there are weekly Skype/meetings/email discussions.

“When the purchase orders are created, we need to inform our suppliers that we have just ordered using this reference and then invoice must be sent to correct company because we have three different companies”

In the discussion **manual labor**, **transaction tracking** and **timestamping** were brought up as well. ERP system creates a **timestamp** so user can see the history of the order. It's possible to see whether the status is “planned”, “acknowledged”, “released” or “closed”. (C) emphasized that it is **important to have flexibility** in the system so its possible to fix human error related mistakes. We also discussed the amount of manual work that is involved in the process. (C) said that when contractors **send us a request to invoice**, DSO must first verify whether the work really has been completed - this requires checking information from another system or talking with contractor on the phone. Sometimes there might be situation of uncertainty for giving the invoicing permission. Supplier contract related information such as supplier name, contract headline, product type, product prices need to be **manually created** in the ERP system. Contracts need to be checked from time-to-time to check if things done correctly, especially whether **invoicing period** is 21 or 30 days.

When discussion about **human error**, (C) said that it highly depends on what kind of **rights the user has** in the ERP system. Mainly human error relates to people who have rights to create purchase orders, they also can **by accident or prematurely close a purchase order**. When discussing **fraud**, (C) brought up **fake invoices** from someone who claims to be our supplier - however in those situations the banking information should be the same as suppliers. Another chance is that our suppliers send fraudulent invoices, which is not probable - but in that situation we quickly recognize the fraud/mistake because we won't be able to match it with a purchase order.

When discussing **transparency** and **accountability in recordkeeping**, (C) agreed that those would benefit the process. At the current situation there is an **information gap** with suppliers, because they don't exactly see other information than **product code**,

order date and **sum.** (C) emphasized that it would be **good if DSO could provide more concrete information digitally** to supplier in order to avoid the need for emailing or calling.

Supply chain traceability related to material origin took place in discussion as it is a current topic related to blockchain technology. According (C) all the materials such as substation buildings, cables ect. are sourced directly from the suppliers or factories in Europe. DSO also has contracts with wholesalers who then buy products from factory and store them for DSO. **Traceability** of the network component depends on the **supplier** and the **component type**. Substations have a **unique ID** - so if there is a complaint from contractors that part of substation is missing, supplier can provide information from final check and prove that everything was in place before delivery. **Traceability of transformers** on the other hand is more **difficult** because they are delivered in batches to wholesaler and wholesaler doesn't know their IDs. A while ago there was an issue with material strength of transformer, so wholesaler had to pick it up and send to factory where tests were made. As the outcome, factory found out that some pieces in a batch didn't meet the standards - but because **no one was tracking** the batch throughout the supply chain, it wasn't possible to tell if there was more **deficient transformers in DSOs possession**. (C) agrees that better traceability and transparency in supply chain would be beneficial from the maintenance perspective.

With (C) we also discussed the **process friction related to delivery**. According (C) the agreements delivery takes 5-8 weeks depending on the complexity of the product. Of course products might be delivered quicker if product is in stock. The process itself has **acceptance, confirmation, production** and **delivery** phases.

- Acceptance phase takes from **few seconds - 2 weeks**.
- Confirmation phase takes between **2 hours - 3 days**. When information goes to suppliers and they have an automated system that checks the warehouse stock and sends the confirmation within **2 hours**.

- Production phase takes a **few days** (if in stock) - **8 weeks** (complex substation building)
- Delivery from the factory to building sight **1 - 4 days** (more if it goes through separate stock in Finland)

Last topic of discussion was related to how blockchain technology could streamline the current procurement process. (C) acknowledged that application of blockchain has potential to reduce double-checking and human error in the system as well as automated payment via smart contracts. A lot of desktop work could be saved and especially related to invoicing, where there are **40 000 /year**. Processing one invoice costs around **30-40 euros taking 3-5 minutes**, messy invoices might take **20 minutes**, thus (C) agreed that **a lot of money can be saved** with such improvement. (C) pointed out that not all invoices can be automated with blockchain but a considerable part of it. (C) was fascinated by the idea of smart contracts where DSO would program a common rule with contractors and suppliers so that when things are completed automated payments will occur. Building an efficient and trusted supply chain benefits all stakeholders by freeing up a lot of time.

Employee interview 4

Invoicing Manager (D) participated in fourth interview. Two main topics that took part in the discussion were processes related to **billing** and **collection of payments**.

(D) says that DSOs **CRM system** works as a **backbone of billing**, holding all the customer and contract related data and there are **many stakeholders involved in the process**. In CRM information is processed and billing batches are formed. Each batch has predefined invoicing date. When we make sure that batch is correct - at that point it is just an invoice data. After all invoices are checked DSO sends the batch to invoicing services company. This company checks which invoices should be sent to customers by **mail** and which by **email**, and which goes to customers to OmaPosti. In addition to

these processes, some of the invoices go as **e-invoices to customers bank**. Large company customers receive a **direct electric invoice** with no bank in between - payment processing company sends them directly to invoice operator. DSO has a special agreement with a major Finnish utility company, to which it delivers part of the invoices. This utility company merges the invoices with their own and creates one that contains both electricity bill and distribution fee - making sure that they receive money DSOs money from the customer.

(D) pointed out that DSOs own heavy **CRM system which processes a lot of data** is the **slowest part** of the billing process. Especially when invoicing department is preparing the billing batch to be sent on a certain date. (D) says that the problem **roots from the slow delivery of metering data and connection issues** to meters. Due to this, the billing batch might be sent **later than planned**. (D) brought up the **lack of transparency** in measurement, therefore the fact that customer has **no place to see the personal consumption** and adjust the upcoming invoice. (D) emphasizes that in invoicing the critical parts are **measurement data and customer's contract information**. If either of those are not accurate the issues arise. With the current process **99,7 - 99,8 %** of invoices are sent in correct time. With the amount of customers, we have even a small enhancement would make a big difference for the business. DSOs partner, credit management company sends around **11 000 notification letters each month** if invoice isn't paid after 14 days from the due date.

(D) **agrees that human error** due to **manual work** is prevalent in the process. Invoice batch is checked manually for outlier amounts (such as too high or too small). Sending an invoice costs **5 euros** so it isn't logical to send invoices lower than that. (D) pointed out that problems in invoicing root also from **customer error**, such as not informing the changed address. With **papermail being constantly reduced** in Finland, the delivery times are slowing down, so it might take too long and therefore customer has less days to pay the bill.

Another process (D) wanted to discuss was **related validation of monetary flow**.

Customer can pay via **online bank** or directly through **portal on our website**. Our postal partner provides a payment option as well. When payment is received, customers bank sends it to DSOs bank which forwards the information to our payment management systems and changes automatically the status in our CRM system as “paid”. (D) says **if reference number can’t be matched** with the payment info - the bill goes to **manual processing**. It might take a lot of manual work, often calling to the customers bank to find out the name of the customer, because it’s anonymized due to GDPR. In addition to this (D) points that banks have **issues in delivering payments** which bring friction to monetary flow. (D) says that payment slowness **decreases customer satisfaction**, since DSO might disconnect electricity from the customer even though the customer has paid it already a day before.

Employee interview 5

With Regulation and Revenue Manager (E) major topics of discussion were related to **metering, billing process, data privacy and monetization, energy communities**. In discussion (E) mentioned often Finnish TSOs datahub and its cons in comparison to blockchain based potential solution. This interviewee had the best knowledge of blockchain technology.

Key stakeholders in the process are grid company, TSOs datahub, seller and supplier and customer. There are 3 intermediaries before customer and many of those are interested in TSOs Datahub related data - for example **tax authority, energy communities** and all kinds of **service providers**. (E) believes that centralized Datahub introduced by TSO creates constraints on the opportunities and interoperability. The information tha DSO sends to datahub is following:

- metering point information
- an information related to grid connection
- the distribution product and pricing

- basic energy series (hourly)
- outage compensation info
- metering switch on or off.

(E) discussed the same billing process as the Invoicing manager (D) introduced and pointed out that there should be **multiple smart contracts**. One could be used for basic **billing process** and another for the paying the **standard compensation** to our customers for the outages. Also (E) said that **reclamation process** could be working on a smart contract when a customer sends reclamation, he/she would have a visibility of the progress - and if the reclamation isn't handled in 10 days customer receives the money back instantly.

(E) brought up **data privacy and monetization issue** - normally the customer owns the data but Datahub would lead to situation where Datahub owns all the information, how can customer could allow parts of data? (E) said that this could also be handled with blockchain, **enabling customers to open parts of data** to service provider and receive **compensation** for it. (E) said that when this data is streamed in crowds it has more value.

What comes to cybersecurity (E) believes that centralized datahub is **more prone to failure or cyberattack than decentralized blockchain**. (E) believes that it is very old school to have a centralized, **heavy and expensive system** and advocates for lighter system. As the whole Finland has 3.4 million transactions from the metering points, thus (E) stated that having a lightweight structure that utilized **Proof-of-Authority (PoA) consensus algorithm**, not requiring mining would be a solution.

Future requirements for the **energy communities** were discussed with (E) as well. (E) said that **next generation smart meters** are needed to enable efficient billing of the energy communities. In the future scenario (E) sees that if DSO will provide a **blockchain platform for P2P trading** it would have PoA consensus algorithm where DSO would act as a validator, because of trusted reputation. If the trading entities would

be located close by, there is a possibility for free electricity distribution. In **apartment building**, DSO could enable **trading of excess electricity** without distribution fees or taxes even earlier because of upcoming legislation 2020-2021. When designing P2P trading platform adding taxes and distribution fees would be complicated.

(E) **opposed the idea of having distribution fees in P2P energy trade**, because it wouldn't get enough users. (E) believes that **benefit** lies in **company reputation** and corporate social responsibility because both solar panel systems and blockchain are hot topics. However (E) **couldn't recognize direct financial benefit** for building such platform. (E) stated that receiving a permission for pilot project would be easy and neutral from cost perspective if we would share results with the other DSOs.

Employee interview 6

In sixth interview there was a discussion with Business development specialist (F) from metering department. With (F) we went deep into the details of the **measurement process, TSOs datahub, P2P trading and supply chain visibility**. (F) has heard about the blockchain technology implementations on microgrid level but isn't very familiar with the topic.

Smart meter measures two types of energy

- From most measuring points DSO is measuring active energy
- From bigger consumers then DSO also measure a reactive power.

DSO has data concentrators installed mainly in transformer. Data concentrator collects measured data autonomously - a few times a day meter reading system contacts with the Data concentrator and it collects all the data that Data Concentrator has. That is done by DSOs service provider which also makes validations. When all those processes are completed measured data is sent to us via message-based transfer SSH connection. We read the data into our balance settlement system or energy data management system, it also makes some validations and processes the data. After that

it makes some calculations - for example we aggregate energy by retailer by our network areas. That data we send to the other market participants.

Delivery sight data (hourly consumption data) **is used for billing purposes** - which DSO sends to customer interaction and sales system. Data is matched to the correct delivery sight. Billing system makes all the calculation for billing purposes. (F) added that DSO collects events and **alarms** that are generated by the meter - which are related to outages, voltage sag or surge etc.. (F) agreed that there might be **possibilities for human error or fraud** due to fact that someone could change the location of smart meter. (F) added that it would be beneficial if we would really know where the meters are installed. Relating to supply chain visibility (F) pointed out that there is an issue that **DSO doesn't know the exact amount of the meters** that are in the warehouses of DSOs contractors. Losing meters is expensive, because regular meters cost around 200 euros, while bigger meters around 1000 euros.

(F) doubted that real-time measurement is even possible today. What comes to **measurement intervals**, (F) couldn't recognize direct fiscal benefits from having real-time intervals, but (F) recognized that seeing measurement more accurately will help DSO to serve customers in better data-driven way. Also, we would get notified quicker if there is an outage, which would also be important from our core business perspective, which is maintaining the grid. According In upcoming project DSO is aiming to get the information directly to ADMS system.

As a topic we discussed the **age of smart meters** and **P2P energy trading**. (F) indicated that for large scale customers smart meters were installed two decades ago and for the rest of the customers between 2011-2013, those meters can be used for 10 years so the upgrade of the meters will be in 2025-2028. (F) said that because meters don't have sophisticated features to enable P2P market calculation and aggregation. (F) believes that in future 5G might be the way to interconnect smart meters between each other for information exchange.

Employee interview 7

Discussion with Data Scientist (G) was mainly related to the **opportunities** that data could provide for the **business internally** and **externally**.

(G) listed that company has

- Network data
- Project related data
- Electricity connection related data
- Sensor or state data
- Customer related data
- Invoicing data

In discussion (G) emphasized that DSO has **information about electricity consumption** which in fact is owned by the customer. Other **valuable information** that DSO has is **related to network management** and **network components**, which (G) indicated would be sellable to the component producers and network builders. (G) said that creating **blockchain based data marketplace** interesting use case. Off course at the moment it's **hard to estimate the cost** of the data and onboarding users on the platform would be critical. As an example, DSO could sell 5-year switch data and technology providers could bid on this data. If the group of DSOs would set up a **marketplace for network related data exchange**, where companies could offer part of their data for free at first. Thus, **hybrid blockchain solution** could be suitable for this. This network data exchange could be as well international, where other DSOs could join too - at least on the European level there are many similarities in the network so it would be rather convenient to benchmark.

From DSOs business perspective the most valuable data is the **billing data**. DSO knows customers payment pattern, such as who pays on time and who delays payments. **Data aggregators** that collect and combine data from a variety of sources to

create insights could be interested in customer consumption and contract data. Also, **loan issuers** might be interested in this data.

(G) agrees that **DSO could benefit from secured, verified and timestamped data**. Databases are mainly in the internal use so there is a rather limited risk for alteration. (G) however, **isn't sure if blockchain is needed**. When it comes to customer related data, customers assume us as a trustworthy company according (G).

(G) brought up TSOs datahub project which will enable customers to see consumption and contract info. Even if there would be an interest to implement blockchain technology in a process TSO which is responsible for datahub project and it has the upper hand and incentive to have processes under own control.

In discussion about tightening metering interval from 1 hour to real-time (G) said that data this has the potential to enable demand response. (G) emphasized that cybersecurity and accuracy of metering would be pre-requisites for the future smart meters. (G) suggested that this smart meter could work on the consumers **own internet connection**, thus enabling faster information exchange. New meters would enable bringing consumption related data to third parties as well as control the home's smart devices. (G) concluded that enabling this would require **educating customers**.

Employee interview 8

8th internal interview was with (H) business development specialist specialized on microgrids. In a case company (H) is responsible for the management of innovation projects related to microgrid. With (H) main topics of discussion were energy communities, solar power ownership, demand response, crowdsourcing.

