**Master's Thesis Internship – master Sustainable Business and Innovation**

# Great Promise with Many Unknowns: An exploration of potential futures of blockchain technology and community energy initiatives


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# List of Abbreviations

**App** - Application

**Blockchain** - referred to in this paper as ‘blockchain’, also termed as ‘the blockchain’, or ‘blockchain technology’ in other literature

**DER** - Distributed Energy Resource

**DSO** - Distribution System Operator

**EV** - Electric Vehicle

**IoT** - Internet of Things

**KwH** - Kilowatt Hour

**M2M** - Machine to Machine

**Prosume**r - a producer and consumer of energy

**P2P** - Peer to Peer

**TSO** - Transmission System Operator

# Executive Summary

Blockchain is an emerging technology and has been hyped for its great promise in its use in the future energy system. Speculation and utopian imaginaries have been built around the future potential of blockchain, its use in the energy system, and potential to help decentralise the production and consumption of renewable energy. Blockchain has also specifically been highlighted as a particularly interesting technology for energy communities in its ability to increase efficiency, reduce costs and enable the scaling of these initiatives from the niche to regime. This research explores the potential role between this technology and its applicability for energy communities. The social acceptability and scaling of blockchain and energy communities were key areas investigated through this research.

Research into imagined and expected futures was conducted to understand the visions and expectations which surround this emerging technology and its potential use for energy communities. A range of stakeholders were interviewed from across the energy sector who were deemed relevant for this research in their knowledge of the energy system, blockchain, and involvement in energy communities.

This research found that some of the common associations of blockchain as a technology, that it enables decentralisation and negates the need for third parties, are not applicable to its potential future use in the energy sector. However, this research did find that blockchain has the potential to help the scaling of energy communities from the niche to meso level. In order for this to be realised, the findings from this research showed that support, specifically from intermediaries, commonly known as third parties, are key. Intermediaries will need to take on a new role and give support to energy communities and embrace the differences and varieties found amongst these community initiatives. This research also found that the future expectations of the development of blockchain and community initiatives were framed in accordance to the wider challenges of the energy transition. As such the development of blockchain as a technology needs to meet the needs and help provide solutions to these challenges. It is therefore likely that the development and applicability of this technology will need to suit the needs of the actors and their pursuit of the energy transition rather than the alternate visions or broader utopian imaginaries which exist around blockchain and the future energy system.

It is also worth mentioning here that this research was conducted independently from the internship organisation, the Blockchain Climate Foundation. However, relevant information on blockchain was acquired during the internship period to help inform the background for this research which fed into the information provided in chapter 2 of this paper. The researcher also gained an in depth perspective on the dynamic roles blockchain technology could offer the energy sector during the internship.

## Acknowledgements

Firstly, I would like to thank all of the stakeholders that were interviewed as part of this research. Of course I would like to name you all in person, however, to keep the valuable information you provided confidential I will instead thank you as an anonymous collective. Secondly, I would like to thank my thesis supervisor, Dr. Alexander Peine, for his help in guiding me through this process, and his welcomed role as a sounding board for my ideas and concerns. I valued our conversations and your guidance helped me negotiate my, often abstract, ideas and thoughts. Of course I also have to thank Rona Nicholson and Jon Broome for their continued support and encouragement, and finally Christopher Price for his warmth and heartening spirit.

# 1. Introduction

Within the new and emerging technologies in the energy sector, blockchain is becoming a hyped phenomenon (Creyts & Trbovich, 2018; Engie, 2017; Metelitsa, 2017; Rosic, 2016). Initially the architecture behind the cryptocurrency Bitcoin, the widespread applicability of blockchain across multiple industries is now becoming apparent (Catalini, 2017; Iansiti & Lakhani, 2017; Swan, 2015). Blockchain is essentially a decentralised digital database which can store and transfer different types of data (International Business Machines, IBM henceforth, n.d.a; Meuiner, 2018). Its decentralised nature, potential efficiency gains, and high security pose as a threat to the status quo of the current centralised configuration of the energy system (Basden & Cottrell, 2017).

Blockchain is a particularly interesting technology in the light of community energy initiatives. It has the potential to increase the size, add momentum to the regime and mid-level scaling of such initiatives, decrease costs, increase efficiency and the ease of setting up these initiatives (Burger, Kuhlmann, Richard, & Weinmann, 2016; Doci, Vasileiadou, & Petersen, 2015; Mengelkamp, Notheisen, Beer, Dauer, & Weinhardt, 2018). Currently a few pilot projects and blockchains are being used to test its use in artificially created local energy markets. A few currently exist in the Netherlands, including the energy token project at De Ceuvel in Amsterdam and the Power2Share energy trading platform in the Green Village, Delft. These projects will help test the practical issues of blockchain and its development. However, a deeper understanding of the social layers surrounding this new technology also needs to be addressed (Borup, Brown, Konrad, & Van Lente, 2006).

This research therefore will help investigate these social layers through the question of the social acceptability and scaling of blockchain and its implications for community energy initiatives. This paper will explore different futures and expectations for the application of blockchain technology in the energy sector with a specific focus on its potential use for community energy initiatives within the scope of the Netherlands. This will provide insight, which has not yet thoroughly been examined, into the opportunities and barriers for this technology, not from a technical viewpoint but instead from a perspective which looks to the beliefs and cultural practices of energy communities and other appropriate stakeholders. This is particularly relevant for this research as there is much hype within the wider discourse of the potential of blockchain and its applicability for energy community initiatives. This research will help add to whether these expectations are inflated and provide more tangible developments for blockchain and community energy initiatives and help understand what these could be for the future. Therefore the aim of this research is not to find the ‘correct’ or ‘best’ future use of blockchain for energy communities, but instead it is to explore what the varying perspectives, tensions, opinions are and what opportunities and barriers may appear for the development of blockchain in the context of energy communities.

The theoretical field of Science and Technology Studies (STS) is used to draw on the dynamic relationship between technology and society. The theories of sociotechnical imaginaries and the sociology of expectations are used to create the framework in which to analyse a social and ‘human’ angle of this emerging technology (Borup et al., 2006; Jasanoff & kim, 2015). These two concepts were chosen to help investigate the futures of blockhain and energy communities which circulate around blockchain and its future potential use. Sociotechnical imaginaries were chosen to help investigate the wider discourse and imaginaries. Expectations are seen to be more concrete and so were chosen to help gather more specific viewpoints from stakeholder expectations; stakeholders are likely to have more material expectations in the future use and implementation of blockchain and energy communities initiatives. Mapping these expectations was done to help examine the opportunities and barriers this technology was done to provide community energy initiatives in the future. As such gathering these expectations could help develop the use of this technology for energy communities past the hype toward more grounded approaches.

Andoni et al. (2019) have conducted one of the first systematic reviews of blockchain in the energy sector with a focus on the technical challenges this emerging technology faces. Few studies on the social implications of blockchain technology have been conducted; Reijers and Coeckelbergh (2018) looked at how blockchain as a technology can influence and change the social world around us. Little research focusing on energy communities and blockchain, and the expectations surrounding them, has been conducted to date. Therefore this paper helps fill this scientific gap.

The social relevance of this research is that blockchain has the potential to speed up the energy transition through increasing the amount of renewables in the energy mix, particularly through enabling the connection of Distributed Energy Resources (DERs) for the consumption and production of green energy. Therefore researching the expectations of the actors involved in the potential future use of this technology, how momentum can be built and how challenges can be overcome, is beneficial to those stakeholders involved, as well as society at large.

Collaboration is understood as a cornerstone to the development of blockchain (Dutch Digital Delta, 2018). Therefore researching different stakeholders' perspectives is the first step in collaboration. Sharing this research will enlighten stakeholders of one another's positions and potentially help progress developments and integrations of this technology. On a more practical level, gaining a deeper understanding into the possible futures of a technology helps direct investment and outline policy recommendations. Currently it is unknown which stage of the energy structure or type of application blockchain will dominate, therefore understanding actors' perspectives about possible future uses of blockchain in the energy market will help flag potential areas where investment could be directed. Moreover recommendations can be made in order to ease any tensions or barriers to the progress of energy communities using blockchain.

# 2. Background to the Energy Transition, Community Energy Initiatives and Blockchain Technology

The United Nations Paris Agreement signed in 2015 was a clear statement of intent for the sustainability transition to be realised, to keep increases in global temperature levels below two degrees, to reach a decarbonised future, and so to help enact the necessary shift from fossil fuels to renewable energy (United Nations Framework Convention on Climate Change, 2015). There is now a practical realisation that new developments need to be acted upon to bring about this transition (Hajer & Pelzer, 2018). New technologies and actors within the energy system are being looked upon as potential change makers. Two such means are energy communities, traditionally small scale local energy initiatives, and blockchain, a potentially fruitful technology originally used for cryptocurrencies but which is now seen as highly suitable for various applications within the energy sector. The following section gives an overview of these areas and the links between them. Firstly a brief introduction to the energy transition will be given concentrating on the challenges specific to enabling more local production of renewable energy. Due to the scope of this paper concentration will be given to the European energy system. This is followed by a short background to energy communities and finally, a brief introduction to blockchain will be given. For more in depth discussions about this technology see Catalini (2017) which provides an interesting introduction to the potential of this technology. Alternatively Adoni et al. (2019) give an overview of the use of blockchain in the context of the energy sector and Mengelkamp et al. (2018) outline a technical analysis of its potential for energy communities.

## The Energy Transition

The energy transition is not a new phenomenon within the Netherlands and was outlined in The National Environmental Policy Plan 2001 (Bosman, Loorbach, Frantzeskaki, & Pistorius, 2014). It is generally accepted that an energy transition is needed across all actors within the energy system; a shift away from fossil fuels to a decarbonised energy system (Hajer & Pelzer, 2018; Kern & Smith, 2008). Bosman et al. (2014) found the rhetoric of the ‘energy transition’ to be dominant amongst the discourse of the Dutch energy sector. However, that being said the progress of the Netherlands in meeting EU targets to increase the amount of renewables in the energy mix is low, as Figure 1 shows below.