According (H) belief energy communities don't exist the way people see them, and majority are pilot cases. (H) says that the **biggest constraints** of energy communities

are the **regulation in Finland**. Forming an energy community is legal but **taxation and regulation** is making it infeasible. Also, in today's model distribution fee should be paid to DSO no matter if the electricity is sold to neighbors. Pulling direct cable in order to sell electricity to neighbor is illegal. (H) has read that **blockchain based solutions** may have the **most potential for sharing the value** in the energy communities because of unregulated transfer of cryptocurrencies. In addition to cost savings (H) indicates that for energy community members green values could be even more important.

When discussing the **motive for forming energy communities** (H) brought up Brooklyn Microgrid project where DSO needed better **congestion management** thus financing the project. In sense DSO benefits from delaying the investments. (H) says that congestion management isn't needed in Finland as the grids are good enough therefore green values would be the main motive for creating energy communities in Finland.

(H) agrees that some business cases would benefit inside from transparency, increased trust and accountability in recordkeeping. (H) believes that rather easy case would be to create energy communities within housing blocks - install solar panels on housing blocks and distribute electricity to the apartments. In apartment blocks would be possible to allocate costs to every apartment using blockchain based system.

(H) was skeptical about the use of **tokens as a representation of ownership in solar panel projects** and didn't really understand the concept. (H) agrees that tokenization would enable the enhanced **democratization** of the process if we suppose that customers would get to **vote** for projects that they would like to see implemented.

(H) described that TSO has 6 different markets used for **stabilizing the grid** in problematic situations. In the future as renewable energy production will grow energy production will fluctuate, with dependency on **weather conditions** thus it will be harder to balance **supply and demand in the grid**. (H) sees that current markets are not able to sever the future needs, because small scale producers can't yet participate as they

don't provide enough flexibility. With flexibility market it would be possible for new market players to **aggregate loads and production** from individual customers and participate in flexibility market. (H) thinks that **transaction settlement with aggregators** could be enhanced with blockchain technology. If there ever will be a flexibility market serving small-scale customers, it will probably be under TSOs management (H) concludes.

Last topic of discussion was crowdfunding related idea, which was the same as Asset Manager (B) indicated. (H) added that **crowdsourcing platform** would provide more competition in area for tasks, bringing more electricians to complete the same job for a lower price and blockchain technology could be used for **tracking quality and performance of the specified electricians**. (H) also advocated for rewarding customers with tokens or cryptocurrency for delivering grid maintenance related information, due to the fact that traditional transaction systems are too heavy and expensive for micropayments. (H) hesitated that what is going to be the actual **exchange rate** for such currency.

Regarding the cybersecurity (H) thinks that it might be more secure to have a distributed ledger depending on the size of microgrid. Similarly, to (E) Regulation Manager (H) thinks that it quite **old fashioned to build a centralized datahub** that puts constraints on the entities providing permission to access their data. (H) also agrees that it could be done more **efficiently using blockchain technology**.

Employee interview 9

This interview was conducted with Sustainability manager (I) whose main responsibilities are related to supply chain sustainability, as well as Corporate Social Responsibility. Major discussions that arose were related to **sustainability auditing and supply chain**. In procurement process when DSO reaches the stage that supplier is picked, DSO sends a **questionnaire to potential supplier** beforehand, supplier fills it

out and sends back to us. This questionnaire helps us to understand which areas DSO focus should on when auditing. DSO uses **external consultant** who does the auditing in one full day, after which DSO gets a report. Report is sent to potential supplier for checking the misunderstandings. As an outcome DSO receives the report where all the practices, observations and weak points are described.

According (I) internally procurement department is responsible for the auditing process, thus **supply chain manager** is always involved. Depending on which product supplier is being audited, **procurement manager** who understands that **network component** is involved. (I) has been taking part in **CSR auditing**, but often quality management department involved is involved. There are often the ones that make the most cooperation with each supplier. The only external stakeholders are **sustainability consultant** and **supplier**.

(I) said that there is **no clear documentation in the auditing process**. Final report is shared with the ones who do the auditing and the ones who's been auditing and saved into DSOs file system. (I) said that consultants work with confidential papers so in a sense they are trusted third party in the process. (I) claims that it is necessary to have consultants assisting in the sustainability audit, because there aren't enough people in the DSO to do this in house.

(I) emphasized that corporate social responsibility as a whole should be better integrated into companies' strategy therefore CSR related workshops are organized for the management group. (I) sees that **enhanced transparency related to company operations** would increase the trust towards our company. Tax related information also would be crucial in this regard. (I) hesitates whether people would really be interested in checking the supply chain related information, but rather **understand the logic behind our pricing models**.

Employee interview 10

10th interview was conducted with procurement manager (J) whose main responsibilities are network material sourcing, tendering, supplier management and follow-ups. With (J) discussion were related to **pain points of sourcing process**.

Main criteria to have sourcing process working that (J) pointed out is **ensuring** that network materials are **delivered on time** and that network materials **fulfill the quality standards**. (J) defined suppliers and contractors as the key stakeholders in the process. (J) said that rather often contractors **by mistake order products** that aren't included in the delivery. This is because contractors define the content of the order, this type of human error can be manually fixed from the ordering system. From cybersecurity perspective (J) emphasized that **network material prices** written in our agreements are **quite sensitive information**, thus it would be important to protect.

Friction in the sourcing process was discussed with (J). Everything starts with tendering that takes many months because it's a public process - but that is something that DSO can't influence. When material supplier is defined based on material specifications, DSO does **factory approval tests** which take **from several weeks to months**, involving DSO employees and external consultants.

When factory review is complete DSO sends **remarks to suppliers** so they can customize the product according to our requirements. When improvements are done, **second approval test** is done. It takes **quite a lot of time to get to the delivery phase**.

DSO has a standardized **checklist** in the factory approval tests, which is done by **sourcing** team and **technology** team. The **audits** are **documented**.

Major part of sourced network materials bought directly through factory approval tests because DSO has company specific technical specifications.

(J) points out that there are quite a lot of **issues on the contractor's side as well**. Contractors receive the materials on the building site, and they do the **checking**, whether something is **missing** or **damaged**. If something is wrong, they are making the **reclamation** in ordering system and DSO **forwards it to material supplier via email** - and this is done **manually**. Reclamation process lasts from **one day** to **several weeks**. Information goes through DSO because DSO is the fact **owner of the materials**. Every second week we make **follow-up calls** with material supplier where we go through the **reclamation status** - checking on how many of those have been **closed**.

Employee interview 11

11th interview was conducted with Land use specialist (K) that has to do a lot with DSOs electric cabling project. Land use is an extremely important process, because it is related to permissions of using land to dig the electric cables under the ground.

Terrain design is an expensive process that is **outsourced**. The information related to landowners is brought from **open civil registry** which is utilized for finding the landowners and sending the **proposed land use contracts**, this is done by external partners. Municipalities can also provide a **compulsory land use rights** in the case that landowner won't agree which takes extra time. The special permission needs to be received from authorities in the situation of special area taking extra time as well. (K) agrees that automation of the current contract throughput process would significantly **improve current planning** and **significantly reduce costs**. Land use agreements must be **retained for many years** even after the cabling project will be finished, thus (K) believes that **accountability in recordkeeping** is important. Having documents registered on blockchain would also ensure the tamper-proof and safety of the information. (K) indicates Significant part of land-use contracts are still in the paper for and part of the **payments are still partially paid manually**. The payment is tied to the completion of **certain distance of cabling**.

Employee interview 12

Privacy expert (L) is working on tasks related to **protecting personal data** of our customers, employees, contractors and other parties as well as ensuring that business processes and such that data is well protected and unnecessary risks related to **personal data processing** are avoided. In practice (L) concludes instructions of how protecting the business data should be done and educate teams on this topic.

(L) says that there are processes that are specific to privacy, because of the GDPR legislation requirements. We have a process for people who want to **inspect the personal data** that DSO has about them, so DSO sends a copy of their data. DSOs customers have the **right to see the data** that we have about them, right to **receive it portably, right to correct** and **ask for erasing** the data as well. (L) also brought up GDPR processes that are related to **breaches of personal data** and how the notifications should be processed. (L) added that DSO handles a lot of customer contact via chat/phone/email and it's complicated to verify the identity of the person contacting. (L) says a lot of risks are related to exposing the information to outsiders, which is particularly a **human error**. (L) concluded that from DSOs business point of view **customers identity management** is the **most critical**, since it's the **largest stakeholder group**. Data related to contractors or suppliers is minor in comparison.

GDPR compliance **isn't a very straightforward process**, having dozens of requirements and compliance with the standards. (L) says that therefore **external GDPR auditing consultant** is needed for evaluating the processes. Systems can have **non-optimal features**, so there can be risks from the system features where systems aren't functioning as well as they should be.

Regarding the **idea of data monetization** (L) emphasized that it depends on who is benefitting and is the customer involved. Selling information behind customers back is illegal process should be open and transparent. (L) agrees that **GDPR process would benefit** from increased trust, transparency and accountability in recordkeeping.

Monetary effect of GDPR compliance can be counted in **risks related to penalties**. (L) pointed out that maximum fine is **20 million euros** or 4% of global turnover, whichever is greater. Smaller companies received penalties in **tens or hundreds of thousands**, and in addition people can sue us and then we need to **pay reparations** to people. **Negative publicity effect** due to unlawful behavior lasts long so the real losses are hard to estimate.

Employee interview 13

Head Development Manager (M) discussed mainly about **possibilities** of making the **future customer more active**. Active customer may have some own production or energy storage and has an interest in participating in different markets. There can be either physically **local energy communities** or **virtual energy communities**. This can be for example an apartment block. According (M) **virtual energy community** in comparison to physical energy community might be easier to implement.

(M) points out that managing the **energy related data** is the crucial enabling factor of **energy community's** operation. (M) supposes that the shorter the transaction interval, the more balanced the market is. However, in the future scenario (M) sees that customers would be given **flexible option to purchase/sell energy** depending on **supply/demand balance** in the interval from/to various suppliers or energy community. (M) says that **enabling transactions** take place in many different directions with a variety of stakeholders is lucrative from new opportunities point of view.

(M) believes there are **technological constraints** in **metering** and handling metering information, as well as **constraints** set by the current **market structures**. (M) sees that best structure for future would be an **autonomous model** which defines rationally which seller or buyer provides the **most value in the transaction**. (M) said that challenging question is to understand the contract relations between the counterpart, and would there be an intermediary taking care of the best choices for customers. (M) assumes

that in first-hand the energy is traded in energy communities and then in the markets - but the question is in which order the system will operate.

(M) agrees that **accountability or recordkeeping** is important but hesitated whether transactions need to be **stored for a long period of time**. Quick and efficient verification of transactions however is important according (M). Similarly, to opinion of (K) and (E), (M) thinks that centralized system is more vulnerable to cybersecurity risk than decentralized system. Regarding to monetary flow current process which goes through bank is static and not viable in case of P2P transaction according (M).

Employee interview 14

Discussion with **Supply Chain Manager (N)** was related to the process of managing supplier relationships. DSO has tiering of suppliers in 3 tiers, where tier 1 is the most important with which also the meetings are held. These meetings aim for relationship development and information sharing. In the process there are certain **construction quality criteria** that DSO focus, includes checking that the quality is the same as in the agreement. Contractors do check quality themselves, since its the legal requirement to inspect their own work or they hand it over to us. It's all about fulfilling the legal requirements and our own requirements. In previous meeting we were checking the **customer reclamations** and how quickly contractors take them under process - there we were sharing this information with them since they don't have constant access to this information. Digitalization of cooperation, work safety, construction quality and customer satisfaction are discussed.

(N) said that network construction audits are completed by the external consultants who inspect if job is completed according DSOs instructions. When the external consultant finds a problem, they create a "ticket" for contractor. Contractor fixes the problem, takes a picture and sends it back to DSO. (N) said that utilization of machine vision was discussed with contractors for validation of results, but technological constraints aren't

enough. (N) concluded that supply chain management is dependent on trust, related not to data but common goals and willingness for cooperation.

Employee interview 15

With ICT-manager (O) metering process, energy loss, data monetization was discussed.

From DSO standpoint process is the backbone of Distribution System Operator is **meter to bill/cash**. It begins by reading measurement information from the meters to DSOs measurement system and then delivering it to DSOs billing system for customer invoice. (O) indicated that from electricity market points of view DSO is responsible for reading the meters, deliver the measurement data to parties - **eSett imbalance settlement** - to them we send a **summary data of the 200-300 regions**. DSO delivers information about delivery sights **to electricity sales companies**, so they can invoice their customers.

(O) said DSO should deliver today, yesterday's measurement data for every meter. But in practice **it's impossible to be connected to every meter every day**. According instructions and rules in this business, the latest **after 5 days** DSOs need to **estimate the energy consumption**. Some energy meters **might be in unreachable state for a long time**, summer cottages - when people leave cottages in autumn they cut the power from cottages so that power is also cut from the energy meter, thus it makes it impossible to reach the meter. Also, there might be some data connection issues. Most of our meters use **PLC power line communication**, so disturbances in power lines may cause the fact that **we aren't able to reach the meter**.

(O) says there are ways to figure out **accuracy of the measurement data**. If there are **vast values** - for those kind cases we quickly figure out before billing the customer. Often it is **noticed** in **measurement system** or **billing system**. Small differences are hard to estimate if they are accurate. In some situation there might be problems with data quality as we get the alarms in the meters. As example, there might be a **memory**

error, you can pretty much be sure that the values **aren't very accurate**. (O) introduced **4 questions** that need to be addressed regarding the measurement values.

- Is the meter working correctly?
- Is that being the metering data transferred correctly into the system?
- Is metering data transferred correctly from metering system into master measurement system?
- Is metering data delivered correctly to different parties from master measurement system?

(O) stated that transforming from 1-hour measurement interval to 15 minutes intervals will especially benefit TSO, helping them to **adjust energy production** and international electricity distribution. (O) commented that from prosumer perspective measurement in real-time would give a **fair picture** of what is happening and what is the balance between consumption and production. (O) discussed the data monetization and said that consumption data could indicate what **type of house is the person living in and what type of electricity products person uses**. (O) said DSO could enable providing additional information as well.

(O) agrees that it's hard to predict if group of entities might want to hack the energy meters or other network components. When discussing cybersecurity (O) said that it's hard to estimate what happens but in that scenario, there might be more incentive in cutting electricity from the whole country than just intruding the energy meters.

7.2 Thematic analysis

Because of the semi-structured interview type various themes were discussed with the case company employees. Many sub-themes were recognized in content analysis as well, which can be seen at (Figure 14.). Analysis of the transcribed and simplified interview data demonstrated that occasionally discussions were related to the

responsibilities that interviewee is responsible for. Overall, out of all themes particularly metering, data, cybersecurity, supply chain stood out as the most often discussed themes. Metering was theme in 9 interviews while data, cybersecurity and supply chain related topics were talked through 5 times each, see (Figure 15.) for comparison.

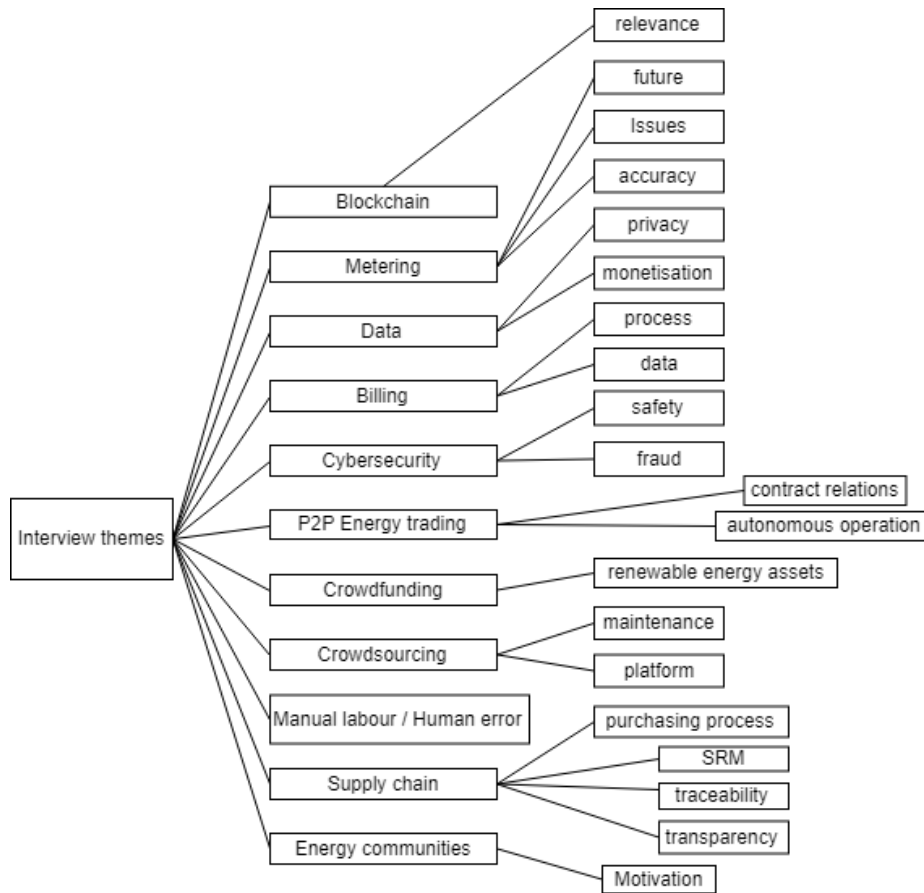


Figure 14. Main interview themes discussed

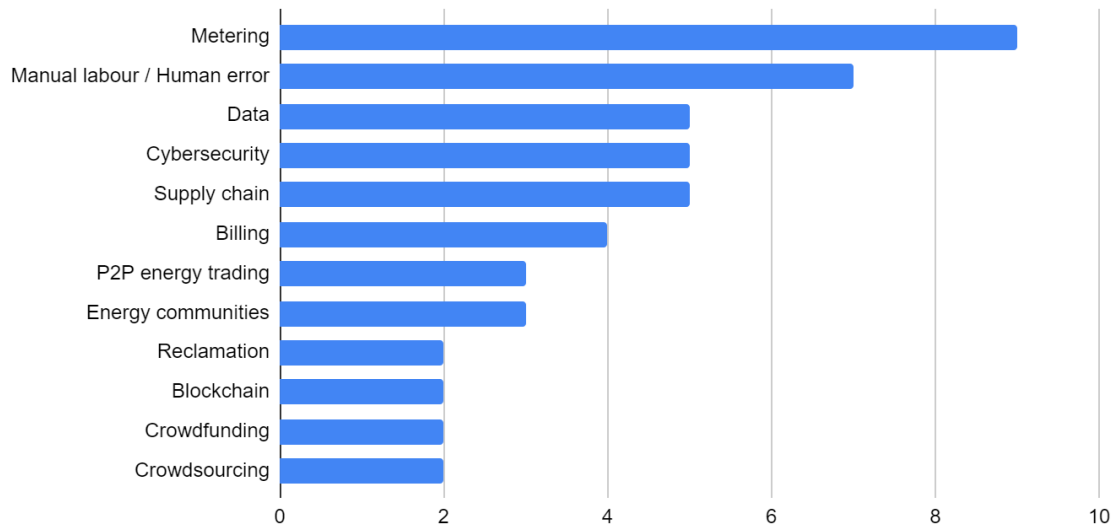


Figure 15. Frequency of the themes in the interviews

When discussing metering interviewees were particularly concerned about the issues, accuracy and future of the smart metering technology. Metering process and accuracy were mainly discussed with Business development specialist, metering (F) and ICT-manager (O). Business development specialist, metering (F) doubted that real-time measurement is possible today and couldn't find financial benefits from implementing it. (F) however, accepted that in case of an outage, DSO would be informed quicker. ICT-manager (O) commented regarding measurement data accuracy that small difference is hard to estimate. Regarding the metering data (O) said that according to the instructions after 5 days without measurement data, DSO is responsible for estimating the energy consumption. Both Asset Manager (B) and Invoicing Manager (D) emphasized the importance of metering by stating that metering is the backbone of invoicing. (D) said that issues with metering complicate the invoicing process as well.

Data related discussion led often to discussion about data privacy and data monetization. Data Scientist (G), Regulation and Revenue Manager (E) and Privacy Expert (L), all emphasized that information about electricity consumption is owned by the customer. (L) said that customers identity management is the most critical, since its the largest stakeholder group, contractor and supplier related data is minor in

comparison. (E) stated that novel centralized datahub project that is being implemented by national TSO would make it complex for customers to open data to third parties and receive compensation for it. Data monetization on the other hand was proposed as a novel business opportunity introduced by Data Scientist (G). ICT-manager (O) commented that with granular consumption data is possible to indicate what type of house the person is living in and what type of electricity products person utilizes. Regarding data monetization (L) stated that the whole process should be open and transparent to customers.

Most comprehensive discussion about billing was with the was mainly discussed with the Invoicing Manager (D) but other interviews commented on billing as well. Regulation and Revenue Manager (E) commented that billing and reclamation process could be both automated with smart contracts. Data Scientist (G) on the other hand mentioned that billing related data could be monetized. Cybersecurity was also among the top themes in the interviews. Cybersecurity was discussed from ensuring safety and preventing fraud.

As Distribution System Operator is responsible for ongoing electricity flow, particularly Asset Manager (B) cybersecurity of distribution line. Regarding cybersecurity Asset Manager (B) discussed fraud, pointing out that minor changes in metering parameters could cause in revenue loss of millions of euros. Regulation and Revenue Manager (E) stated that centralized datahub solution more prone to cyberattack than decentralized blockchain solution.

P2P Energy Trading was brought up in discussions from various angles. Development Project Manager (A) noted that prosumers are complaining about too low price for excess electricity that is sold to the grid and are frustrated that they can't do anything about it. (A) said that the main motive for prosumers to engage in P2P energy trading is price level and the maximal convenience of solution. Head Development Manager (M) pointed out that the challenge is to formulate the contract relations between parties and mentioned that autonomous market exchange model should be implemented for that.

(M) also stated that accountability in recordkeeping regarding the transactions is a must, but not necessary for a long period of time. Regulation and Revenue Manager (E) opposed having distribution fees in P2P Energy trading, because it wouldn't motivate onboarding of the users enough but also believe that in future DSO could be the blockchain platform operator enabling such exchange. Both Business development specialist (H) and Regulation and Revenue Manager (E) mentioned that P2P energy trade within housing blocks, could be closer to reality than P2P energy trading in neighborhoods.

Crowdfunding of renewable energy assets was discussed with Development Project Manager (A) and Business development specialist, microgrids (H). Development Project Manager (A) stated that it would be sensible to own small fraction of solar power production plant, because not everyone wants to build own plant. Development Project Manager (A) agreed that crowdfunding with tokens would lower barriers for customers to join sustainable energy production as well as earn extra income. Both (H) and (A) hesitated whether customers would understand the concept of tokenized ownership on blockchain.

Crowdsourcing for asset maintenance and inspection was mainly introduced by Asset Manager (B) but it was also discussed by Business development specialist, microgrids (H). Asset Manager (B) proposed a platform for crowdsourcing where both inspection and repair would be done with less cost than at the current moment. (B) stated that such crowdsourcing platform would enable 24/7 network maintenance at significantly lower costs. Gamification aspect was also introduced by (B), which would make the experience much more like a game where network assets are marked on the map as checkpoints that offer rewards.

Manual labor and human error discussions were predominantly related to supply chain and billing processes. These themes can be grouped because related question in semi-structured interview "*Is the current system prone to errors due to manual processes or duplication of effort?*", assume that one is a consequence of another. According the

interview majorly supply chain seems to have issues with human error due to manual labor. According Purchasing Manager (C) purchasing process involves manual labor. Procurement manager (J) stated that when contractors that build the network receive damaged goods or some part of the goods are missing the reclamation process requires a manual labor taking 1 day to several weeks. Invoicing manager (D) mentioned that before sending invoices to customers, invoice batch is checked manually for outlier values (too high or too small). Also (D) pointed out that manual labor in billing process stems often from mistakes made by customers. Privacy expert (L) mentioned that there is a risk in exposing information to outsiders as it is hard to verify the identity of the person who is contacting the customer service.

Nevertheless, manual labor and human error are strongly connected to supply chain there are various other sub-themes discussed. Purchasing manager (C) discussed the process of purchasing and pointed out that most crucial there is that ERP system has up-to-date information business information, business identity codes and correct bank accounts. According (C) main external stakeholders in the process are suppliers and contractors, while internal stakeholders are procurement department, project managers and finance department. Supply Chain Manager (N) pointed out that Supplier Relationship Management one of the key tasks of responsibility and suppliers are tiered from 1-3. The discussions that take place at the meetings with suppliers occasionally are related to monitoring how manual tasks such as reclamations are going. Traceability of the network components were popular among sub-themes. Purchasing manager (C) mentioned that currently traceability depends on the component type, as substations are traceable due to unique ID, while transformers less non-traceable. Business development specialist, metering (F) added that traceability of the smart meters is an issue, since case company doesn't know the exact number of meters and losing smart meters is costly to the case company. (C) pointed out that better traceability would be useful from network maintenance and reclamation process standpoint. Potential for improved transparency for supply chain of the brought by blockchain technology was discussed as well. Regarding improved transparency of supply chain Sustainability Manager (F) stated that it would increase the trust towards the case company.

Current and future energy communities were brought up in the discussion as well often in relation with the P2P Energy trading. Discussion with Head Development Manager (M) was completely related to local and virtual energy communities and their future design. Business development specialist, microgrids (H) said that biggest motives for establishing energy communities from DSO perspective are congestion management and opportunity to delay investments. (H) added that congestion management in Finland is not needed because grids are good enough. Regarding P2P Energy trading (M) said that challenging part is to design fair market mechanism for the energy communities. According the opinion of (H) energy communities merely don't exist on a big scale, and so far the majority of them are pilot projects.

7.3 Benchmarking Analysis

Previous chapter helped to understand what the current challenges DSOs are have in their business model. In this chapter the aim of the master thesis is to use case company interviews as guiding direction for recognizing and benchmarking blockchain innovation project clusters that respond to these challenges. In the next part we used Gassmann's Magic triangle (Figure 2.) that is designed for business model innovation consisting of four components: target customer, value proposition, value chain, value capture.

Table 13. List of blockchain energy companies

Company	Field of activity	Website
Sun Exchange	Crowdfunding	https://thesunexchange.com/
SolarDAO	Crowdfunding	https://solardao.me/
XiWatt	Crowdfunding	https://xiwatt.io/
Streamr	Data monetization	https://www.streamr.com/
Ocean Protocol	Data monetization	https://oceanprotocol.com/

IOTA Data Marketplace	Data monetization	https://data.iota.org
Datapace	Data monetization	https://datapace.io/
Geon Network	Crowdsourcing	https://www.geon.network/
Zebralancer	Crowdsourcing	https://arxiv.org/pdf/1803.01256.pdf
CrowdBC	Crowdsourcing	https://eprint.iacr.org/2017/444.pdf
Vizsafe	Crowdsourcing	https://www.vizsafe.com/
Gridchain (Ponton)	Grid management	https://enerchain.ponton.de/index.php/16-gridchain-blockchain-based-process-integration-for-the-smart-grids-of-the-future
Gridsingularity	Grid management	http://gridsingularity.com/d3a/
PROSUME	Grid management	https://prosume.io/
Filament	Asset management	https://filament.com/
Slock.it	Asset management	https://slock.it/
Pylon Network	Metering	https://pylon-network.org/
Verv	Metering	https://verv.energy/
Gridx (Gridbox)	Metering	https://gridx.de/
Grid+	Billing	https://www.gridplus.io/
Request Network	Billing	https://request.network/en/
DEEP	Billing	https://www.d33p.org/
B2P	Procurement	http://blog.dv.co.th/b2p-th.php
Skuchain	Procurement	http://www.skuchain.com
Power Ledger	P2P energy trade	https://www.powerledger.io/

7.4 P2P energy trading

Out of all blockchain innovation project clusters, according analysis of Andoni (2019) P2P trading is the most sizable and as well as it has variations of business models. There are projects that are operating as a Proof-of-Concept (PoC) on a restricted area with certain prosumers that agreed on participating in the pilot. Due to the regulatory obstacles, majority projects operate within regulatory exemptions (Richter et al. 2018).

Another typology is the of these projects such as GridSingularity just offer a P2P energy exchange, without providing the solutions for infrastructure. Out of all clusters Andoni (2019) introduced P2P trading platforms have the clear nature of a multi-sided platform because of the various stakeholders that can participate in the grid. Burger et al. (2016) defined P2P energy trading as a platform. P2P energy platforms have each own operative design. Some are designed in a way that prosumers need to make decisions to buy or sell and other platforms include autonomous agents that trade independently.