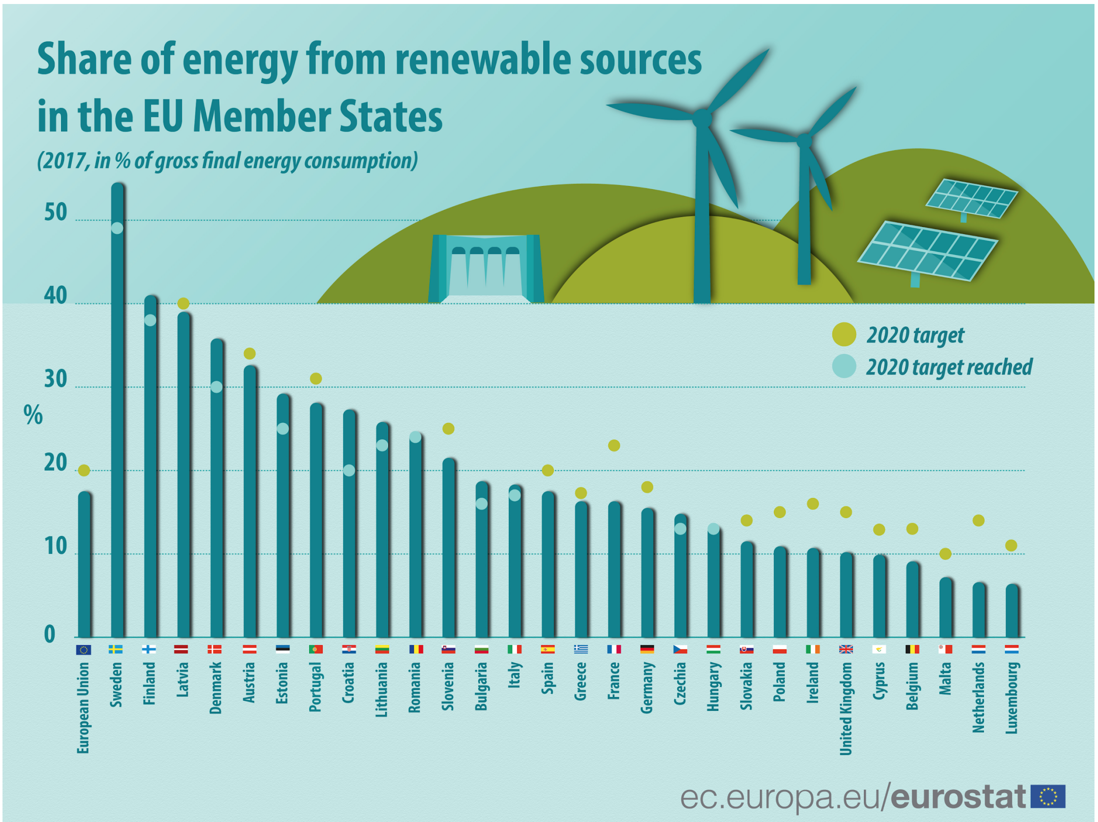


Figure 1: EU member states share of renewable energy from 2017

Source: Eurostat, 2019

A number of challenges are present in the energy sector which need to be overcome to enable the renewable transition. The market for renewable energy is becoming competitive with many new and emerging technological solutions being offered to help progress the transition. Many of these new technologies have changed how energy is produced, consumed, and stored, creating a market of DERs. These technologies have made room for new roles such as consumers becoming energy producers, or ‘prosumers’, facilitating Peer-to-Peer (P2P) energy trading (Jiayi, Chuanwen, & Rong, 2008; Mengelkamp et al., 2018). These developments have meant that the decentralization of energy is more attainable than ever (Adil & Ko, 2016; Mengelkamp et al., 2018; Verbong & Geels, 2007). However, how these new technologies, along with other energy using assets, such as Electric Vehicles (EVs), are integrated within the energy system is a challenge. Moreover, decentralised energy production and consumption leads to smaller ‘micro’ units of energy being traded which causes difficulties in balancing the grid to match the supply and demand of energy (Ellis & Hubbard, 2018). These micro units of energy are also open to large fluctuations through the day, week, or year, as they come from renewable sources which are affected by the weather.

As many actors are involved in the energy transition and the changes needed to move from the current energy system which is entrenched in large centralised production of primarily non renewable energy. How large systems can be changed has been investigated in the literature of sustainability transitions but this will not be explored within the paper. However, the work of

Geels (2002; 2005) is a useful source of information on transitions theory and the framework of the multi-level perspective (MLP) in particular. This conceptualises the different levels of actors and ideologies which are at play within a large complex system and the dynamics of where change can come about within this system.

## Community Energy Initiatives

The introduction of DERs and the liberalisation of the green energy market during the early 2000s aided the creation and growth of community energy developments in the Netherlands (Kwant, 2003). Within the Netherlands, Gui and MacGill (2017) found that community energy developments are to be key in the future green energy market. The presence of these communities in the Netherlands is small but is growing (Oteman, Wiering, & Helderman, 2014).

Community initiatives are generally set up in groups by members of civil society for the provision of renewable energy within a local vicinity (Boon & Dieperink, 2014; Ruggiero, Martiskainen, & Onkila, 2018). Their configuration has the potential to decentralize the energy system and progress the production of clean energy (Mengelkamp et al., 2018; Van Der Schoor, Van Lente, Scholtens, & Peine, 2016). With the rise in different configurations of ownership of local energy systems what constitutes a ‘community’ model comes into question (Adil & Ko, 2016; Walker & Devine-Wright, 2008). However, by and large community energy initiatives aim to generate the production of green energy locally, and on a wider scale, help create a more sustainable energy system (Seyfang & Smith, 2007). However, issues occur in the integration of these local energy systems within the existing traditional and centralised energy system. Also community energy projects often encounter difficulties as they are run by volunteers so time and skills are constrained, as well as the lack of institutional assistance or structures which help them, such as funding and policy (Hoppe, Warbroek, Lammers & Lepping, 2015).

Research has shown energy communities to be novel innovators and, as actors for potential change in the energy landscape, with the potential scale up the community model (Hargreaves, Hielscher, Seyfang, & Smith, 2013; Seyfang & Haxeltine, 2012; Seyfang & Smith, 2007). The scalability of the community model has been seen as growing from a niche activity where ‘grassroots innovations’ exist, to growing to the regime through civil action rather than purely technological innovations.

The work of Seyfang and Smith (2007) looks at the link between social grassroots activities and their place within the MLP. The concept of ‘green niches’ (Seyfang & Smith, 2007, p.589), which are focused on sustainability related activities, specifically looks at finding solutions to problems, for example increasing the amount of renewable energy in the system. Community niches differ; some wish to scale up to join the mainstream regime, whereas others wish to stay as an alternative ideology. Seyfang and Smith (2007) differentiate these two perspectives as: firstly ‘simple niches’ (p.593) where regime change is not desired and instead the insular qualities of the niche are appreciated versus ‘strategic niches’ (p.593) which desire to break from the niche to wide system transformation on the regime level.

Research has shown the reason many community energy initiatives have come to fruition is the independence, autonomy, and sense of community these initiatives bring rather than other factors such as financial savings (Adil & Ko, 2016; Arentsen & Bellekom, 2014; Walker & Devine-Wright, 2008). This is echoed in the ideas of Richard Sennett and his analysis of communities in general. In his book *Together* (2012) Sennett links community to identity, both socially and physically with local being an important aspect of communities.

Thus local energy communities are often not just driven by providing alternative renewable energy sources but are also defined by their desire to engage and empower, often with wider ideologies, such as decentralisation, as a goal (Hoppe et al., 2015; Oteman et al., 2014; Ruggiero et al., 2018). Wenger (1998) explained this desire for communities to share and learn from one another and other groups in the concept of 'communities of practice' where goals and visions are key to forming identities and engagement for the creation of communities. This can be seen in the development of different typologies of energy communities being established from 'innovation communities', to 'energy democracies' based on the collective interests of certain groups (Chilvers & Pallett, 2018; Van Oost, Verhaegh, & Oudshoorn, 2009). These initiatives embrace the multiple ways the public can now engage with a more decentralised production and consumption of energy, also enabled by the increase in DERs.

## Blockchain

Blockchain is an emerging technology predominantly associated with the cryptocurrency Bitcoin, where it was first used (Nakamoto, 2008). It can be defined as a distributed, digital ledger (database) which can be used to hold different types of information, or 'value', which can be many different things from transactions, to records, to personal data (Sikorski, Haughton, & Kraft, 2017; Yli-Huumo, Ko, Choi, Park, & Smolander, 2016). It has a cryptographic function and works with a decentralised system (Mengelkamp et al., 2018). It is essentially a modernisation of the traditional ledger, born during the Renaissance, which historically was a book where records were kept (Yamey, 1964). Inefficiencies arise with traditional ledgers; for example data can become out of synch between different parties, they are subject to tampering which can cause inaccurate information, fraud and disputes over inaccurate information between different parties (Brakeville & Perepa, 2018). Consequentially as blockchain is a distributed ledger it is shared so all parties have access to the same information which in turn makes tampering extremely difficult and so transparency and trust are ensured (Meuiner, 2018).

Many have heralded the revolutionary potential of blockchain; much has been written about how blockchain will dramatically change many industries from the financial sector, to healthcare, to the energy sector (Gupta, 2017; Mulligan, Scott, Warren, & Rangaswami, 2018). Melanie Swan (2015) in *Blockchain: A blueprint for a new economy* argues that the advent of the next computing revolution can be brought about by blockchain technology. It is often described as a 'disruptive' technology that has the potential to change practices in our daily lives and how businesses operate (Mattila et al., 2016; Reijers & Coeckelbergh, 2018; Rosic, 2016). Iansiti and Lakhani (2017) go a step further and argue that blockchain is in fact not a disruptive technology but a foundational one; blockchain has the capability to become the backbone to our digital and social structures.

What makes blockchain a unique and attractive technology is that its core characteristics of being digital, distributed and cryptographic, mean that it creates high levels of trust, security and transparency to the information added on to the ledger. Consensus is needed from the participants of the blockchain network in order for a transaction, or piece of data, to be approved (IBM, n.d.a). The hash, a unique code, is the cryptographic element of blockchain which ensures its security; no one block can have the same hash (IBM, n.d.a). The chain is formed as some of the characters from one block are integrated into the unique hash of the next block (Goldman Sachs, n.d.). It proposes a new model for how data can be stored and trust ensured; cryptography ensures validity, a decentralised architecture means that third parties, also known as intermediaries or middlemen, are not necessarily needed within the network, and that the ownership and storage of data can be distributed amongst those that produced the data (Meunier, 2018). This differs to the current common use of centralised databases and business models many companies have of ensuring trust as intermediaries, hence why blockchain has caused a lot of speculation around its use and implementation (Catalini, 2017).

It is also worth noting that blockchain can look very different and act very differently depending on its architecture and configuration, which are determined by its use and function. Whilst the term 'blockchain' is commonly used, its application or configuration will not necessarily be the same in different use cases or contexts. Examples of the developments and functions of blockchain include blockchain 1.0 where digital transactions can be made (Swan, 2015). Blockchain 2.0 is the integration of smart contracts which is an automated protocol where preset criteria can be matched, for example a transaction between the consumer and energy provider for electricity bills can be made digitally and automatically (Price Waterhouse Cooper, PwC henceforth, 2016; Swan, 2015). Blockchain 3.0 is the use of automated and autonomous smart contracts, for example integrating the IoT in keeping efficient levels of energy in the grid (Swan, 2015).

Different types of blockchain also include: private, public and consortium. A private blockchain is open only to those that are invited into it (Mengelkamp et al., 2018). For example, an energy company could have a private blockchain and only allow its customers on to it and see their energy transactions. A public blockchain is open allowing anybody to join, a good example of this type of blockchain is the cryptocurrency Bitcoin. A consortium blockchain is quasi-public-private configuration where a few selected members of the blockchain are selected as trusted parties (Mengelkamp et al., 2018). This type of blockchain is seen to be important for collaborative ventures, so a few energy providers could all have permission to the same blockchain. There are ongoing debates, within literature, both academic and grey, on the technicalities and differences between blockchain features, Buterin (2015) and Vukolić (2017) are examples. So the type of blockchain architecture chosen will depend on how and where it is going to be used (Meunier, 2018).

## Blockchain and the Energy Sector

Involvement of blockchain in the energy sector is still in preliminary developments. It ranges from blockchain based digital transactions being sent between parties, to the creation of virtual marketplaces with built in smart contracts. A number of pilots and blockchain projects have been launched with Power Ledger and LO3's Brooklyn Grid being notable successes to date. Within the Netherlands, preliminary investments have been made and the main activities are in the testing of blockchain pilots many of which involve energy communities (Dutch Digital Delta, 2018). As such blockchain is in its elementary phase of use and a number of areas have been highlighted which need further research, namely scalability, security and usability (Burger et al., 2016; Dutch Digital Delta, 2018; Mengelkamp et al., 2018).

There are many ideas for how blockchain can be used in the future energy sector. These range from developing new ways to raise capital for often underfunded green energy projects, to using blockchain for emissions trading (Mihaylov, Razo-Zapata, & Nowé, 2018). The Blockchain for Climate Foundation is a good example in developing this use case to put the climate targets 2015 UN Paris Agreement onto a global blockchain (Pallant, n.d.). Providing a secure and trusted mechanism which can give proof of the origin of energy and trace energy certificates is another potential use for blockchain technology (Andoni et al., 2019). Blockchain also offers possibilities in the energy sector as a coordination technology; it offers an architecture which can support the integration of multiple parties and assets. This is particularly suitable for the energy sector and the expected increase in DERs and other digital devices such as IoT. The administrative potential of blockchain is also suitable for processing payments and transactions between different parties in an efficient and cost effective manner, and which is especially appropriate for the future energy sector where there is an expectation in the growth of prosumers, and individuals who will participate (Andoni et al., 2019). The use of tokens to monetise energy is another possible example use which blockchain could support. A relevant example is the NRGCoin which uses a blockchain architecture to support a reward structure for tokens where both producers and consumers of energy are rewarded (Mihaylov et al., 2018).

Blockchain also offers the possibility for more decentralised energy trading and feeds into utopian visions of a democratic supply of energy (Lyons, 2018; Woodhall, 2018). Transactions have consequently been a forerunning model for the potential use of blockchain in the energy sector and specifically the consumption and production of local energy and the operation of energy communities. P2P trading is the dominant conceptualization of this with the example of the direct trading of energy between neighbours frequently used to explain this concept. The allure of the immediacy of this model is preferential over the current and more lengthy process of validating contracts via a third party and could eliminate the need for an intermediary, like a utility company (Gupta, 2017; PwC, 2016). It could cut costs by eliminating the transaction costs between the consumer, producer and intermediary (Burger et al., 2016; Mengelkamp et al., 2018; PwC, 2016). Financial support has been highlighted as a concern for many community energy initiatives and blockchain offers cost saving potential through the lowering of currently high transaction costs (Gui & MacGill, 2017; Oteman et al., 2014). Blockchain has the potential to create new business models and new markets, and energy communities could have a role in this development (Burger et al., 2016).

Many of the examples above are applicable for the use by energy communities and show why blockchain is a particularly interesting in the context of community energy initiatives. This technology has the potential to help scale these initiatives through reduced costs, increased efficiencies, bureaucratic gains and increased transparency (Burger et al., 2016; Doci et al., 2015; Mengelkamp et al., 2018; PwC, 2016). Blockchain also has the potential to help deliver decentralised green energy whilst potentially enabling greater autonomy for energy communities.

The innate characteristics of blockchain; decentralized, digital, large, dispersed, potential to be anonymous, versus community energy initiatives which are localized, clustered and ethos centred, is an interesting duality. The potentials for links between blockchain technology and energy communities has already been made and this research will help develop these promises and see if the potential match between this technology and community initiatives can live up to the hype. This will be done by looking at the imaginaries this technology sits within and by collecting stakeholder expectations on the barriers and opportunities for blockchain to become accepted by and help scale energy communities.

# 3. Theory

The following section outlines the theoretical concepts of the sociology of expectations and sociotechnical imaginaries which were used in this research to study futures (referred to as expectations and imaginaries henceforth) (Borup et al., 2006; Jasanoff & Kim, 2015; Van Lente, 1993; 2000; Van Lente & Bakker, 2010). Both concepts deal with trying to analyse the future in the present, investigating different imagined versions of possible futures. This is unlike the commonly held notion that the future is unpredictable and often shrouded in a sense of mystery. There is another point of view found in futures research, namely, that the future is not passive but instead future visions and developments in the present can impact on future outcomes (Van Lente & Rip, 1998).

Both theories are grounded in the domain of Science and Technology Studies (STS). This field of academic research is founded on the assertion that technology and society mutually shape each other (Bijker, Hughes, & Pinch, 2012; Hackett, Amsterdamska, Lynch, & Wajcman, 2008). As such Sneltvedt (2017) states that 'technological futures cannot be separated from social futures' (p.47). Technologies are not just made and consumed, they are socially constructed over time with various participants and processes including political, democratic, and cultural inputs (Hackett et al., 2008). Expectations and imaginaries have been chosen as they are investigative and socially engaging and will help provide the framework to look at different possible futures for an elementary technology, in this case blockchain technology and its use for community energy initiatives.

## Expectations

Expectations studies began with the work of Van Lente (1993) and have developed into the 'sociology of expectations'; a good overview of this theory is given by Borup et al. (2006). This field of study looks at how expectations in science and technology are created and circulated amongst different groups of actors which 'refer to what is possible in the future' (Van Lente, 2012, p.772). Borup et al. (2006) describe the role of expectations for technological development whereby future technologies and their potential competencies are assessed in the present. As such expectations are a useful theory to explore the visions and potential areas of development for blockchain, which is in the elementary phases of innovation within the energy sector.

There are no set criteria on what an expectation has to include or describe; expectations can be abstract or detailed, with social or technical content, in how they outline a possible future (Van Lente, 2012). However, what an expectation includes or describes is understood as a 'script' (Van Lente & Rip, 1998, p.203) which includes the description and framing of an imagined future.

Expectations are especially useful for technologies in the early stages of development as they help create guiding visions and 'promises' (Van Lente & Rip, 1998) for that innovation. So expectations are performed and used to define roles amongst stakeholders, often initiating the mobilisation of resources toward the achievement of an expectation (Van Lente & Bakker, 2010, p.694). Berkhout (2006) addresses the dual nature of expectations consisting of both practical and symbolic elements. Practically, expectations help to organise resources and direct investments, as well as construct a network of actors around an expectation which takes on a symbolic and binding role (Borup et al., 2006). Van Lente and Bakker (2010) discuss the competition of expectations where more than one expectation can exist, and often compete, in the early developments of a technology. Competition during this ‘expectation’ period is not based on market determinants such as price but on other criteria such as potential future performance (Van Lente & Bakker, 2010).