Gridsingularity is working on D3A which is a solution for modeling, simulating and optimizing energy grid. Company states that it offers Energy Exchange as a Service and before deploying P2P trading testing of scenarios are needed. Company has an open source business model, making it possible for 3rd party developers to build applications on the platform. D3A (Decentralized Autonomous Area Agent) consists of the set of smart contracts which are needed for building the energy exchange with easy access. This platform allows energy devices of arbitrary dimension to exchange electricity using scalable P2P market mechanism. At the current state, D3A is a simulation tool for studying cutting edge technology that enhance operating mechanisms of the smart grid. D3A aims for enabling to create more customizable sophisticated market structures and bidding strategies. Market hierarchies in the grid are also taken into account in such a way that it encourages trade on the local level but makes energy trading municipal and national levels possible as well. Value proposition for the energy communities is such that more renewable energy can be used and costs can be reduced. From DSO perspective it reduces the resources that DSO needs to provide for the community to keep it balanced and online. (GridSingularity 2019)

Australian startup PowerLedger offers μ Grid and xGrid solutions. μ Grid allows apartment block residents to trade solar energy with each other in the way that all residents are using the same amount of energy or are getting a fair amount for their investment. Therefore, μ Grid enables more efficient energy use and cheaper prices, improved visibility over energy consumption and improved sustainability. Also, real-estate developers can benefit from this by integrating this solution in new projects

bringing more value to the finished building. xGrid on the other hand is a solution for neighborhoods enabling P2P energy trade between neighbors, but with the feature of automatic conversion of electricity credits into FIAT currency. Power Leder Platform has an open source business model allowing 3rd parties to develop applications on top of it. Platform ecosystem utilizes two types of tokens POWR and Sparkz. Sparkz tokens are released and redeemed in the local currency for example Australia1Sparkz = 1cent AUD in exchange for POWR tokens. Application host need to purchase sufficient amount of POWR tokens to open access to the platform, similarly to software licensing. From a technology point of view Power Leder uses private Proof-of-Stake low power consumption consortium blockchain EcoChain which is responsible for Sparkz token creation, fiat payment processing, smart meter data storage and verification.

7.4.1 Opportunity for Distribution System Operator

P2P energy trading utilizes blockchain technology for disintermediation. In this use case streamlining especially the monetary flow process via smart contracts, brings big benefits by reduction of cost related to governance. Because P2P energy trading requires two-way flow of electricity in almost real time and data storage. Situation for Finland is quite good because smart meter coverage is high. Establishing a blockchain network nodes would require gateway devices to be installed which are analyzed in the *Metering & billing* chapter. P2P energy trade startups often use Ethereum blockchain network, since it capabilities such as smart contracts, linking tokens to transactions and decent speed of transactions. Mechanisms that are used for market allocation and pricing mechanisms differ from each other a lot. In majority of the mechanisms pricing is simply based on scarcity or surplus of electricity. Business models are predominantly vague, probably because the majority of are still in Proof-of-Concept phase. However, including either transaction or market access fees are possible. With adoption of cryptocurrencies designing token economics might have some potential in this use case. This can be seen either as an opportunity or threat for the DSOs current business model. The development of P2P energy trade marketplaces may potentially turn out into

a situation where network asset ownership and network operation might be limited or separated by legislators. So far, integrated network operation is seen as working efficiently under DSO and TSO cooperation, but there is a risk that tech companies break into this business with their platform solutions. Whoever platform owners might be, they will shape the governance and maintain customer relations. Cooperating with blockchain startups and electricity power system stakeholders would help to formulate business model that is mutually beneficial. This would mean having both reduced distribution fee and taxes integrated in the P2P trading platform. Another case would be that DSO would be owner of the platform itself and thereby could focus on collecting low platform transaction fees. As most viable P2P energy trading solutions are executing trades autonomously, adding high transaction fees isn't justifiable.

Distribution System Operator has a choice to either build their own P2P energy trading platform or purchase PAAS (platform-as-a-service) solution from external provider. DSOs companies benefit by reduction of administrative related cost as well as are able to grow their customer satisfaction. For the customers enabling P2P energy trading would result in reduced energy costs, enhanced choice of local green energy consumption and better transparency. As both prosumers and consumers receive more power over their decision making, it is likely that they will act and feel more as a community. In the current electricity system that is rather impossible to experience.

From a legislative standpoint starting in 2020-2021 DSOs could enable P2P trading in apartment blocks located in Finland. Therefore, something similar to μ Grid by Power Ledger might be implemented on a small-scale in collaboration with real-estate developers or housing cooperatives. When building a solution there is a need to take in consideration the hierarchical structure of the electricity markets.

DSOs majorly benefit from P2P energy trading platforms because the energy production becomes more local and thus can potentially reduce the congestion of the grid. In parallel depending on the structure of the monetization could be done by integrating transaction fees to the platform. Establishment of local energy markets paired with the

self-balancing mechanisms have potential to improve the overall grid efficiency. From a legislative point of view case company could enable P2P trading in apartment blocks located in Finland.

Table 14. Business model for blockchain enabled P2P energy trade

P2P energy trade from DSOs perspective	
Who is the target customer?	Customer groups <ul style="list-style-type: none"> - Prosumers - Housing cooperatives - Real-estate developers - TSO
What is offered to customer? (Value proposition)	Prosumers <ul style="list-style-type: none"> - Low entry barrier - Neighborhoods receive green energy - Lower electricity bill - Autonomous platform operation Housing cooperatives <ul style="list-style-type: none"> - System for fair electricity exchange between owners - Reduced energy bill Real-estate developers <ul style="list-style-type: none"> - Higher valuation of the project - Green buildings TSO <ul style="list-style-type: none"> - Better balanced grid
How is revenue created? (Value Capture)	Monetisation options <ul style="list-style-type: none"> - Transaction fees - Cryptocurrency with exchange fees - Licensing fees
How is the value proposition created? (Value Chain)	Business activities <ul style="list-style-type: none"> - Forming energy communities Technology <ul style="list-style-type: none"> - Smart meters enabling bi-directional electricity flow - Hardware connected to smart meter - Market/pricing mechanism adjusted for Finnish markets - Scalable blockchain technology Provider <ul style="list-style-type: none"> - Platform as a Service (PaaS)

7.5 Crowdfunding platform

Startups have recognized that crowdfunding on blockchain due to its programmable nature of storing and sharing value is a feasible use case. In energy sector these crowdfunding platforms such as SunExchange, XiWatt and SolarDAO provide an opportunity for individual investors located anywhere in the world to fund solar PV projects and receive a rental payment on their stake. Such crowdfunding platform enables possibilities of participating in sustainable energy production at affordable rates. SunExchange crowdfunding platform assesses project viability using industry standard due diligence, engage local operation and maintenance providers, structure the lease and other contracts, provide and lease balance of system equipment, establish account to segregate funds, arrange foreign currency / digital currency transactions, monitor equipment using solar smart meters. Out of the case companies of this cluster SunExchange has a working product, while SolarDAO and XiWatt are in a development phase.

Blockchain technology is utilized for splitting the solar panel ownership per single solar cell using tokenization and payments. The property owner that is using the solar panels have agreed to pay to individual investors through a lease rental contract. Property owner payments go to third-party escrow account. As property owner uses the solar system, funds from escrow account are transferred to individual investors accounts automatically. In the case of SunExchange payments are paid in either ZAR or bitcoin. SunExchange that operates in South Africa realized that financing is very common constraint for deployment of solar panels, therefore cryptocurrencies open borderless opportunities for addressing this. Through crowdfunding platform individual investors have direct access to real-time performance data and rental income generation. Crowdfunding platform is multi-sided, since it has more than 2 entities involved in the

business. SunExchange has 6 entities involved: Lessee, Lessor, Insurance company, Solar Panel equipment provider, Bank, Cryptocurrency exchange (SunExchange 2019b).

Overall, Sunexchagne, SolarDAO and XiWatt crowdfunding platforms have many similarities. However, differences there are some differences in the features. Especially novel patented Cloud Net Metering application by XiWatt allows users to pay electricity bill using energy credits generated by their tokenized ownership of renewable energy projects regardless of the utility provider (Choudhry et al. 2018).

7.5.1 Opportunities for Distribution System Operator

Blockchain-enabled crowdfunding platform doesn't have a direct disruptive impact on the DSO's business model, but it demonstrates the real use case for crowd ownership of real-world assets. Case company's strategy is to grow the number of solar panels installed in its region and foster sustainability. The goal of installing more solar PVs is aligned with policies related to climate change. Such crowdfunding platform makes installation PV accessible to more people, especially to those living in countries with high interest rates on capital.

According discussion with Development Project manager (A) there would be sense in owning smaller fractions of a solar power production plant, because everyone doesn't have enough funds to purchase complete solar panel. (A) also emphasized that it would lower the barriers for customers to join sustainable energy production, but the issue might be in the familiarity of Finnish people with tokens. Distributed profits from solar panel leasing could be used to offset distribution fees, reducing the cost for customers. Crowdfunding business model can also function in benefit for financing the projects that property owners in Finland propose. Sustainability oriented customers would be eager to invest in profitable projects that enhance sustainability in developing countries. Off course in order to invest in the project KYC/AML need to be taken in consideration from

the legislative standpoint, as well as taxation. Such crowdfunding democratizes investment opportunities making them accessible to the public. Crowdfunding business model is flexible so it could also be applied for financing battery storage, electric vehicle charging stations, wind or hydro energy projects - basically any infrastructure that can generate income. Crowdfunding model could be even further democratized by enabling individual investors to vote on service provider completing the work and insurance company in the investment phase.

Benefits of having blockchain enabled crowdfunding is that it makes funding process safe and globally accessible. In the well-known crowdfunding platforms such as Indiegogo or Kickstarter, there are a variety of transaction fees charged. Utilizing smart contracts can lower both the transaction costs to all parties and automatize the dividend payout. Integrating smart contracts in the platform enables better accountability in crowdfunding - project could have set milestones that would constrain funds from being transferred without provenance as to the project's legitimacy. Having tokens representing the ownership provides an opportunity for liquidity of physical asset ownership, thus secondary market for the tokens could be established as well.

Table 15. Business model for blockchain enabled crowdfunding

Crowdfunding platform from DSO perspective	
Who is the target customer?	<p>Customer groups</p> <ul style="list-style-type: none"> - DSOs Customers - Individual investors - Property owners - Insurance - Renewable energy hardware producers
What is offered to customer? (Value proposition)	<p>Individual investors</p> <ul style="list-style-type: none"> - Receive rental payments for their ownership in the projects. - Profits from sustainable energy production can also be donated to charities.

	<p>Property owners</p> <ul style="list-style-type: none"> - Reduction of overall energy costs without having to deploy their own capital - Lowers carbon emissions <p>Renewable energy hardware installers</p> <ul style="list-style-type: none"> - Companies receive more projects for fulfillment.
How is revenue created? (Value capture)	<p>Adopted from (Sunexchange 2019)</p> <ul style="list-style-type: none"> - Service fee - Dealer markup on project value - Ownership of plant balance equipment - Operational and financial data - Increased Corporate Social Responsibility
How is the value proposition created? (Value Chain)	<p>Business operations</p> <ul style="list-style-type: none"> - Marketing activities - Leasing arrangements with lessee - Establishment of Special Purpose Entity for the project - Profit distribution to lessors <p>Technology</p> <ul style="list-style-type: none"> - Tokenization of renewable energy asset ownership - Platform for listing projects - Blockchain technology for ownership registration - Smart Contracts

7.6 Data marketplace

Data monetization use case is rather related to almost any contemporary business, but as it was brought up in the interviews, it is equally relevant in the energy industry. When compared with antecedents, blockchain enabled data marketplaces emphasize fairness and privacy in their business models. Majority of analyzed companies have open source business model and they are in prototype phase (Streamr 2019; IOTA 2019; Ocean Protocol 2019). In opposition one of the analyzed companies - Datapace is based on private and permissioned blockchain, thus only authorized participants can join and read. As an example, Streamr Network enables entities to capitalize on their personal data streams through marketplace using DATA cryptocurrency (Streamr 2017). Analyzed data marketplaces don't focus on specific types of data but are trying to grow

their platforms with any type of data streams. What these data marketplaces have in common, data streams listed on the platforms come mainly from IoT-devices (Streamr 2019; IOTA 2019; Datapace 2019). The need for this type of data marketplaces is inevitable, because enterprises generate plenty of data that is stored in silos, while they could provide value across enterprises (IOTA 2019). In addition, there is an imbalance in the amount of data, as some companies have enormous datasets in their possession (Ocean Protocol 2019). Analysts state that unlocking data streams in the open market has potential for improving Artificial Intelligence (AI) models to become more accurate. Blockchain enabled data marketplaces unlock the possibility for a fair data economy where data owners can capture value on their own terms and enterprises access new data streams legally. Data streams on these platforms are sold on an hourly rate. Blockchain based data marketplaces are multi-sided because in addition to buyers and sellers they involve transaction validators who are incentivized with cryptocurrency.

Data marketplaces utilize both blockchain technology for secure transactions and smart contracts for automation of data stream exchange. Blockchain is used to verify that data comes from trusted sources, quality of the data is validated by the network.

7.6.1 Opportunities for Distribution System Operator

According to a Data Scientist (G) a Distribution System Operator manages various amounts of data related to network, electricity connection, IoT sensors, customer and invoicing data. Anything but the customer and invoicing related data could be put freely on the data marketplace. As in discussion with Data Scientist (G) of the case company especially network management and network components related data would be sellable. There are of course possibilities to sell the customer data if the customer consent is received. Instead of doing that, the case company has an option to enable customers to open their data on the data marketplace. For example, Streamr enables customers to create a data community and have one-to-many split of cryptocurrency payments with DATA token for the bundled data stream. This could be applied for any

streaming data for example smart meter data. Startups or technology companies could be interested in using such data for training their AI, building ancillary services or improve hardware solution while customers would receive a fair payment for their participation. IOTA Foundation sees a concept of “smart business models” where data marketplaces create means to create and capture value in the environment where sensors and IoT devices will trade data directly.

Existing open source model blockchain enabled data marketplaces provide a low barrier for frictionless, safe and secure data exchange. There is a clear interest among energy sector in blockchain enabled data marketplace - as example IOTA Proof-of-Concept Data Marketplace had Alliander, Agder Energi, Enexis, Elering, Engie Lab as participants (Harbor 2019). In discussion with (G) pricing of the data was brought up as a complex problem. Ocean Protocol has a separates pricing in three levels: free data, regulated non-free fungible data, regulated non-free non-fungible data (Ocean Protocol 2019).

Table 16. Business model for blockchain based data marketplace

Data marketplace from DSOs perspective	
Who is the target customer?	<ul style="list-style-type: none"> - European DSOs - European TSOs - Network component producers - Startups companies - DSO customers
What is offered to customer? (Value Proposition)	<p>All customers are able to exchange data in traceable, secure and private manner.</p> <p>European DSOs and TSOs</p> <ul style="list-style-type: none"> - Opportunity to capitalize on the network component data - Make business more data driven <p>Network component producers</p> <ul style="list-style-type: none"> - Purchasing data for component improvement - Benchmarking <p>Startup companies</p> <ul style="list-style-type: none"> - Purchase data for training AI models

	<p>Marketing companies</p> <ul style="list-style-type: none"> - Bundling electricity consumption data to create better insights <p>DSO customers</p> <ul style="list-style-type: none"> - Can sell self-generated consumption data
How is revenue created? (Value capture)	<ul style="list-style-type: none"> - Creating native cryptocurrency to the platform that is required to purchase in order to transact on the platform.
How is the value proposition created? (Value Chain)	<p>Technology</p> <ul style="list-style-type: none"> - Public blockchain infrastructure - Smartphone application interface for customers - Smart contracts - Zero knowledge proofs

7.7 Crowdsourcing platform

According to Howe (2006) crowdsourcing is “*The act of taking a job traditionally performed by a designated agent (usually an employee) and outsourcing it to an undefined, generally large group of people in the form of an open call*”. It was difficult to find operating crowdsourcing platforms that use blockchain. Mainly there are scientific papers proposing a solution named Zebralancer and CrowdBC. They focus on creating blockchain based platform for sourcing tasks that are carried out online. Mainstream crowdsourcing platforms such as Upwork, Amazon Mechanical Turk or Freelancer utilize centralized servers, which are prone to cyberattacks and are single point of failure (Li et al. 2018). Since these platforms store user sensitive information, for malicious actors it is a lucrative target. In addition, platforms also tend to collect fees between 5-20% on the completed work, while operating as a trusted third party (Upwork 2019).

Proposed decentralized crowdsourcing would guarantee privacy by allowing users to register without true identity and storing encrypted solutions in the distributed storage, ensuring the protection from DDos and Sybil attacks. Service fees are replaced

with small transaction fees. CrowdBC solution would utilize smart contracts through the whole process such as task posting, task receiving and reward assignment, without the need for central authority. CrowdBC prototype was implemented on Ethereum public testnet and could handle basic crowdsourcing process, but there is more complex situation to handle. (Li et al. 2018)

The working crowdsourcing blockchain applications are linking the physical world to blockchain. Vizsafe is building the first blockchain solution that incentivizes the crowd to improve safety awareness everywhere people go. This application is in use at some of the world's most valuable facilities - Vizsafe platform enhances is situational awareness with real-time actionable information for any issue of concern such as faulty equipment, lost children, inappropriate behavior and even major security threats. Solution combines blockchain with crowdsourcing by providing open transparent and tamper-proof record for safety security and risk management applications. With smartphone cameras - staff, partners and visitors can share geo-located photos and videos to reduce safety risk and speed resolution. Streamlining response and resolution Vizsafe can prevent millions of dollars in potential losses while creating a strong public economy of information. Through this ecosystem customers are able to purchase Vizsafe's SPOT tokens to reward anyone who contributes to distributed public ledger of safety reports. (Vizsafe 2018)

Another blockchain based decentralized application is Geon App, which allows users to get paid with Geon coins cryptocurrency for visiting real-world locations. In exchange for the Geon coins users can redeem rewards such as gift cards. Businesses can purchase Geons and place them in the location they want on the map with the secret message such as discount codes or other surprises to the customers. Geon Network is mainly used for location-based marketing, but it can be used for other purposes as well such as charity. Geon Witness is the proof-of-location platform that acts as a major part of the Network, creating the digital certificate that encodes devices coordinates at certain times. Witness offers a verifiable, immutable and trustless mechanism for devices to demonstrate their geographical location, while preserving user privacy. Geon Coin is an

in-application stablecoin that is pegged 1:1 to USD, therefore avoiding the price fluctuations of cryptocurrencies. Utilization of smart contracts ensures that rules defined by the Geon creators can't be altered by the platform. (Geon Network 2018)

Both Geon Network and Vizsafe are decentralized applications which are freely available on the smartphone. Both of them act as a two-sided market connecting the requester and worker. Geon Network utilizes augmented reality and gamification making the process of finding Geons exciting for the user. The benefit of using blockchain in the platforms are the fact that transactions become trustless, immutable and auditable.

7.7.1 Opportunities for Distribution System Operator

As it was discussed with Asset Manager (B) of case company there is an interest in using crowdsourcing for completing the network inspection and maintenance tasks. This is due to the fact that distances between case company assets such as substations and cabinets are getting longer and therefore costs related to inspection and maintenance related tasks will increase per each asset. (B) emphasized that crowdsourcing platform should be designed in a way that it is open to everyone, does not store any personal data, information can be verified, and rewards are paid out in tokens. The platform interface would show a map that indicates the location of the assets that need inspection. (B) also brought up the possibility of gamification, making it more engaging and competitive. User would be required to provide text and footage information the case company needs for inspection.

As discussed in the previous paragraph the existing application have something in common with the criteria that (B) set. The application would require a cryptocurrency that would be pegged to the value of the euro to avoid the fluctuation, naturally some transaction fees would occur while exchanging token for euro, or otherwise. Instead of exchanging the tokens for FIAT currency, it could be exchangeable for gift cards or

reduced from the customers distribution fee. Especially in such platform it would be important to validate that person is really located near the network asset, therefore similar proof-of-location validation method like in Geon Network could be utilized. Geon application collects data related to GPS coordinates, Base Transceiver Stations, Wifi networks, Bluetooth devices, device fingerprint and does cross-validation. Having collected the aforementioned data, it should be enough to verify that application user is really located near DSOs network assets. Also, the marks on the map could be programmed into being re-occurring enabling continual network inspection rate. Asset-related Information provided by the user should be encrypted and stored on a blockchain to ensure security. Machine vision could be used to validate whether the network asset is damaged.

(B) also discussed that opening the crowdsourcing of small jobs for electricians would be useful too, since they could complete them on the go. This type of a job marketplace integrated in the same application that rewards users for completing the inspection. Such structure would make inspect - repair loop possible, streamlining the process of posting the jobs automatically if damaged asset is found. Streamlining is made possible with smart contracts that unlock the rewards as the job is completed. At first the the DSOs employees create smart contracts them in the system by marking the exact geolocations of the assets on the map. In such platform it would be important to verify that the electrician is licensed. License verification could be done using Zero-knowledge proof which allows to prove that something is true without showing it. (H) Business development manager specializing in microgrids stated that use of blockchain could be used for tracking quality and performance of the specified electricians in the crowdsourcing platform.

Table 17. Business model for blockchain crowdsourcing platform

Crowdsourcing platform from DSOs perspective	
Who is the target customer?	<ul style="list-style-type: none"> - Application Users - DSOs customers - Electricians

<p>What is offered to customer? (Value proposition)</p>	<p>Application Users</p> <ul style="list-style-type: none"> - Fun and gamified experience with AR - Ranking among app users - Quick extra income <p>DSOs customers</p> <ul style="list-style-type: none"> - 24/7 maintenance of the grid - Quicker fixation of outages <p>Electricians</p> <ul style="list-style-type: none"> - Platform for receiving jobs that can be completed on the go - Quick extra income
<p>How is revenue created? (Value capture)</p>	<ul style="list-style-type: none"> - DSO is able to become more agile in procuring electricians - Network asset inspection costs reduces significantly
<p>How is the value proposition created? (Value Chain)</p>	<p>Business activities</p> <ul style="list-style-type: none"> - Platform marketing - Educating users <p>Technology</p> <ul style="list-style-type: none"> - Smartphone application interface - Proof-of-location validation method - Blockchain technology - Token reward system - Smart contracts - Zero knowledge proofs for identity verification

7.8 Blockchain enabled metering and billing

In order to provide better metering to current system blockchain startups such as Filament, Pylon Network and Verv. All of them provide metering solutions to enable P2P energy trading in the coming future reducing the role of DSOs.

Filament offers blockchain solution for real-time monitoring, smart metering and asset management enabled by their Blocklet hardware devices. Hardware devices are deployed to sign verify, sign, hash and encrypt bidirectional power flows. Filament uses private blockchain and therefore data is transmitted to predefined validator node which confirms that smart meter isn't fraudulent and adds transaction to the ledger. Particular

benefit of this solution can be easily integrated into current infrastructure. (Filament 2019)

In comparison Pylon Network developed blockchain integrated smart meter Klenergy Metron that is capable of tracing, recording energy produced and consumed in real-time as well as making transactions using Pyloncoin cryptocurrency. So far the company hasn't released the working product. (Pylon Network 2017)

Verv Energy offers a hardware device that can be connected to any smart meter without the need for an electrician. Most smart meters take readings every 15-30 seconds while Verv checks the electrical signal million times a second enabling the to see real time how much electricity is being used, what appliances are live and how much their usage costs and what is their condition. Verv can be connected via Wifi to devices and enable remote monitoring and control over them. The device is listed on Amazon.uk for 255 pounds. Due to hardware and machine learning capabilities, Verv decided to move further into creating own Peer-to-Peer energy trade platform. (Vlux 2018)

In UK, Electron introduced a blockchain based system for registering smart meters that would serve consumers better. In the novel system, customers are able to switch electricity supplier in a matter of minutes. The current solution is offered free of charge to utilities, because Electrons aim is to build ancillary services on top of it. Concept has been tested on Ethereum blockchain with 53 million metering points and 60 energy suppliers. (Fuelsave 2016)

Regarding billing DEEP has introduced an application for decentralized billing tailored specifically for the energy sector. Decentralized application significantly shortens meter-to-cash cycle and enables more flexible products based on vast amounts of collected data. Aforementioned DEEP billing app have been implemented countrywide in Luxemburg by Enovos. Using DEEP system operators are able to incorporate more than 5000 data points daily per each smart meter. Solution is built on private Ethereum network enabling transactions speed of 200-300 transactions per second. Assuming

that chain would be hosted on the Amazon Web Services (AWS), price per invoice would be between 1.50 € - 1.80 €. (DEEP 2018)

Another notable blockchain based solution for billing is introduced by Request Network which is open network for transaction requests empowering anyone to produce, store and access invoices in overreaching, decentralized network. This solution can be integrated into existing software. The features include automated reconciliation linking the invoices with payments, supporting any currency and secure financial records. (Request Network 2018)

7.8.1 Opportunities for Distribution System Operator

In discussion with Asset Manager (B) and Regulation & Revenue Manager (E) particularly safety and cybersecurity of distribution line and measurement data accuracy was discussed. (B) indicated that use of blockchain in the registration and storage of network related information and metering information might be useful. ICT-Manager (O) said that from DSO it's impossible to be connected to every meter constantly and mainly meters use Power Line Cable communication. According discussion with (O) particular issues in the metering process are related to information transfer between systems and to external parties' systems. Invoicing manager (D) pointed out that problem in invoicing roots from the slow delivery of metering data, connection issues and faulty customer contract information. In discussion with (D) invoicing process has variation of intermediaries and ways to complete the payment making it complex. (D) said that payment slowness affects customer satisfaction. (E) proposed use of smart contracts for billing and reclamation process.

Measurement process as it is working now is rather complex and point of failure exist. For DSO it has a role in both current core business because of the direct linkage to billing, but also in future better measurement is required to enable Peer-to-Peer energy trading and data marketplace. At current state looks like streamlining the meter-to-cash

process might be the most helpful for the overall improvement of the DSOs core business.

In the current customer invoicing process problem lies the fact that the big amount of bills is still sent over the mail because of the consumers preference. Therefore, removing intermediaries from the current process is difficult. This process is more related to educating customer than to use contemporary ways of payment. Bypassing current structure would require educating customers on using the web services and introducing a novel cryptocurrency for transferring the value. DSO could collaborate with electricity retailers and provide billing services where both sides will win, and the transaction costs can be split equally driving down costs even lower. Another approach would be to build a solution and charge retail companies with invoicing fees.

Table 18. Blockchain enabled metering and billing

Blockchain based metering and billing from DSOs perspective	
Who is the target customer?	<ul style="list-style-type: none"> - DSO - TSO - DSOs customers - Energy retailer - Third-party providers
What is offered to customer? (Value Proposition)	<p>DSO</p> <ul style="list-style-type: none"> - Immutable records and transparent processes enhance regulatory compliance - Improved security of the system - Enabling other use cases <p>DSO customers</p> <ul style="list-style-type: none"> - Speedy and transparent measurement process. - Granularity of the measurement - Near real-time billing - Option to switch electricity supplier dynamically - Optimization of electricity bill <p>Energy retailer</p> <ul style="list-style-type: none"> - Better customer experience <p>Third-party providers</p> <ul style="list-style-type: none"> - Opportunity to build ancillary services on top

How is revenue created? (Value capture)	<ul style="list-style-type: none"> - Billing processes will need less manual labour bringing costs savings - Novel billing process will improve the payment rates and reduce the transaction fees
How is the value proposition created? (Value Chain)	<p>Technology</p> <ul style="list-style-type: none"> - Hardware devices connected to smart meters or updated smart meters - Blockchain platform - Smart contracts

7.9 Blockchain enabled procurement

Out of all interviews particularly Purchasing manager (C), Procurement manager (J) and Supply Chain Manager (N) discussed the pain points of the current supply chain process. Especially discussion with (C) indicated that procurement has the most friction in the whole supply chain process. In this process, external stakeholders are suppliers and contractors who build the network. In discussion it was revealed that there is quite some manual labor related to communication with stakeholders, verifying and processing invoices. There wasn't as much concern about fraudulent invoices, but traceability of the network assets is an issue because in some situation company doesn't know the exact amount of assets. Currently traceability is dependent on supplier and component type. Substations have unique ID, but transformers are delivered in batches to wholesaler and they aren't identified anyhow. (C) agreed that better traceability and would support both reclamation and maintenance processes.

Procurement manager (J) pointed out that factory approval tests that have 2 rounds and it takes from several weeks to months. After the first review is completed remarks are sent to supplier and supplier does changes in the product. When changes are done, another test is completed. The whole process is completed by sourcing and technology team using standardized checklist. In discussion with (J) pain points of reclamation process of the contractors was discussed as well. Always when contractors receive the delivery they are required to check and verify whether something is missing or

damaged. If something happened, contractors create a reclamation in ordering system and case company forwards them to material supplier manually via email. Once in 2 weeks there are follow up calls with supplier where status of reclamations is gone through.

Suitability of blockchain is high in the procurement, because it eliminates the need to double check and match information as it guarantees authenticity, accuracy. Therefore, blockchain can make numerous procure to pay documentations irrelevant. Often blockchain enabled procurement could require case company to establish a common system with the suppliers and contractors based on the consortium blockchain. Therefore, enhancing the process would require case company's external stakeholders to benefit equally from the application. In this process interests are aligned and therefore it is highly likely that such collaboration is possible. Also, technical challenge lies in building a connection between the ERP system and the ledger where information is stored.

Out of the all use cases for blockchain procurement is the most mature from regulatory perspective and has the quickest impact on operational efficiency and savings, but it doesn't capture more value. Blockchain procurement startups analyzed in this study are highly focused on driving value to enterprises using private blockchain solutions.