Expectations bridge between personal visions and collective expectations. Berkhout (2006) draws out this relationship stating that the private self-motivation of actors is a reason behind their support for a particular expectation. Van Lente and Rip (1998) examine expectations by drawing on fictional comparisons; they describe stakeholders gaining approval of an expectation through turning them into ‘characters in the story’ (p.206) within the ‘plot’ (p.206) of the imagined future. This suggests that expectations can be found within narratives; as expectations compete different narrations exist with different ‘plots’ or points of view.

Moreover expectations do not sit passively; they adapt and change over time (Brown & Michael, 2003). In this sense expectations can be seen as cyclical and have been aligned to the hype cycle of innovation studies (Van Lente, 2012). This line of theory highlights the rise and fall of an expectation and links to the peaks and troughs, hype and disappointments, associated with emerging technologies, as seen in figure 2 below.

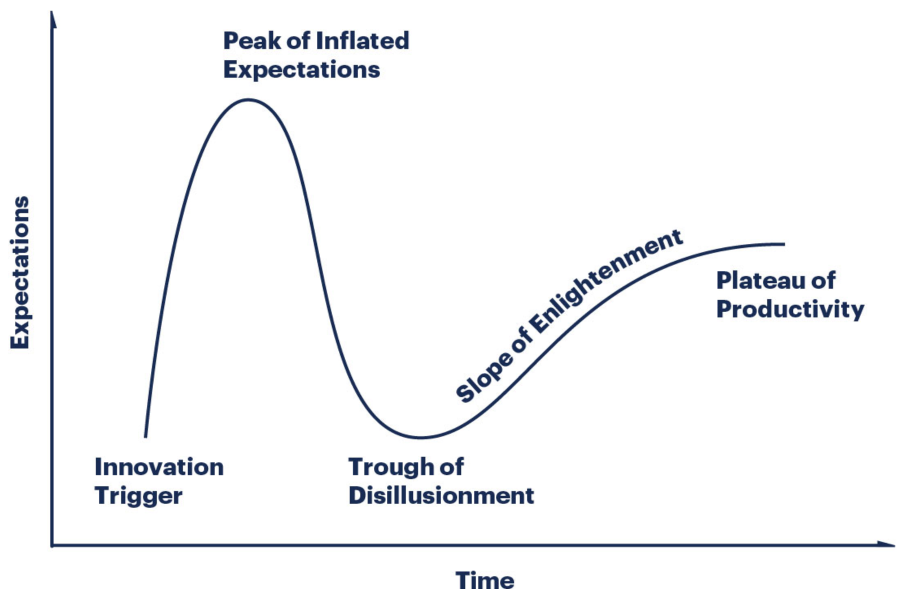


Figure 2: The Gartner Hype Cycle.

Source: Gartner, n.d.

Hype and the associated Gartner cycle have been used to explain the nature of inflated expectations and the consequential disappointment, the ‘trough of disillusionment’, of this hype being fulfilled (Brown & Michael, 2003). This gives a succinct overview of the change in expectations versus the reality of the development of most technologies. However, Borup et al.

(2006) critique this 'neat' (p.291) journey from hype to disappointment and instead suggest that the process of hype and disillusionment is instead a continual process which develops and changes over time according to the different developments of technologies.

## Sociotechnical Imaginaries

The theoretical concept of sociotechnical imaginaries was introduced by Jasanoff and Kim (2009) as a new framework to understand the socio-political dimensions of science and technology and this theory looks at how future visions are produced. Like expectations, imaginaries are not neutral, and are performed; imaginaries are political in that multiple different actors are competing against different visions and how they are communicated through their framing (Ballo, 2015; Jasanoff, 2015).

Such sociotechnical imaginaries are defined as being:

> 'collectively held, institutionally stabilized, and publicly performed visions of desirable futures, animated by shared understandings of forms of social life and social order attainable through, supportive of, advances in science and technology.' (Jasanoff, 2015, p.4)

Like expectations, multiple imaginaries are able to exist at the same time and compete against one another (Jasanoff, 2015). Imaginaries are understood to evolve over time with their form changing and reconfiguring, and can span from an individual to a global scale. As they are collectively held they adapt and grow with the input of many actors, institutions and larger forces, for example political and societal structures (Jasanoff & Kim, 2015). This is exemplified in the work of Jasanoff and Kim (2009) which investigated imaginaries being constructed on a national scale. They are therefore complex, occupy a large territory, are found within the public sphere, and take time to fully understand and analyse (Science and Technology Studies Research Platform, n.d.).

Imaginaries specifically look at 'desirable futures' (Jasanoff, 2015, p.4), are often utopian visions revealing alternative futures or ways of living, or propose new ideologies and structures. They embody both threat and opportunity; threat to the current order of doing things but also present opportunities for a more positive future (Jasanoff & Kim, 2015). It is this possibility for tension and revealing deeper layers behind a future vision which give imaginaries a moral weight suggesting 'how life ought, or ought not, to be lived' (Jasanoff, 2015, p.4). Technologies can be seen as the tangible manifestations of these values and are objects of something less tangible but more extensive in meaning (Jasanoff, 2015). In terms of blockchain, the values attached to this technology in the context of energy are associated with distribution: specifically a decentralised energy system, clean energy resources and the renewable energy transition, and a more equitable energy system, and the desire and movement for the democratisation of energy. (Basden, & Cottrell, 2017; Creyts & Trbovich, 2018; Singh, 2017). As such utopian energy futures dominate the associations with the future energy system in general and specifically with the use of blockchain.

## Framework

Both imaginaries and expectations examine futures and have been chosen to form the theoretical framework to examine the potential futures of blockchain and energy communities for this research. Multiple, primarily utopian, imaginaries exist around the potential future uses of blockchain in the energy sector and specifically for community energy initiatives. Imaginaries focus on desirable futures and have been chosen to help analyse the larger discourse, and hype, of the imagined futures. Desirable imaginaries specifically point to the potential of blockchain in 'undoing' the current centralised configuration of the energy system (Creyts & Trbovich, 2018; Woodhall, 2018). Imaginaries are found in the broader discourse and as such a wider lens will be used to examine these futures through exploratory research. Specifically a discourse analysis and grey literature will be used to find these positive visions of the future. These imaginaries formed the basis for the scenarios which were used to lead the stakeholder interviews. This is discussed in more detail in the following methodology chapter.

The wider imaginaries of blockchain and energy can be seen to occupy a macro level. In order to then gain a more concrete understanding of the future potentials of blockchain and energy communities a more focused lens is needed. This is where the theory of expectations is appropriate. In this research, expectations are seen to operate on the meso level, can be used to articulate more concrete, personal, visions than imaginaries and so will be used to collect the perceptions of stakeholders. A simple representation of the space these two theories occupy, as conceptualised for this research, can be seen in figure 3 below.

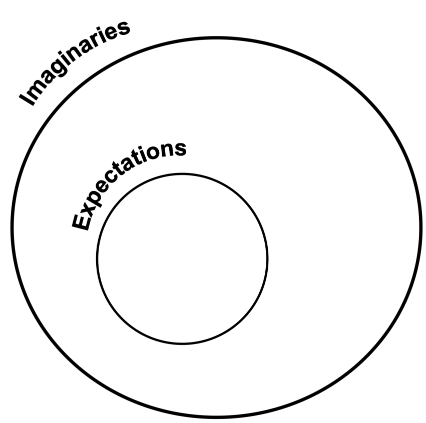


Figure 3: Imaginaries and expectations visual conceptualisation

Expectations are useful to addressing more concrete visions of potential futures of blockchain and energy communities from stakeholders. Interactive interviews with stakeholders were used to gain a more focused direction in how, and whether, this technology will be appropriate for communities in the future, and where the expectations of the stakeholders sit within the wider discourse of imaginaries. From this any opportunities or barriers were able to be analysed to address the potential futures of blockchain and community energy initiatives with a more practical and tangible understanding. This more focused approach is particularly necessary for the potential applicability of blockchain and energy communities as there has been little research carried out which has measured stakeholders expectations to date.

# 4. Methodology

## Research Design

A research design which can explore the current imaginaries which exist, can then be built upon to reveal the expectations and visions of different stakeholder groups and help analyse this collected data to assess a direction in the future of blockchain and energy community initiatives was needed. As such a design with multiple methods of data generation, collection and analysis which fed into one another was created with three main parts to the research process: exploratory research, interactive interviews and mapping stakeholder expectations. The research was designed to begin with scoping exploratory research where the study of both textual and visual sources was conducted in order to gain an understanding of the broader imaginaries surrounding possible futures and visualisations of blockchain and energy communities. These imaginaries were then used to help guide the interactive interviews with relevant stakeholders where scenarios were used as an interview tool. These semi-structured interviews were chosen to collect the more concrete expectations of stakeholders. The data collected was then analysed through mapping stakeholder expectations. Thematic coding helped organise and map the stakeholders expectations into different categories drawing out opportunities and tensions from the data to help explore the use of blockchain and community initiatives in the future.

It is worth noting that the research process below has been described in different categories beginning with exploratory research, followed by interactive interviews, case selection and stakeholder mapping of expectations. It describes a neat process, however, the reality of this research is that each process did not directly follow on from the next, and instead activities performed in one step were done simultaneously to other activities in another step. For example, during the exploratory research a thorough review of literature was conducted as part of the desk research. However, at various stages after this, for example during the stakeholder interviews, additional desk research was conducted. So all in all a thorough literature review was carried out over the course of the research process. This is only mentioned to provide a true and transparent account of the research process undertaken.

### Methods of Data Collection

Qualitative data was collected through desk research and a visual discourse analysis in the exploratory research phase and then in the interactive interviews. A qualitative research strategy was chosen as it is suitable to collecting data for exploratory investigations, technologies in the early phases of development, and research studying social perspectives (Bryman, 2016; Ritchie, Lewis, Nicholls, & Ormston, 2013).