B2P is Procure-to-Pay solution that is still in production phase and is using Corda blockchain technology. The solution is possible to easily integrate with existing ERP systems enabling managing purchase orders and goods received using platform. B2P platform enables all parties that participate in procurement process to access relevant information from the issuance of purchase order to completion of payment. In case that buyer hasn't paid on time it also enables efficient invoice financing. Platform automatically does match between purchase orders, goods received and invoices. Invoice financing capability is integrated as well taking process down to days from weeks. (R3 Corda 2018)

B2P works in the following way. When buyer orders the goods, the purchase order is sent from ERP to B2P platform and is promptly visible to supplier. After goods are delivered “goods received” from ERP is sent to the platform and is also visible to counterparties. Supplier submits electronic invoice via B2P platform or can request invoice financing service from the bank. During invoice verification platform automatically validates information against purchasing order and goods received. After invoice is approved it will be visible to supplier and bank - on the due date bank transfers specified amount into suppliers account. (Digital Ventures 2018)

Another blockchain solution that takes more end-to-end approach is Skuchain EC3 platform that enables secure sharing of data among stakeholders. Skuchain platform uses Popcodes traceability and Brackets smart contracts technologies which can be deployed in applications to match tailored use cases. EC3 is designed to be integrated in enterprise IT, with capabilities of bringing data from ERP, industrial scanners, 3rd party supply chain management tools and Excel sheets. (Skuchain 2019)

Brackets smart contract technology is used for governing the whole purchasing process. It is capable of offering instant audit of financial transactions that exceeds ERP systems. Purchase Orders, Invoices, Letters of Credit or other supply chain transaction related information can be automated execution based off the trigger on the blockchain. These triggers are flexible: they can be partly manual, tied to IoT or set workflow operations. (Skuchain 2019) EC3 platforms introduce Collaborative Resource Planning (CRP) that allows stakeholders to cooperate on decentralized ERP. Three main functions of CRP are Event Broadcaster, the Contract Builder and BOM Buyer. Event Broadcaster sends information through supply chain, CRP platform is powered by Zero Knowledge proofs, technology that enables proving that something is true without revealing the actual information. CRP platform reduces amount of procurement errors, faulty finished products and late deliveries. (Skuchain 2019b)

Skuchain also offers Proof-of Provenance codes (Popcodes) which are tokenized identifiers that provide traceability to track products in the supply chain. Technology is

advanced enough to track the transformation of components or materials into finished product providing full transparency over the life cycle. (Skuchain 2019c)

Table 19. Blockchain enabled procurement

Blockchain enabled procurement from DSO perspective	
Who is the target customer?	<ul style="list-style-type: none"> - DSO - Suppliers - Contractors - Manufacturers
What is offered to customer? (Value Proposition)	<p>DSO</p> <ul style="list-style-type: none"> - Collaborative resource planning - Quick, secure and transparent Procure-to-Pay process - Up-to-date information in ERP systems - Enhanced traceability of network assets - Follow ups not required - Reduced manual labor <p>Suppliers</p> <ul style="list-style-type: none"> - Better collaboration with DSO - Quicker payments - Enhanced traceability of products - Precise and quick disputes solving <p>Contractors</p> <ul style="list-style-type: none"> - Speedy reclamation process - Frictionless material ordering - Faster communication <p>Manufacturers</p> <ul style="list-style-type: none"> - Transparency in production process - Traceability of the manufactured parts
How is revenue created? (Value capture)	<ul style="list-style-type: none"> - No revenue is created, but sizable and sustainable procurement related cost savings
How is the value proposition created? (Value Chain)	<p>Business activities</p> <ul style="list-style-type: none"> - Requires partnering with suppliers and contractors - Negotiating the splitting of cost if implementing the solution - Attaching tokenized identifiers to the parts <p>Technology</p> <ul style="list-style-type: none"> - Consortium blockchain solution - Integration with ERP systems and other systems

	<ul style="list-style-type: none">- Zero knowledge proofs- Tokenized identifiers
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7.10 Decentralized Grid Management

Companies that provide decentralized grid management majorly focus on coordination between grid operators, verification of grid asset, visibility of distributed resources and assets. The challenge that is faced related to decentralized grid management is the requirement of smart meters, grid infrastructure, control and communication systems to be connected to distributed ledger (Andoni et al. 2019). Grid management cluster oversees the whole electricity power system; therefore, it overlaps with metering and billing clusters.

Flexibility in power grids are provided mainly by large-scale generators. But as in the future more small-scale producers and prosumers join the network, complexity of the system will increase but the same level of supply and demand must be achieved. Gridchain offers a solution for requesting balancing and congestion management between TSOs, DSOs and aggregators. In grid congestion situation DSOs can request balancing before the delivery period. With this solution overall communication can be improved. (PONTON 2018)

Prosume Solutions is aiming to create ECP (Energy Commons Protocol) system where settlement process of locally measured energy data exchange can be addressed between providers, utilities, DSOs, TSOs and clients without the need for intermediary. Company introduces decentralized pool of data that would allow prosumers to contribute to grid balancing, unlock near real-time data for individual consumers. (Prosume 2019)

TSO TenneT and energy storage provider Sonnen teamed up to build decentralized PV storage systems on blockchain to help stabilize the grid. Pilot project launched in 2017 ended successfully in 2019 with TenneT continuing on examining other use cases as well. TenneT used virtual power station aggregated from Sonnen energy storage systems that were giving or taking out excess electricity in near real-time. All the measures of the storage systems were registered singularly on the IBMs Hyperledger private blockchain. It was proven that blockchain is quick and secure solution with small transaction fees. Close collaboration with DSOs was emphasized on further development of blockchain pilots (TenneT 2019).

7.10.1 Opportunities for Distribution System Operator

In the opinion of (H) demand response markets will most likely be supervised by Transmission Service Operator which currently has 6 different grid balancing markets. These markets are maintained with other Nordic TSOs. Currently the participation there requires making contract with Finnish TSO Fingrid and that is only possible if entity can offer a considerable amount of production or load capacity. Balancing markets currently are working operation on hourly basis with rigid pricing of upper balancing energy prices and lower balancing energy price. Prices for balancing energy can be seen from Nord Pool electricity exchange 2 hours before the actual balancing need.

The main benefits regarding the grid management for DSO lay in enabling the possibility for better communication with the TSO and other electricity power system stakeholders. Enhanced data sharing would increase current operational efficiency, acting as a stepping stone before the full-fledged automation. Pilot project between TenneT and Sonnen showed that potential scenario for the future balancing markets in Finland might become more inclusive with prosumers in the case if PV and battery storages will get adopted. Enabling small scale producers and maybe even EV car owners to offer flexibility to the market would be possible. Opportunity derives from increased customer satisfaction if such market is established, unlocking the extra

income for the customer. However when it comes to balancing the grid in Finland, studies have indicated that currently Finnish distribution networks are strong despite the growing amount of EVs and distributed energy production, therefore there is a small amount of congestion (Energiategollisuus 2018).

Table 20. Decentralized grid management

Decentralized Grid Management from DSOs point of view	
Who is the target customer?	<ul style="list-style-type: none"> - DSOs - TSO - Prosumers
What is offered to customer? (Value Proposition)	<p>TSO</p> <ul style="list-style-type: none"> - Improved grid balancing - Better communication with DSO <p>DSO</p> <ul style="list-style-type: none"> - Less manual labor - More autonomous grid management <p>Prosumers</p> <ul style="list-style-type: none"> - Autonomous grid operating
How is revenue created? (Value capture)	<ul style="list-style-type: none"> - No revenue is created but reduction of manual labor will reduce the operational costs
How is the value proposition created? (Value Chain)	<p>Business activities</p> <ul style="list-style-type: none"> - Negotiating with TSO and other local DSOs to establish a common private blockchain <p>Technology</p> <ul style="list-style-type: none"> - Private or consortium blockchain - Smart contracts - Oracles - Integrating existing systems

7.11 Business model innovation typology analysis

This part aims to categorize business models that were analyzed through typologies that Foss and Saebi (2017) introduced in literature review. According Foss and Saebi (2017) business models are categorized into four types: evolutionary, adaptive, focused and complex business models in terms of “scope” and “novelty”. Scope refers to size of architectural and modular change. Novelty on the other hand is measured on scale new to firm and new to industry.

Goal is to define typologies of the business models analyzed in the previous chapter. Thus, P2P energy trading, crowdfunding platform, data marketplace, maintenance crowdsourcing, metering and billing, blockchain enabled procurement and decentralized grid management will be placed in the typology matrix. The results of the analysis are concluded in the Table 21.

Table 21. Typologies of the blockchain based business model innovations

Blockchain based business model Innovation	Defined typology
P2P energy trading	Complex BMI
Crowdfunding platform	Evolutionary BMI
Data marketplace	Focused / Complex BMI
Maintenance crowdsourcing	Evolutionary BMI
Blockchain enabled metering and billing	Focused BMI
Blockchain enabled procurement	Focused BMI
Decentralized grid management	Focused BMI

P2P energy trading hasn't yet been fully implemented and some companies are just testing it's application. It's the type of innovation that fully shifts the whole electricity power system from electricity markets and electricity distribution standpoint. Potential effect on the core business model of DSO can be major. Deducting that Peer-to-Peer energy trading is a rather incumbent solution with a big impact on the business models

architectural changes it can be defined as *complex BMI*. P2P energy trading has also strong linkage to adoption of renewable energy assets, as more of those are established, more renewable energy owners would want to sell self-produced energy directly to their neighborhood.

Crowdfunding platform for renewable energy projects as business model innovation isn't exactly novel to the industry since there has been existing platforms that don't utilize blockchain technology (Solarplaza 2014). From DSOs standpoint this business model is not related to the core business therefore it in a sense would be a modular change that has the potential to foster the customer engagement (Development Project Manager (A)). Based on these aforementioned statements from DSO standpoint crowdfunding platform can be seen as *evolutionary BMI*. Additionally, establishing crowdfunding platform would support the P2P energy trading platform business model, because it would bring more users there.

Data marketplace Energy companies have been participating in PoC (Proof-of-Concept) data marketplaces but the fact is that data is still siloed and not utilized properly, therefore it is a novel business model for the whole industry. Even through other businesses do data-driven decision-making energy companies are also adapting it slowly. If DSO becomes a data marketplace operator it can be seen as a *complex BMI*, but if DSO just decides to participate in data marketplace it's more of a *focused BMI*. From DSOs core business model standpoint data marketplace is a *focused BMI* but depending on the future changes it could be defined as *complex BMI*.

Maintenance crowdsourcing as a business model innovation maintenance crowdsourcing isn't that novel to the industry since SAP Coremoments Crowd Service solution used by 162 million people worldwide is also marketed to energy, power and utilities sector (Coremoments 2019). Maintenance process is the one already operating therefore fine-tuning it with blockchain would touch only part of the whole business model, therefore it could be defined as *evolutionary BMI*.

Blockchain enabled metering and billing Blockchain based metering and billing has been tested in pilot projects therefore it is still clearly new to industry. Therefore, its arguable to declare that blockchain enabled metering and billing is new to the firm. From DSOs core business perspective, the change requires a lot of work, but it is a rather modular than architectural. Smart metering devices have been existing for over a decade (Business development specialist, metering F) and invoicing processes have been existing from the very beginning. Therefore, improving metering and billing process with blockchain is a focused *BMI*.

Blockchain enabled procurement There hasn't been found evidence that utility companies might be using blockchain enabled procurement, therefore it can be defined as rather new to the industry. However, out of all use cases blockchain enabled procurement has been the most mature business model innovation. From DSOs core business perspective procurement has an especially important role at the point when big network upgrades are happening, but not these are not happening constantly. Improving procurement process with blockchain would therefore be *focused BMI*.

Decentralized grid management Proof-of-concepts (Gridchain 2019) related to decentralized grid management exist, but it is still relatively novel innovation to the industry as real implementation is still lacking working implementation. Therefore, decentralized grid management can be seen as a rather new to the industry. From DSO core business perspective grid management is one of the major tasks of the company but improving grid management coordination would be a modular shift in the business model therefore it can be defined as *focused BMI*.

7.12 Designing platforms from business models

After analyzing business models that blockchain enables for Distribution System Operators, some of them were recognized as multi-sided platforms, since they involve multiple entities that transact inside platform ecosystem. In the business model analysis

clear two-sided or multi-sided platforms recognized were **P2P Energy trading, Crowdfunding platform, Data Marketplace** and **Crowdsourcing platform**. In this chapter the potential scenarios for these platforms will be using novel Platform Design Toolkit methodology introduced by Cicero (2019). Out of whole toolset particularly Ecosystem Canvas and Motivations Matrix will be used. Aim of this chapter is to define platform entities of the multi-sided platforms that were recognized in benchmarking analysis and estimate their motivations for value exchange. Secondary aim is to validate suitability of Platform Design Toolkit methodology for assessing blockchain-based platforms.

7.12.1 P2P energy trading platform scenario

Ecosystem canvas was relatively suitable for designing the P2P energy trading platform (Figure 16.), but the complexity of the whole business model structure made it difficult to bundle electricity market counterparts into cluster due to their distinct nature. As entities that collaborate with *Utilities* cluster consist of Transmission Service Operator (TSO) and Distribution System Operators (DSO). *Platform Developers* on the other hand includes the blockchain startups, hardware startups and 3rd party developers - is a cluster that build the technological basis to the platform and solves the complex customer requirements. External stakeholders are loosely clustered, and they are energy authority, tax office, government and municipalities. Energy authority regulates and fosters the operation of the electricity markets, use of renewable energy and emission reductions. Tax office is interested in the taxation of locally produced electricity. Government defines the legislative frameworks for the platform.

Prosumers cluster consists of both housing cooperatives that produce renewable energy and house owners that produce renewable energy. Using ecosystem canvas, it was difficult to define whether prosumers are peer producers or peer consumers, since they will actively both consume self-produced energy as well as sell it to customers.

Customers cluster is broad as well since electricity could be sold to different markets on micro level from individual customers and macro level to energy retailers, aggregators and wholesalers. In this platform DSO could act as an owner because the expertise and

market position is closest to the individual customers and prosumers (see Electricity Power System chapter), therefore it would be a clear evolution enable Peer-to-Peer energy trading as more distributed energy resources are joining the grid.