## Exploratory Research

During this step of the research process the goal was to understand the imaginaries and possible futures of blockchain and energy, with a focus on community energy initiatives, which already existed, in both textual and visual forms. It was also to gather information to help build the scenarios which were presented during the interactive interviews to spark the imaginations of the stakeholders interviewed. The use of scenarios as a tool to elicit reactions and draw out expectations is explained in greater detail in the interactive interviews section to follow.

Firstly, desk research was conducted by looking at academic and grey literature in order to understand the main visions and developments of blockchain in the energy sector. It is worth noting here that some findings from the desk research also helped inform parts of the background information outlined in chapter 2. Grey sources dedicated to blockchain developments, such as GreenTechMedia or Energerati, were used alongside company reports, many of which have signalled the main trends for blockchain. These ranged from corporate companies, for example IBM, to innovative energy startups such as LO3 Energy. Developments within the energy sector including pilot projects or concept models, for example the community run Brooklyn Microgrid (n.d.) in New York and Stedin and Energy21's layered energy model (2018), were also consulted for the applicability of blockchain in the energy sector including its use for local sharing and energy communities. Academic literature as well as policy papers from the EU and the quasi-public private Dutch Blockchain Coalition were also sources of insight, most of which focused on the technical research on blockchain and its use in the energy sector.

Secondly, a visual discourse analysis was conducted, see Appendix I for a summary of this research. This was conducted to explore the visual representations of blockchain, again through desk based research. This analysis concentrated on the broader scope of visualisations of blockchain and the energy sector as there were only a few examples which existed visually showing blockchain and community energy futures. This method sits within discourse analysis where commonly linguistic analysis is conducted to search for symbols and themes (Pink, 2004; Silverman, 2011). The same logic was applied here, however, the focus was instead on visual language. A series of images were compiled from various sources, primarily from grey literature and company websites, collated in a visual database using the software Dropbox. The images and their sources were analysed, including visual annotation, for signs or recurring themes which included efficiency, the everyday, and the urban. Sources included websites specifically devoted to blockchain such as the Coin Centre and Ethnews, as well as energy companies including WePower. The STS programme within the Harvard Kennedy School (STS Research Platform, n.d.) states that using this methodology is often more enlightening for how futures from non-governmental actors are portrayed which was useful to understanding the broader imaginaries of blockchain and the energy sector.

A visual discourse analysis was chosen as an interesting exercise to accompany the desk research. Again, following the methodological guidelines of Imaginaries (Jasanoff & Kim, 2015), where the juxtaposition of different sources is encouraged as a comparative tool to analyse the different ways a future vision is enacted and displayed. This method addressed the performativity of futures, specifically through how they are visually enacted. We as humans have emotional reactions and connotations to images which stay within our visual memory and therefore influence our perceptions and acceptance of things (Barry, 1997; Nicholson-Cole, 2005). This idea is acutely put by John Berger (1972): 'the way we see things is affected by what we know or what we believe' (p.8). Therefore, to reference the common phrase *a picture speaks a thousand words*, is often very true. Visualisation is specifically interesting in the case of blockchain which is a digital technology; blockchain's tangibility is virtual therefore how it is visually represented could be difficult to negotiate, especially to the end user or those not directly involved in its use or development. Moreover blockchain is a backbone technology, it itself is not user facing, instead apps are used and built on top of it. Therefore how it is communicated visually, including any symbolic attachments, is interesting and suggestive of its future uses or development.

Thirdly, scenarios were created. They were designed based off of the imaginaries found in the desk research and the visual discourse analysis alongside 'creative techniques, intuition and implicit knowledge' of the researcher (Kosow & Gaßner, 2008, p.61). As such the scenarios are a concise summary of the imaginaries alongside inventive additions made by the researcher. Specifically creative narrative scenarios were used as they are suited to exploratory research and engaging the interviewee with futures (Kosow & Gaßner, 2008). The scenarios were presented as two extremes, following a 2X2 structure which is a simple form of scenario development, where two variables are chosen and presented in two opposing extremes. The two variables were configuration and value. Table 1 below gives an overview of the four scenarios, a more detailed version which was used during the interviews can be found in Appendix II.

| Scenario | Variables | Overview |
|---|---|---|
| **Machine Autonomy** | Decentralised, self-optimization | Energy is openly supplied but automatically processed by machines |
| **Libertarian Utopia** | Decentralised, system sharing | Everyone participates in the energy system with a social role |
| **Enclave Communities** | Centralised, system sharing | The energy system is polarised between self-sufficient communities and centralised grid production/consumption |
| **Green Markets** | Centralised, self-optimisation | Only regional markets exist and distribute energy based only on price and efficiency |

Table 1: Overview of the four interview scenarios

## Interactive Interviews

Interactive interviews were used to collect primary data on the expectations of the stakeholders interviewed through semi-structured interviews. The aim of this part of the research process was to begin a discussion around the scenarios, broader ideas about blockchain and community energy developments, and any tensions, opportunities or barriers that come with it. The intended outcome was to generate discussion and gain knowledge in order to map the positioning of the stakeholders.

The scenarios were presented and used as a tool with the interviewees in order to engage in futuring with different stakeholders, see Appendix II for the scenarios presented to stakeholders.

Scenarios were used by the researcher to foster a participatory approach toward the interviewee to enable creativity and to help look beyond any short term visions or goals they might have (Energy Research Knowledge Centre, 2014, p.4). As such the scenarios were used as a meditative point of interaction to spark ideas, opinions or debate in order to gain insight and knowledge from the interviewee. Chakraborty and McMillan (2015) stress the generative ability of scenarios which help create 'new insights that may not emerge through conventional decision making' (p.18). Moreover scenarios were chosen over other futuring techniques as they do not look for the 'correct' answer or future and instead open discussion and opinion (Chermack, Lynham, & Ruona, 2001). As such they were designed to be both provocative and plausible (Rounsevell & Metzger, 2010). Visual images were also presented alongside the scenarios, primarily to spark the interviewees imagination.

A semi-structured interview method was used. Discussion begun around the scenarios which were laid out in front of the interviewee. They were then discussed with the interviewee allowing freedom of the interviewee to discuss specific details or opinions about the scenarios or offer alternative scenarios. The scenarios were primarily based on the imaginaries of blockchain and community energy opinions and so there was also discussion about this wider discourse. Semi-structured questions were then posed to the interviewee to move the interview along and to gather their insight and expectations on areas which were deemed relevant by the researcher. An overview of these topic areas can be found in Appendix III.

During the interviews presentations and reports from different stakeholders were shown and discussed with the researcher. These were then sent to the researcher and used as part of the data analysis of this research in mapping stakeholder expectations.

## Case selection

16 interviews were conducted with 17 stakeholders and lasted 60 minutes on average. 41 stakeholders were picked and contacted for interviews with 17 responding and accepting this request. The stakeholders contacted for interviews were chosen based on their involvement in energy communities participating in blockchain pilot projects, energy related companies, from small consultants to large utilities, involved in blockchain related projects, and blockchain software companies involved in projects associated with local energy. The size of the case selection was in part determined by the practical restrictions of time and known contacts. However, stakeholders from nearly all of the major blockchain and community energy pilots in the Netherlands were interviewed as part of the data collection for this research.

A purposive sampling method was used. The reason for choosing this sampling method is its suitability for qualitative research and it allowed for specific stakeholders to be chosen based on their knowledge of blockchain developments in the energy sector and involvement in community energy initiatives (Tashakkori & Teddlie, 2010; Teddlie & Yu, 2007). Alternative participants, such as lawyers specialising in blockchain, seemed interesting potential interviewees, however, their background was not deemed specialised enough for the context of this research.

Figure 4 below gives an overview of the categories of stakeholders interviewed. See Appendix IV for a more comprehensive list of the stakeholders and their relevance. The breadth of actors across the energy system were chosen due to their relevance to energy futures. Moreover it was deemed important to try to gain insight from different stakeholders across the system as the integration and dependence on actors within the system is high. Therefore the expectations of a future or change within the system will affect multiple actors within the system.

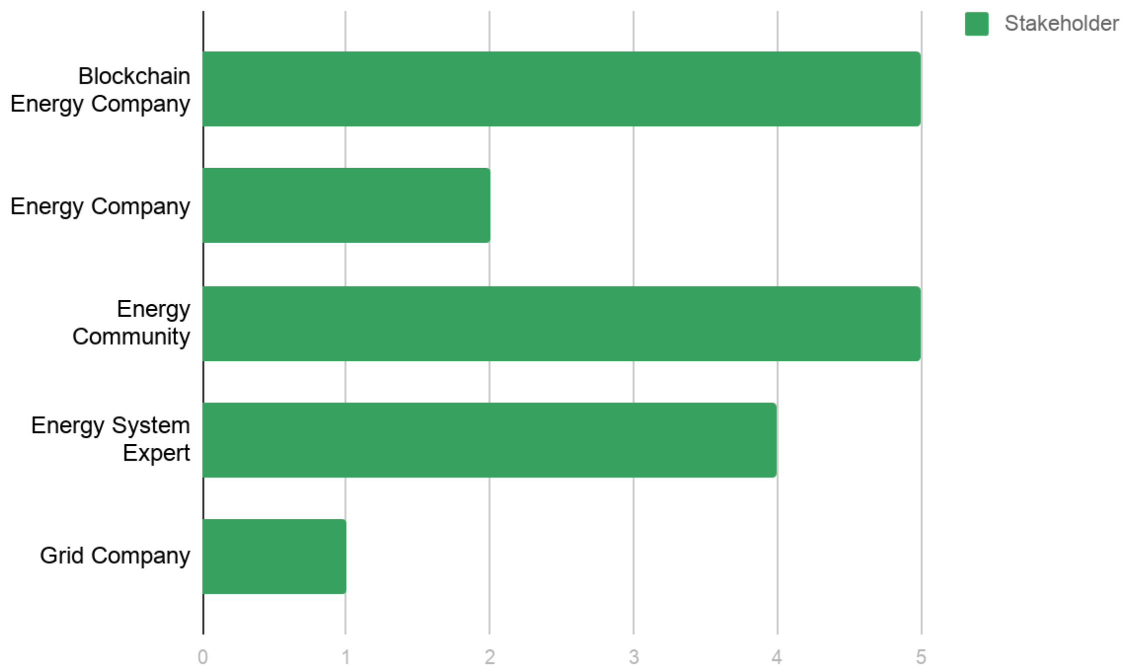


Figure 4: Overview of the different categories of stakeholders interviewed

Many of the stakeholders overlap across their involvement in different areas across the energy sector and therefore could be attributed to more than one of the given categories. To avoid double counting the stakeholders have been categorised according to the researcher's interest in originally choosing them as a participant in this research. For example, all of those interviewed that are involved in energy communities do so in their spare time, and also work for energy companies or as energy experts. In this case they have remained under the category of an energy community.