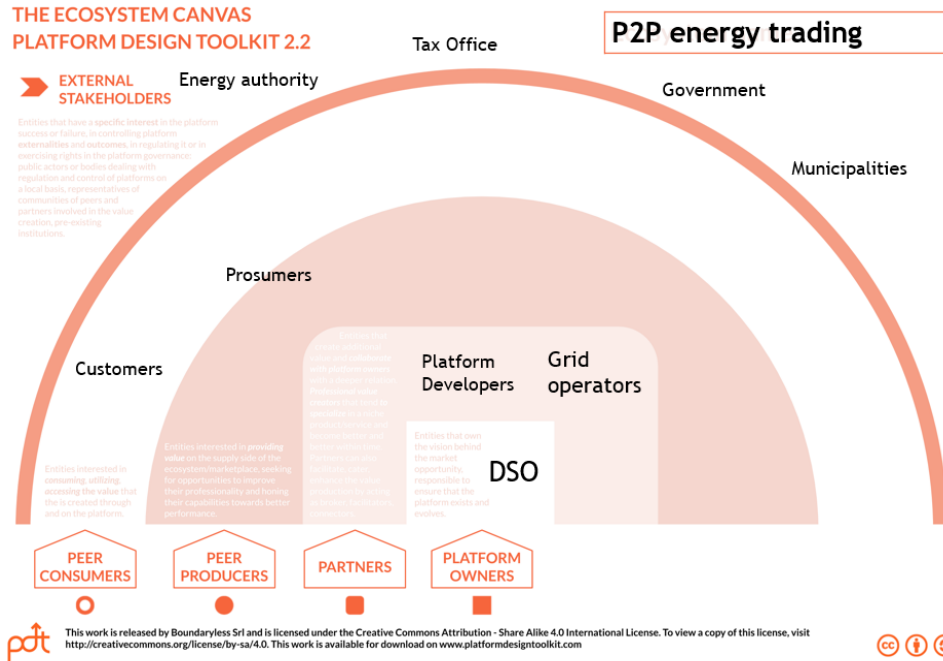






















Figure 16. Ecosystem canvas of P2P energy trading platform

Motivations matrix (Table 22.) demonstrates that diverse value exchange is happening in the platform both related to exchange of actions, electricity, money and information. Platform developers mainly exchange information for improvement and deliver novel solutions to the existing ecosystem. Grid operators have responsibility in grid electricity exchange and providing information for the platform developers so those can serve prosumers and customers better. When it comes to monetary value exchange, majority in this scenario happen in interchange between customer and prosumer clusters.

Table 22. Motivations matrix of blockchain based P2P energy trading platform

THE ECOSYSTEM'S MOTIVATIONS MATRIX PLATFORM DESIGN TOOLKIT 2.2		P2P energy trading			
gives to 	Platform developers	Grid operators	Prosumers	Customers	role
Platform developers   	-tight collaboration -assistance	-platform improvement	-novel solutions -opportunities to capture value	-energy use and cost optimization	
Grid operators   	-technical specifications -feedback	-experience -electricity exchange	-grid flexibility -grid maintenance	-optimized electricity use	
Prosumers   	-development ideas -feedback	-grid flexibility -measurement values	-money exchange -electricity exchange -guidance	-affordable local green energy -inspiration to become prosumers	
Customers   	-development ideas -feedback	-measurement values -feedback	-money -real-time	-discussion	
role   					

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7.12.2 Crowdfunding platform scenario

No complications were met when utilizing ecosystem canvas for designing crowdfunding platform (Figure 17.). DSO acts as a platform owner after it is established in collaboration with technology providers and external regulators. As crowdfunding is related to monetary flows and ownership, particularly important external stakeholder is Financial Supervisory Authority enforcing the Anti-Money Laundering (AML) and Know-Your-Customer (KYC) regulation. *Project owners* are defined as peer producers because they list new projects on the platform and without them it's impossible to onboard investors on the platform. In *Investors* cluster can be anyone who fulfills regulatory requirements to participate in investing activities on the platform. *Service*

companies cluster includes insurance, banks, renewable energy hardware installers, maintenance service that collaborate on fulfilling and supporting the projects.

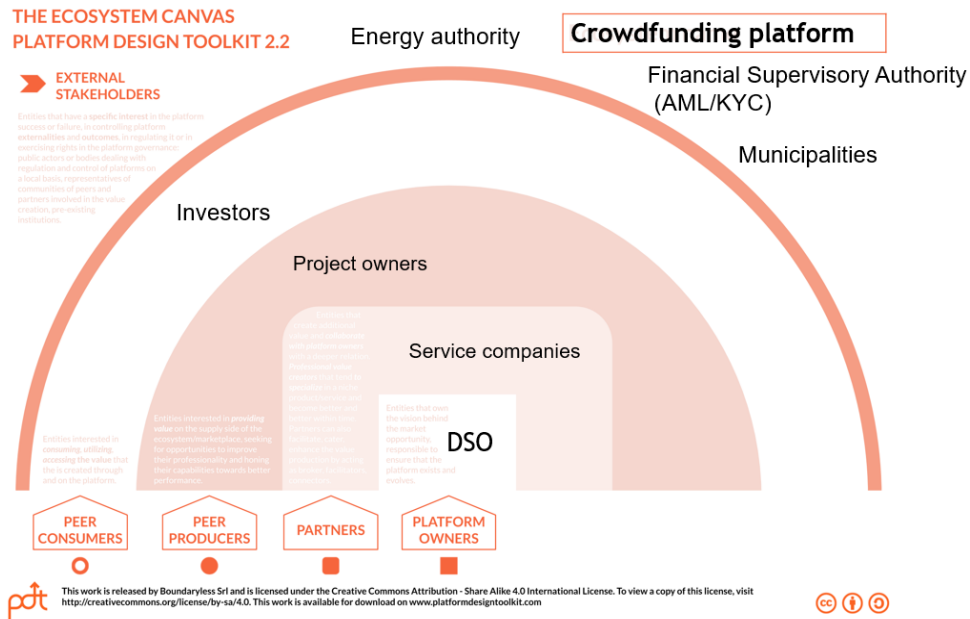



Figure 17. Ecosystem canvas for crowdfunding platform



Structuring motivations matrix of crowdfunding platform (Figure x.) has been relatively straightforward since incentives to participate in crowdfunding platform are clear. . Motivations matrix (Table 23.) showed that social nature of this platform should be taken in account, so dialogue between entities is important. *Investors* can trade ownership of renewable energy projects in the established secondary market with each other, they take risk by investing in the projects and lower barrier for renewable energy production plants. There is also indirect money flow towards service providers because the costs are already included when investors purchase ownership in a renewable energy project. *Project owners* pay off rental fees to the investors over a period of time, they are able to benchmark the success of the funding campaigns from platform analytics and discussions with other project owners. Service companies have clear monetary incentive because they receive long-term clients, but they are needed in order to manage risk from both investors and own perspective. Naturally *service companies* might be located in different geographical areas, but to some distinct for example

insurance companies and renewable energy hardware providers will compete through offers.

Table 23. Motivations matrix of blockchain based crowdfunding platform

THE ECOSYSTEM'S MOTIVATIONS MATRIX PLATFORM DESIGN TOOLKIT 2.2				Crowdfunding platform	
gives to 	Investors	Project owners	Service companies	role	role
Investors <small>Pa PP PC</small>	-secondary market -peer support	-money and trust -opportunity to turn green	-sustaining funds -opportunity to support green evolution		
Project owners <small>Pa PP PC</small>	-rental payments -feeling of ownership	-experience -benchmarking	-service fees -benchmarking		
Service companies <small>Pa PP PC</small>	-risk management -sense of security	-servicing the project long term -risk reduction	-competition		
role <small>Pa PP PC</small>					
role <small>Pa PP PC</small>					

What could the role on the vertical axis on the left give to the role on the horizontal axis on top?
 What could role of the same type exchange between each others


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7.12.3 Data Marketplace scenario

No complications were either met in defining entities in data marketplace (Figure 18.) This business model is different in the way that there are two platform owners, DSO establishes a platform on top of open blockchain protocol which provides tokenized service layer (Ocean Protocol 2019). Both platform operators capture value, but blockchain protocol has potential to capture more value. *Platform developers* cluster includes 3rd party developers and DSOs development and innovation department. *Utilities* cluster consist of DSOs and TSOs from European region as well as their *Utility customers* cluster - these are defined as peer producers, since they key aim is to supply data to the marketplace and capitalize on it. The broadest cluster defined as peer consumers in this platform is *SMEs* which could be any type of enterprise which would

like to use data streams that utility companies produce. SMEs could use these data streams in example for hardware product development, decision-making, training artificial intelligence models. However, in this platform utilities are expected to act as peer consumers as well, since using each other's data streams can enable benchmarking and data-driven decision making.

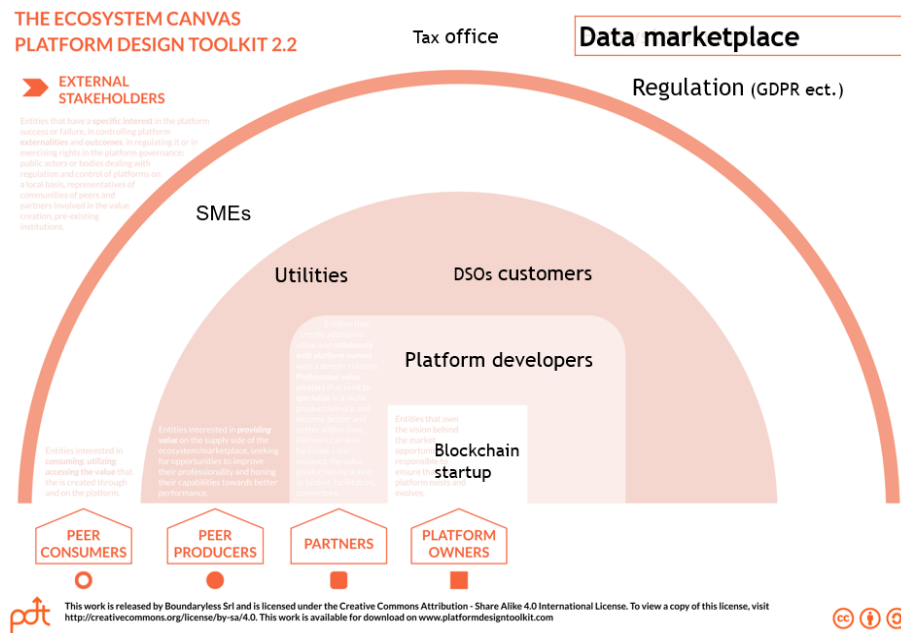



Figure 18. Ecosystem canvas of data marketplace platform



Creating motivations matrix (Table 24.) scenario wasn't complicated, since there are clear differences between the parties. *Platform developers* have facilitative role on the platform, they mainly listen to the other entities so they can respond to the needs with new technological improvements. Platform developers are also actively involved in the monetary flow as they are rewarded with part of transaction fees. *Utilities* actively sell and buy self-generated data streams, by joining the marketplace they enable customers opportunity to have control over own data and monetize it. *Utility customers* sell collective data about their usage to other platform participants, which could be segmented in marketplace according the information they specify about themselves. Onboarding of new utility customers goes through word-of-mouth about new possibility to receive reward for the data streams that were previously not monetized. As the

biggest group of individuals, they have an impact on changes and improvements platform developers will make in the platform.

Table 24. Motivations matrix of blockchain based data marketplace platform

gives to 		SMEs	Utilities	Utility customers	Platform developers	role
SMEs Pa PP PC		-collective data purchase	-money stream -data requirements	-money stream -data requirements	-development feedback -ne	
Utilities Pa PP PC		-data streams	-benchmarking -improvements	-opportunity for monetization -control over data	-indirect development funds	
Utility customers Pa PP PC		-collective personal data streams	-measurement values	-inspiration to join platform -grouping	-development feedback	
Platform developers Pa PP PC		-novel solutions to needs	-novel solutions to emerging needs	-novel solutions to emerging needs	-help -community	
role Pa PP PC						

What could the role on the vertical axis on the left give to the role on the horizontal axis on top?
 What could role of the same type exchange between each others?

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7.12.4 Maintenance crowdsourcing platform scenario

Out of all business models that were analyzed, maintenance crowdsourcing platform (Figure 19.) has the simplest structure in comparison to other platforms. *DSO* acts as a platform owner, because main function is maintenance of the grid. *Utilities* cluster consists of other local DSOs and TSO that could be interested in this platform similarly to hire electricians to complete small jobs. This way DSO can possibly scale the platform from DSOs and other *Inspectors* cluster consists of all the application users that receive DSOs network asset inspection tasks on the map and for safety reasons it might be restricted to certain age which would be verified in onboarding phase.

Maintenance providers are licensed maintenance service companies or individual electricians that have time to fix network assets on the go. They are defined as peer producers, since they serve platform owner via information provided by inspectors. Since platform can be used to generate income and financial transactions take place in platform ecosystem Tax Office and Financial Supervisory Authority. In addition, Labor Market Organizations are interested in having regulated pricing on the platform and General Data Protection law applies as well since platform is dealing with identity information.

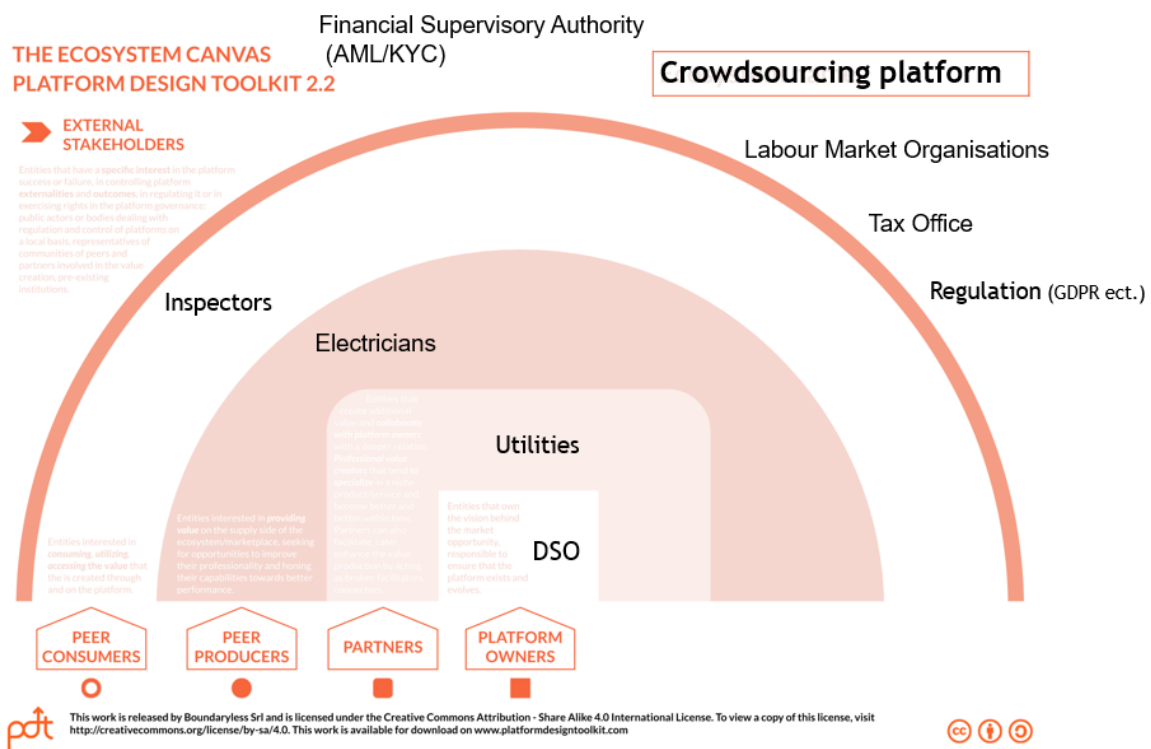



Figure 19. Ecosystem canvas of crowdsourcing platform

In this motivation's matrix (Target 25.) there can be seen some similarities to crowdsourcing platform figure. Both have 3 distinct entities but in crowdsourcing monetary flow moves from platform provider (DSO) and utilities to inspectors and maintenance providers. Inspectors get rewarded less, since their job is relatively easy, whereas maintenance providers receive bigger compensation as they are completing a more complex job. *Inspectors* provide the underlying information that unlocks the jobs



for electricians, therefore it is crucial to grow that part of the platform first. In addition, the aforementioned information can be used for network condition analytics or monetized in the data marketplace platform.