Different stakeholders from the listed categories were interviewed to gain different perspectives on the future expectations of blockchain and energy communities. Similar topics of decentralisation and local energy production, energy transition challenges, and the characteristics and challenges of blockchain frequently came up amongst all stakeholders. However, during the interview process different stakeholders discussed new and relevant insights and topic areas which were then pursued by the researcher. However, a point was reached where the interviews were generating the same themes and insights. The researcher decided that a level of theoretical saturation had been met where it was no longer productive to interview further stakeholders as no new insights which were deemed relevant to exploring futures on blockchain and energy communities would be generated from these interviews (Bryman, 2016).

## Mapping Stakeholder Expectations

Stakeholder expectations were mapped in order to see the positions of different stakeholders, if any relationships or themes from the interviews emerged, including any barriers and opportunities in how to move forward in the use and acceptability of blockchain and community energy initiatives. It is worth noting here that mapping was understood as outlining the different perspectives, expectations and positions amongst the stakeholders which were interviewed.

In order to do this coding and thematic analysis were conducted in order to analyse the data generated from the interactive interviews. The interviews were transcribed and analysed through coding using Nvivo software. Any additional presentations or reports sent or discussed by the stakeholders were also coded using Nvivo software.

Constant comparison was used during the interview process in order to analyse the data generated. This method is based in grounded theory whereby new data that is generated is continuously compare to data previously generated (Boeije, 2002; Bryman, 2016). This was done using an open coding process (Bryman, 2016). After each interview the recording was transcribed and codes were assigned to the transcribed text based on its content or meaning. As such new codes were developed after each interview as new content and meaning continued to be derived. This was then compared to previous interviews conducted to search for relationships or emerging themes. Through this process themes were derived which were identified through emerging patterns and similarities across the data. As more interviews were conducted themes and relationships began to emerge and so the frequency of new codes being created diminished. The reason for using this approach is that it allowed for new insights and relevant questions to be asked in future interviews with stakeholders (Boeije, 2002).

After all of the interviews were conducted the transcripts were then reread, as recommended by Bryman (2016), in order to code any themes or meaning which were developed towards the end of the research process. This also helped identify key themes and sub themes from looking across all of the data.

Three themes were derived from the analysis of the coding process, as represented in figure 5 below in the essence thematic scheme. This scheme was created by the researcher and based off of the categorization of open codes of the grounded theory approach where themes and patterns are found during the coding and process of data analysis. This approach looks for the 'essence' (Corbin & Strauss, 1990, p.15), the essential idea or characteristic which comes from within the data. The essence of the three themes is the overarching theme at the top; the relationship between the three themes below is unified by the overarching theme above. From analysing the coded transcripts the overarching theme was identified as *New interactions in the future energy sector*. Theme 1 was identified as *Decentralisation* and describes possible future configurations of the energy system and what role blockchain could have in this. Theme 2 was identified as *Value* and addresses the acceptability of blockchain and energy communities and theme 3, *Participation*, explores how this might happen in the future and the different roles actors may play in these expected futures. These themes are discussed in greater detail in the results section to follow and helped frame the key points within the discussion section, outlined in chapter 6 of this paper.

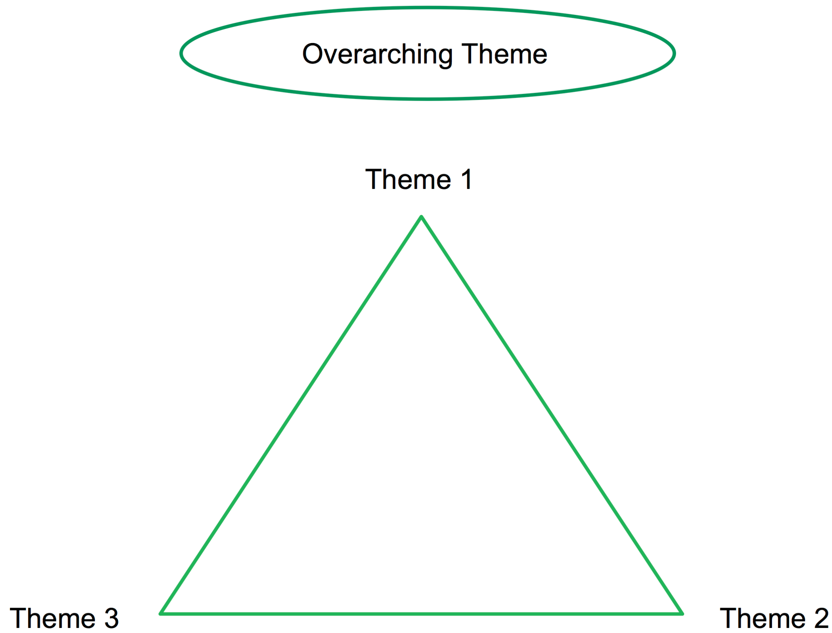


Figure 5: Essence thematic scheme

The themes were analysed and compared to look for similarities, differences and areas of possible tension between the different stakeholders. This helped establish areas of opportunity and barriers for the potential use and development of blockchain and community energy initiatives. This is also outlined in the discussion section of this paper.

# 5. Results

The following section gives a summary of the data collected from the interactive interviews with stakeholders and the analysis of this data from the mapping of these stakeholders' expectations, as outlined in section 4. The results which follow have been themed using the essence thematic scheme outlined in section 4, and as shown below in figure 6. The overarching theme of *New interactions in the future energy sector* links the three main themes of *Decentralisation*, *Value* and *Participation*. The overarching theme highlights the problem framing of the energy transition. The theme of *Decentralisation* groups the expectations of the role of the local, flexibility, the multi-layered and multi-tiered system and the role of blockchain and decentralisation in the future energy system. The theme of *Value* presents future expectations associated with social acceptability and incentives, service oriented business models, the socio-cultural beliefs of end users and how blockchain can deliver value. The final theme, *Participation*, gives an overview of the new players and roles in the future, the expectations of autonomy, the collaboration, negotiation and competition amongst actors, the change from active to passive participation, and the relationship between blockchain and participation in the future energy system.

## Thematic breakdown

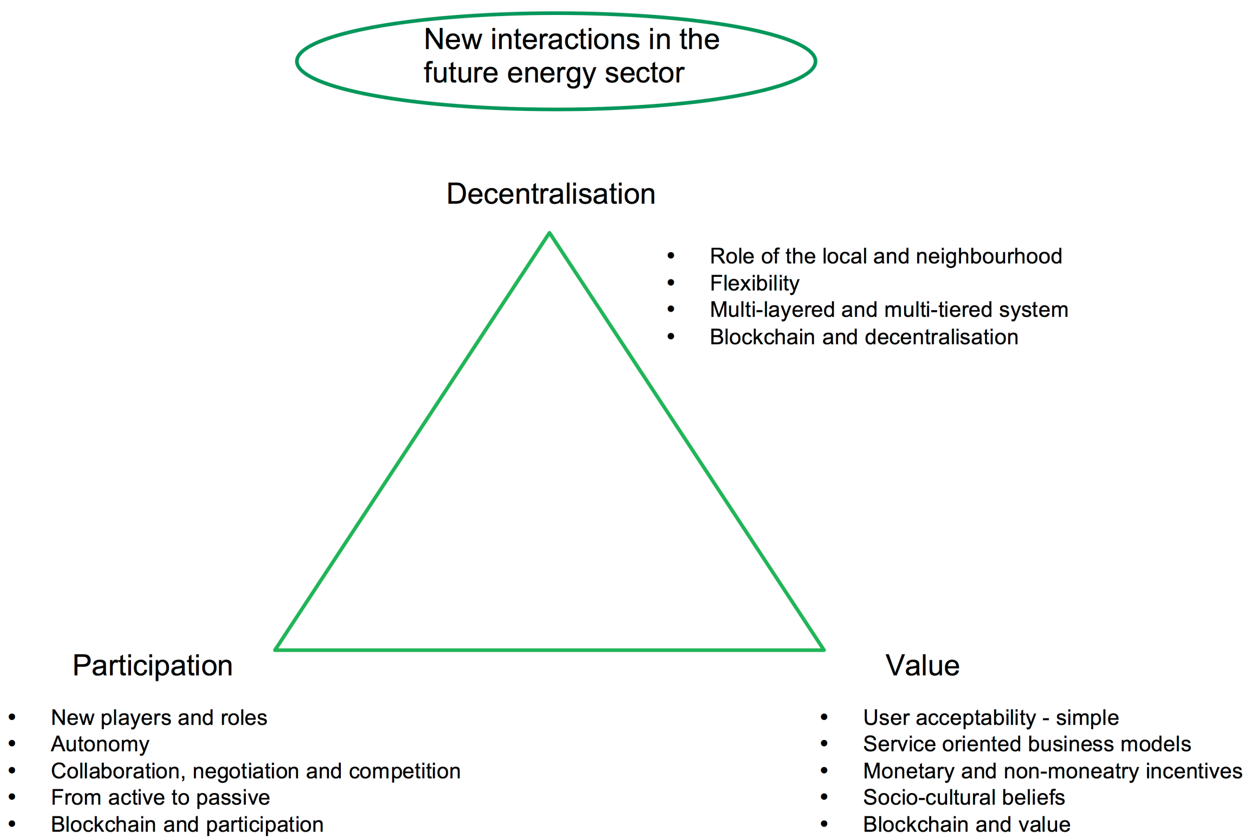


Figure 6: Thematic breakdown of stakeholder expectations

## New Interactions in the Future Energy Sector

When discussing energy futures, regardless of the involvement of blockchain, all stakeholders highlighted the challenges facing the energy system of the future. All stakeholders acknowledged that there will be a shift towards democratisation, digitisation and decarbonisation as part of the energy transition where the future energy system will be very different from the present day. The importance of the energy transition for informing future expectations was found in statements echoing from all stakeholders similar to the following below:

> "*renewable energy will play a much more important role in our energy system*" [R3]

As such, the issues facing the energy sector are seen to come first, according to the majority of stakeholders interviewed, and then followed by the possible use of blockchain, or alternative technologies. A technological solution is expected to fit to the energy challenges of the future; *"there will be technology, I don't care if it is going to be blockchain or something else but, something will be there that solves this problem"* [R12]. So the framing of the future is guided by challenges which are already established and therefore stakeholders are looking for fitting solutions to these.

## Decentralisation

> *"More of a social trend, we don't want to be dependent on the large utilities, we want to have our own energy - that's also happening, we are going more decentralised, especially with the local energy production possibilities which are out there"* [R3]

It is unanimously agreed that the energy market will become more decentralised in the future; *"it is a fact that things are going to be decentralised - you can't stop that"* [R10]. The system will become more open in comparison to its current centralised configuration. This is shown in figure 7 below, which approximately marks the expectations of where the stakeholders interviewed see the future energy system, using the same axis from the scenarios shown to them during the interviews (the original version can be found in Appendix II). New market entrants and role changes are expected with new and existing actors reforming their relationships with others in the system. Energy communities and prosumers are expected to increase in number. As such a move towards a more local production and consumption of energy is also widely accepted as a definite future.

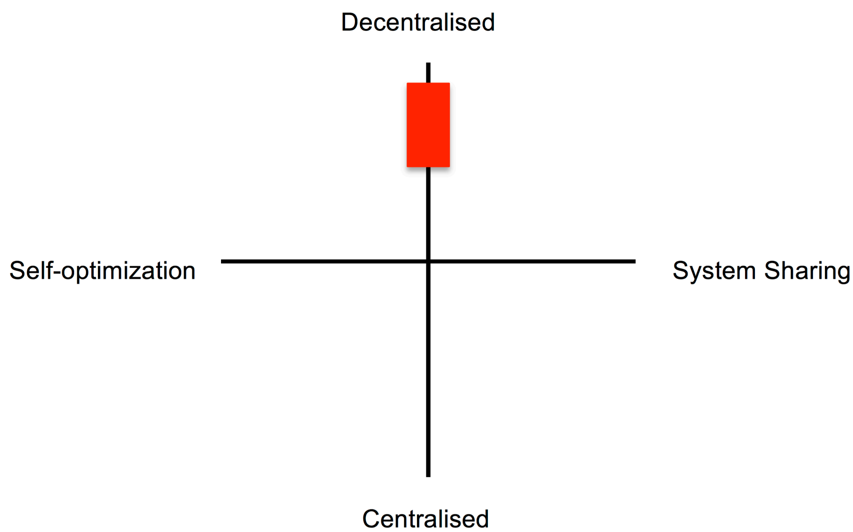


Figure 7: Stakeholder expectations of decentralisation

Flexibility is needed so an openness to matching supply and demand between more actors in the system is able to happen. Blockchain is seen as an effective mechanism to do so where you can use "*blockchain to match consumption and production all the time*" [R9]. More actors are expected within the system operating on a local, and therefore smaller scale with a commonly held vision of a multi-layered and multi-tiered system amongst stakeholders. This layered system enables different scales of markets to be open to one another and in some expectations hierarchies exist between these markets, or layers.

Decentralisation is also expected to bring the end consumer, and increasingly the prosumer, more choice. The move towards a more decentralised energy system is seen to be related to wider trends of more choice and the decentralisation of other parts of our lives. One stakeholder commented: "*I always think of the content we produce today and the electricity we will produce in the future would go in the same direction*" [R7]. A more decentralised system brings greater choice, especially for the end user. They are able to act with more parity within the system, amongst other actors, and have more of a key role in providing and balancing energy within the system.

A future expectation for further in the future is the creation of a singular or completely connected blockchain, which effectively connects all of these layers and multiple blockchains together, creating a meshed decentralised chain.

### The role of the local and the neighbourhood

A switch from a centralised to a more decentralised energy system in how energy is produced and consumed means that a change in scale in the production and consumption of energy is expected. A move to a smaller scale is expected where the 'local' is a key vision in this. This local approach to energy is fitting to the smaller energy quantities produced from DERs, which are expected to increase in number amongst households. The local is also expected to be cost effective where these small amounts of energy are being consumed and produced; "*there are* *no transport costs because it is all local. It is a very logical conclusion that it should become cheaper*" [R10].

The local is also to do with scale; there is an expectation that there will be multiple scales of energy markets or groups which will interact with one another. One stakeholder described this as "*in the future it could be a local market with nested local markets within them or parallel local markets*" [R12]. The size of these groups is not explicitly defined; some see communities being the size of one hundred households whereas others see them as small as two households, albeit in a rural context. How these scales are expected to be organised is open to debate. However, how these scales will interact is expected to be done autonomously.

How local markets will be defined is not explicitly envisioned. Some described the 'local' as 'neighbourhoods', and used these two terms interchangeably. Some stakeholders expect physical boundaries, such as the existing physical grid or municipal distinctions, as existing and sensible definitions for new distributed local markets for energy generation and consumption. Others suggest that this is an artificial and top down approach and instead believe delineation will happen organically from bottom up initiatives; "*we use the word community way too rough and soon. Policymakers like having rough concepts, like a community, that neatly fits*" [R13]. Instead these stakeholders believe that local markets should be established by the will of local energy communities. This gives more power to the role of energy communities as drivers of change; *"energy cooperatives - those guys will take over the energy market"* [R9]. Along with this expectation is the general idea that energy communities will also grow in size and number.

### Flexibility

Flexibility is expected in the future energy system; *"markets are not only going to be about energy but also about flexibility and those flexibilities are going to be available at different scales and at different price points"* [R11]. As renewables are expected to increase in the energy mix and, as these are fluctuating resources, dependent on the sun or wind for example, a flexible demand and supply of energy is needed to balance the overall levels of energy within the system. It is also expected that the market will have more assets that need to be balanced, these include EVs, IoT and DERs, so the number of producers of energy will increase as will the number of assets which use energy.

For some stakeholders energy communities are a key actor in helping to match supply and demand offering flexibility and therefore helping to balance the grid. Energy communities are seen to be able to provide value as either consumers or providers of energy when it is needed to deal with energy fluctuations. In these scenarios the local energy communities act as connectors, bridging between a group of households and the national grid or large energy plants such as offshore wind parks. In this vision, communities operate beyond the local and are situated in between the national and local. Such energy communities can be seen as key new actors for TSOs and DSOs who need to balance the grid.

In this future the "*flex*" [R12] that communities can provide is of value. This was identified by stakeholders from both in and not in energy communities and is seen as a new business opportunity that energy communities could capitalise on. This was stated by one stakeholder: "*I see it more as a new business model for local communities to operate the local network*" [R16]. Energy communities are an active and important actor in this future –they are semiautonomous, they trade within their community, within their locality, and when needed offer to take energy or give surpluses to balance the larger grid network. Communities are expected to be rewarded for this service they will be providing. So their role and responsibility increases in this future scenario.

However, there are differences in opinion around the role different energy communities wish to take and the level of involvement they want from large actors within the system. Some see flexibility as a "*backup*" [R14] where energy communities have just one single small, physical connection to the main grid. This was an expectation from stakeholders not just from energy communities many of whom desire more autarky from the energy system, but from energy suppliers and experts too. A single connection reduces the risk of having no power and allows for surplus energy still to be sold. However, the role of the community is diminished in this expectation with the connection seen more as a risk mitigation strategy; *"a lot of energy communities think this too, lets try and make this completely independent from the grid and use the grid as a backup"* [R14]. A common expectation is that all actors within the energy system will still remain connected to the main physical grid.

### Multi-layered and multi-tiered system

Multiplicity within the future energy system is a universally held future vision. A layered or multi-tiered system is a common expectation shared amongst the stakeholders interviewed with one describing their future expectation as: *"it is going to be multi-tier or multi-scale. There will be multiple autonomous scales at which the system is organised. It is not going to be centralised top down neither is it going to be decentralised where there will be no centralised authority"* [R11]. Different phrases were used by the stakeholders including a "*layered system*" [R6], a "*multi-level*" [R16] configuration, to a "*competitive environment*" [R3] with multiple "*nested local markets*" [R12] or "*parallel markets*" [R12]. These multiplicities, of markets or groups, are expected to be arranged in layers or hierarchies and operate on different scales.

Community energy developments will play a key role in forming many of these local markets, with some respondents envisioning a community energy operator who would mediate between different tiers in the system. In terms of the configuration of these different layers, multiple blockchains are expected to be used with each individual market level run on its own blockchain based platform.

Tiered or hierarchical market expectations acknowledge different actors, the scale they operate on, and the balancing of energy within the system. Connectivity and an understanding of the energy system operating as a whole is associated with this expectation. Local markets are connected to wider regional or national markets which are operated by service providers or grid companies.