The more inspectors and maintenance providers are using the platform the more competition there is for the tasks that are submitted by DSO and Utilities. Platform could be designed to have autonomous pricing mechanism dependent on different parameters, but there could be a feature that both DSO and Utilities would be able to optimize the pricing.

Table 25. Motivations matrix of blockchain based crowdsourcing platform

THE ECOSYSTEM'S MOTIVATIONS MATRIX PLATFORM DESIGN TOOLKIT 2.2				Crowdsourcing platform	
gives to 	Inspectors	Maintenance providers	Utilities	role	role
Inspectors Pa PP PC	-competition -communication	-information -enabling jobs	-network condition analytics		
Maintenance providers Pa PP PC	-feedback	-competition -advice	-quick and easy asset fix -reduced maintenance costs		
Utilities Pa PP PC	-network asset location -monetary reward	-maintenance jobs -monetary reward	-benchmarking -jobs pricing optimization		
role					
role					

What could the role on the vertical axis on the left give to the role on the horizontal axis on top?
 What could role of the same type exchange between each others

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8 CONCLUSIONS

This study has enhanced understanding of interplay between blockchain technology, business model innovation and platforms in the context of (DSO) Distribution System Operator. It contributes to existing research related to blockchain technology in the energy sector by proposing findings that haven't yet been discovered. In this chapter major managerial and theoretical implications are pointed out. It synthesizes with theories and brings recommendations to DSOs management on what parts of business model they can address with the blockchain technology. In the latter part research limitations and suggestions for future research are elaborated.

8.1 Theoretical implications

This paper makes contribution via studying how novel technology impacts business model innovation from the perspective of multi-sided platform. No matter that there is clear gap, previous researchers haven't particularly studied technology as enabling factor for multi-sided platform. Additionally, study expands understanding in the field of multi-sided platforms, as it hasn't been studied in the context of Distribution System Operator. This paper reinforces the prior findings about business model innovation in the energy sector (Richter 2012; Hamwi and Iban 2016; Ilieva and Jayaprakash 2018) and blockchains impact on business model innovation (Nowiński and Kozma 2017; Lokøy and Nyberg 2018). Previous studies have analyzed business model innovation in different contexts (e.g. Richter 2012; Hall and Roelich 2016) This study is amidst the earliest ones (Zheng et al. 2016) on investigating the phenomenon of blockchain from business model innovation perspective of Distribution System Operator.

Foss and Saebi (2017) recognized 4 typologies of business model innovation: evolutionary, adaptive focused and complex. This study showed that in the case of blockchain based multi-sided platforms, as business model innovations they are often

defined as complex, since they require architectural changes and is new to the industry. On the contrary, the optimization of the specific business processes would be either evolutionary or adaptive business model innovation.

This study supports the earlier findings regarding the business model innovation outcomes such as changed industry structure (Gambardella and McGahan 2010), value creation for customers (Sorescu et al. 2011), competitiveness (Liu and Jiang 2013). Enabling P2P energy trade with blockchain would have the impact on industry structure by introducing small-scale energy producers to the market. In results of the benchmarking analysis it was recognized that particularly blockchain based multi-sided platforms create value for the customers. Generally, these platforms serve them by inclusion, improved decision-making power and convenience.

Regarding barriers of business model innovation previous research has recognized external (Birkin et al. 2009; Lange et al. 2015) and internal (Chesbrough 2010) barriers. From blockchain technology in energy sector standpoint, external barriers that this study recognized are technological and regulatory incumbency. When taken in consideration the internal barriers (Koen et al. 2010) mentioned that companies current business model may act as a constraint for business model innovation. In the case of Distribution System Operator this is true, because of its monopolistic nature and regulatory constraints.

From methodological contribution standpoint, this study tests a novel framework Platform Design Toolkit (Cicero 2019) for building a blockchain based multi-sided platform scenarios. It needs to be taken into consideration that this study utilizes Ecosystem Canvas and Motivations Matrix tools out of eight tools for scenario building and thus results are insufficient. However, Platform Design Toolkit has proven to be effective methodological approach for designing blockchain based multi-sided platforms.

8.2 Managerial implications

Findings indicate that blockchain enables many opportunities for Distribution System Operators. From an innovation management standpoint, findings of this research will benefit particularly Distribution System Operators and their management to understand what challenges can be addressed with blockchain technology how it can be taken into consideration in designing novel business models for the future. It will also provide management a basic understanding of the capabilities of technology.

Subq1. *What are the major challenges in DSOs current business model and related processes that can be addressed with blockchain technology?*

Major challenges that DSO face with the current business model and its processes are related to

- Metering frequency and accuracy
- Data privacy and monetization
- Cybersecurity of the systems
- Supply chain traceability
- Manual labor and coordination in procurement
- Customer billing inefficiencies
- Maintenance crowdsourcing
- Adoption of distributed energy resources

Empirical part, particularly benchmarking analysis demonstrated that all of these challenges can be addressed with blockchain technology. Benchmarking analysis has shown that blockchain based business model innovations are either related to processes or platforms, supporting the study of Burger et al. (2016). This research gives managers direction and assist them in focusing on relevant business models. As a recommendation, every Distribution System Operator should choose the goal of

business model innovation whether it is aimed to improve an existing process or create a totally new platform.

Subq2. *How blockchain technology could impact Business model Innovation of DSOs?*

From business process optimization perspective particularly decentralized grid management, blockchain enabled metering and billing, blockchain enabled procurement were recognized. Optimization of aforementioned business processes have potential to bring considerable cost savings, improve security and automate processes. Decentralized grid management has potential to improve DSO coordination with TSO and improve balance of supply and demand. Blockchain enabled billing eliminates considerably the need for trusted third parties and reduces the costs and errors from the current billing process. Blockchain based metering gateway devices are required in enabling P2P energy trade, demand response as well as an ancillary service. Regarding the network upgrades, blockchain enabled procurement can bring considerable efficiency improvements to the resource planning, eliminate the need for manual invoice handling, component traceability can be granular and simplify commercial transactions between parties.

Study has shown, how technical functionalities related to blockchain technology such as decentralized architecture, smart contracts, tokenization and zero-knowledge proofs make blockchain platforms powerful in comparison with incumbent industry platforms. Additionally, assessing the business model innovation typologies helps to distinguish how heavily different blockchain based business models might affect the core business model of Distribution System Operator. Some of the introduced business models require a modular change while other more complex require architectural changes. P2P energy trading platform and data marketplace platforms were considered as complex business model innovations among all introduced business cases.

Viewing the platform business model through tools such as Ecosystem canvas and Motivation matrix that are included in platform design toolkit helps management to build the scenarios and map out the strongest linkages in the ecosystem. As an outcome of

the study particularly P2P energy trading, crowdfunding platform, data marketplace and crowdsourcing platform were recognized as platform business models for the future with the most potential. Furthermore, these blockchain-enabled multi-sided platform business models tend to complement each other. For example, crowdfunding platform creates more users for P2P energy trading. Data marketplace platform supports the current business model of DSO by enabling both customers and DSO to monetize on the data that they own. Maintenance crowdsourcing platform is designed to serve DSOs network maintenance, but in case that it proves to be an effective solution, platform access could be offered to other grid operators that are located geographically close.

8.3 Research limitations

Limitations are boundaries and implications that cannot be controlled by the study. They appear from the context and methodology set by the research. As the structure of distribution system operator business model is distinct from business models of other companies, context is setting the clear limits. Due to this, results aren't applicable to other industries. For this study, it also implies limited access to financial resources and time constraints. Also, blockchain technology is still not a mature technology and due to this fact, there might be a limited amount of relevant information.

Case study approach enabled to study the topic from a broader perspective, but also it limited the research to a one case company. Results could have been divergent if the empirical data would be collected from multiple sources or using different methods. The data collection method is lacking the interviews conducted to experts from blockchain based energy startups. Incorporating external experts might have clarified some additional aspects of the blockchain based business models from the perspective of Distribution System Operator. However, due to time and resource constraints, it would not be possible within this research.

8.4 Suggestions for future research

This study took a perspective of business model innovation as an architectural configuration consisting of target customer, value proposition, value chain and value capture (Gassmann et al. 2014). It would be recommended to study further how blockchain technology impacts these elements individually. In the research it has been recognized that technology has an impact on business model innovation (Berman et al. 2012), making it appropriate to conduct a similar research using different technology.

According to Carson et al. (2018) when a company is designing blockchain based business model it needs to take in consideration standardization and regulatory barriers. Thus, a secondary suggestion for the research is to study barriers of business model innovation as it hasn't been studied much (Birkin et al. 2009; Lange et al. 2015; Chesbrough 2010).

In the future research it is possible to combine qualitative and quantitative methods with the same context or pick the perspective of other electricity power system stakeholders. Additionally, instead of focusing solely on platforms, in future research could be possible to position from business process optimization approach and study how particularly blockchain technology affects business processes.

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Appendix 1. Studies related to business model innovation in energy sector

Business model innovation in energy sector			
Study	Data	Method	Findings

Business model innovation for sustainable energy: how German municipal utilities invest in offshore wind energy (Richter 2012)	<ul style="list-style-type: none"> - Practitioner journals and presentations from practitioner conferences - 11 interviews to representatives of municipal utilities 	<ul style="list-style-type: none"> -Explorative research -Semi-structured interviews 	<ul style="list-style-type: none"> - Municipal utilities should strive to capture value from their first mover position in the field of offshore wind energy. - Municipal utilities should strengthen their business model innovation capabilities to successfully meet the challenges of the energy transition.
Business model innovation in electricity supply markets (Hall and Roelich 2016)	<ul style="list-style-type: none"> -Academic and grey literature review on local energy opportunities -12 interviews -Questionnaire -15 focus groups: 16 private company representatives, 4 government agency representatives, 28 civil society organization representatives 	<ul style="list-style-type: none"> -Qualitative method -Semi-structured interviews -Qualitative questionnaire -Focus groups 	<ul style="list-style-type: none"> -Emerging business models in the electricity supply market have significant potential to lead to substantive benefits in terms of system efficiency but also in terms of socio-economic gains
The Smart Grid Impact on the Danish DSOs' Business Model (Zheng et al. 2016)	<ul style="list-style-type: none"> -Secondary sources: two case studies -2 neural experts interviewed 	<ul style="list-style-type: none"> -Case study method 	<ul style="list-style-type: none"> Framework for Danish DSOs and description on how smart grid influences the 4 elements of the framework: smart meters, distributed energy resources, bidirectional electricity flow, R&D
Business model innovation for energy transition in household sector (Hamwi and Iban 2016)	<ul style="list-style-type: none"> -Literature review -Greenplay project 	<ul style="list-style-type: none"> -Qualitative method 	<ul style="list-style-type: none"> Exploiting technology by good business model is better than exploiting good technology by trivial BM.
Energy storage as a trigger for business model innovation in the energy sector (Ilieva and Jayaprakash 2018)	<ul style="list-style-type: none"> -Secondary sources -Energy storage pilot projects 	<ul style="list-style-type: none"> -Qualitative method 	<ul style="list-style-type: none"> Traditional business models are giving way to diverse modes of ownership and operation of energy storage in the grid.

Appendix 2. Studies related to impact of blockchain on business model innovation

Blockchain and business model innovation			
Study	Data	Methodology	Findings
How Can Blockchain Technology Disrupt the Existing Business Models? (Nowiński and Kozma 2017)	-Business press papers, professional reports, company web pages, blog commentaries	-Qualitative method -Literature review -Desk research	-3 ways in which blockchain technology can affect and disrupt business models: by authenticating traded goods, via disintermediation and via lowering transaction costs.
A case study on business model innovations using Blockchain: focusing on financial institutions (Oh and Shong 2017)	-Secondary sources -Interviews of ICT officers of major South Korean bank	-Qualitative case study method	Blockchain technology has a potential to improve the existing information handling process of financial institutions. Reviewing the suitability of the distributed structure of blockchain technology for the automation of financial institution's business process, rather than applying it to the entire financial system or individual financial institutions.
The Impact of Blockchain on Business Models: A study on how the attributes of blockchain affect the elements of Business Model (Kamal and Tayyab 2017)	-Panel expert interviews	-Qualitative method -3 round Delphi study	Financial services and real estate industries can use the 'speed' attribute of blockchain and make their 'customer facing processes' related to transaction clearing more efficient
Blockchain Business Models - a case study of incumbents in established industries in the Nordic region (Lokøy and Nyberg 2018)	-Interviews with employees of blockchain projects -Secondary sources: articles, whitepapers, blogs, academic	-Qualitative research method -Semi-structured interviews -Participant-observation study	Study has found private blockchain not to be a disruptive innovation, while public and consortium blockchains have characteristics of disruptive innovation. Four dimensions of business models will be affected by blockchain technology, and that most of blockchain traits will have multidimensional impact. Business model canvas is not an

	papers		effective tool for constructing consortium blockchain business models.
How blockchain technologies impact your business model (Morkunas et al. 2019)	-Secondary sources	-Qualitative research method	Explanation on how two types of blockchain technologies present opportunities for value creation for firms business model via Business Model Canvas framework

Appendix 3.

Q.	Semi-structured interview questions
	Describe a business process/es step-by-step.
1	What would be the main criteria that should be in place to have the process working?
2	Who are the key stakeholders involved in the process?
3	What kind of problems/mistakes emerge in the process?
3	Does the process involve tracking transactions executed between more than two parties?
4	Can the process benefit from increased trust, transparency, and accountability in recordkeeping?
5	Is the current transaction system vulnerable to fraud, cyber-attack and human error?
6	Do you believe that the current way of doing overly complicated or pricey, possibly due to the need for intermediaries or a central point of control?