### Blockchain and decentralisation

Generally blockchain is seen as a fitting technological solution to the decentralisation of the future energy system with many stakeholders expecting blockchain to play a key role; *"it [blockchain] does fit the ideals with the decentralised nature of the grid"* [R4]. The mechanism blockchain can provide is generally understood to be suited to a more decentralised system, and the challenges this presents including having no single centralised party, the coordination of multiple assets, and offering flexibility within the grid. This was summarised by one stakeholder interviewed:

"*blockchain allows you to have no one person or entity be in control of it or can be in control of it - so you can have a democratization of energy and the coordination of lots of prosumer assets, EVs, rooftop solar, and allow the integration of these assets into a new system without the necessity of those assets being centrally controlled*." [R15]

A decentralised system means that it is no longer centrally controlled by a top down party and "*blockchain is a way to overcome that there is not one single point of trust*" [R4]. A more decentralised energy system also raises questions around how it will be regulated; "*it can be made acceptable without the need for big administrators - that is where blockchain is the perfect solution*" [R12]. Blockchain is understood to enable regulation and monitoring of the system without being top down or the need for a centralised party. So blockchain is expected to enable a form of decentralised regulation.

Some stakeholders see blockchain as the perfect technology to some of the problems associated with the future energy system and the management of lots of decentralised assets. A common challenge which has been on the news that was brought up many times by stakeholders was that solar panels, were being banned from the grid across countries in Europe, including the Netherlands, as the grid could not handle them. Blockchain is seen as a way of dealing with this problem, as it could help manage the fluctuations in the energy mix that DERs bring with them, and coordinate the increasing number of assets in the energy system. Blockchain is seen to be able to help manage the future flexibility needed in the grid and as a tool to help balance the grid "*by using blockchain to match consumption and production all the time*"[R9].

The expectations surrounding the sharing and coordination of assets in the future are that this will happen on different scales in the energy system. Blockchain fits into the expectation of a multi-layered and multi-tiered system in the coordination of assets across these different layers; one expectation is that in "*a system with lots of layers in that hierarchy and you can have a sort of balancing at different levels or layers within that*" [R15]. However, expectations also address the role of blockchain and asset sharing on a smaller, community scale; *"assets could be shared with the help of blockchain in single communities"* [R7].

A commonly held expectation amongst the stakeholders interviewed was that the coordination and integration of multiple assets in the future would not just be renewables but other devices too with EVs and IoT commonly referenced. Blockchain is seen as a technology to help coordinate these individual assets as part of the digitisation of the energy sector: "*if you digitise you will need some of the solutions or a lot of them that are on blockchains*" [R13].

## Value

> "*The ideal future we would see developing...you would have the choice to make decisions about your own values and have that realised through the system*" [R15]

Figure 8 below gives a visual representation the expectations of value of the stakeholders interviewed according to the axis of scenarios given to them during the interview process. This was created according to approximations of the stakeholders expectations. As shown, there was a wide range of expectations in how value can be attained in the future energy system with blockchain. Different ideas about what can and should be valued, both monetary and non monetary were voiced by the stakeholders and the need for these incentives to be worth the while of the end user were frequently mentioned.

Blockchain is expected to be a "*backbone*" [R15] technology that can provide a platform or mechanism in which innovation and different value propositions can be built and experimented with; *"you can produce this common good for the space and then allow people to innovate on top of that"* [R15]. However, what this value might be is not exactly known and many stakeholders suggest that in time the end user and real use cases will help work this out. So it is not the technological boundaries of blockchain that will determine this; the expectation is that whilst there are many technical possibilities the probability is that the direction of future developments will be based on moral and social ideals.

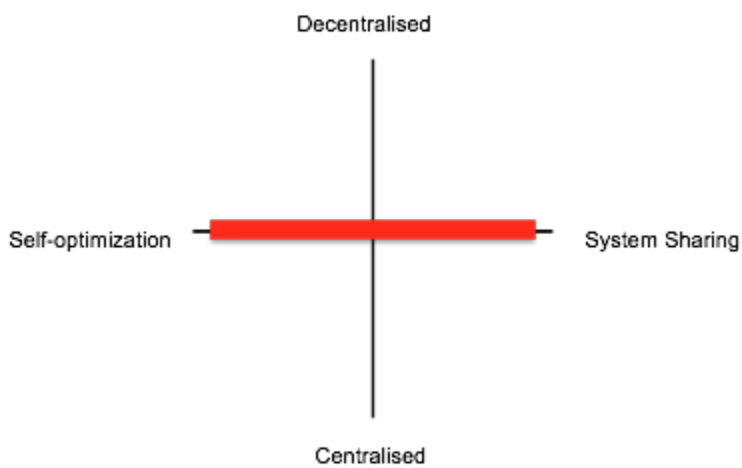


Figure 8: Stakeholder expectations of value

### User acceptability - simple

Simplicity, especially for the end user, is a common shared expectation and necessity for many of the stakeholders; *"it should be very simple and a system with blockchain can make it simple"* [R10]. Simple interfaces, most likely used via apps were frequently referred to. It is expected that interaction with the blockchain, by either the end user or an energy community, will not be necessary. Instead the blockchain will be "*hidden*" [R3] with multiple stakeholders stating that many users will not need to understand or even know that they are using a blockchain based platform. One stakeholder explained this as the following:

*"in the end I think for blockchain to succeed it doesn't have to be totally understood by everyone how it actually works because the majority of people don't really understand how the internet works either, they just need to have a service, and by chance it happens to be run on a blockchain."* [R6]

Instead interaction with the blockchain will happen via an app which is built on top of it. As such blockchain will be an underlying "*foundational*" [R17] technology. An analogy with the internet that most people rely on it every day but do not really understand how it works was referred to by 60% of the interviewees.

### Service oriented business models

Choice will increase around energy decisions and the value propositions to end consumers through new business models. One stakeholder explicitly stated this expectation as: *"what I see is that it will be the battle of business models"* [R7]. Some stakeholders are clear about what these new business models will be and have established goals and timelines to reach these - but they do admit these are predictions based on desired visions. Others are less explicit, mainly the larger energy players, and instead state they will be dictated by what the end consumer wants.

New business models are expected in the future energy system and with the active role of the prosumer the supply of energy is no longer a key business model for energy companies. Instead, providing a service is seen as the key new direction for companies and other actors within the energy system. Comfort was mentioned by various stakeholders as a future model, where a consumer no longer pays for the amount of energy consumed but pays for the service of keeping their house comfortable according to their household energy preferences. This is therefore linked with energy forecasting and understanding the end consumer's energy consumption patterns and needs.

Expectations which surround service business models for energy communities are also well established. A key expectation is that energy communities will use the services of companies who will provide a blockchain based platform and marketplace which will enable the local consumption and production of energy. *"It is up to the energy cooperative how they run their commercial activity, we just do the platform"* [R14] was the expectation of one of the blockchain energy software companies interviewed. There are differing expectations surrounding who these service providers will be, some see it as a mix of software and technology companies and existing energy retailers whereas others only see existing energy companies as providing this new role. The integration and value generated by other sectors was also mentioned by some stakeholders, particularly housing developers. Blockchain is seen to be able to help deliver lower energy costs and offer comfort levels expected in a modern home.

### Monetary and non-monetary incentives

The majority of interviewees stated that monetary incentives would be the main driver for an increase in participation in the energy system and what most consumers would value in the future; "*for the masses the financial is still important*" [R12]. Blockchain specifically is expected to help create future monetary incentives through helping to deliver lower costs which will be passed onto the consumer. One stakeholder explicitly stated that "*this is reflected in the bills of* *the consumer, they pay less*" [R16]. Blockchain based energy markets are expected to provide peak and off peak energy prices in accordance with energy supply and demand levels. A number of stakeholders also expect monetary incentives to be implemented through tax, or specifically that local energy and the markets it is traded in would be tax free.

Alternative non-monetary incentives are also expected to form in the future. One stakeholder described this as a shift from monetary to non-monetary incentives based on a change to the value proposition: *"it will remain to be driven primarily by price until something interesting pops up which makes energy a sort of social status"* [R7]. These include a social value of energy where excess energy is not sold for profit but passed onto others in the community, neighbours or the church were examples mentioned. Associations with the local economy were made with many of these future expectations including the use of energy tokens. These could be used in local shops where tokens could be created specifically to your neighbourhood and help boost local business. One stakeholder described this scenario as "*I sold you electricity, and then i'm given tokens, and then you own a restaurant and so with that token I can buy a beer*" [R9]. Nearly all stakeholders who discussed tokens linked the tokenization of energy to the monetary value of energy.

There was also general agreement that different segments of the population will have different incentives to using more green energy. Energy communities will be driven by non-monetary incentives whereas the majority of the population are expected to prioritise price over other values. However, a shift in this mentality was acknowledged by a few stakeholders who expect the younger generations to prioritise the social value or "*social status*" [R7] of green energy over price. Visions of non-monetary priorities include knowing the origin of the green energy you consume, having solar panels, owning your data rather than selling it to companies and giving surplus energy for free to those more in need. Different values and the choice for different business models based on these values are expected in the future.

### Socio-cultural beliefs

The different scenarios brought up different principles and philosophies in the expectations of what will be socially and culturally valued in the future. Fairness, engagement, and belief were broader issues which came up during discussions. These are all wider issues and moral questions which stakeholders are considering in the future configuration of the energy system; *"the question is do you acknowledge differences, do you want them to be there? What understanding of fairness do you apply from the outside world, which is a societal problem"* [R11]. All stakeholders expect that a change from the current system will happen, however, in what way and according to what principles is still unclear.

Some took a firmer stance that fairness and energy poverty could exist in some futures and should be considered. The suggestion that energy communities be used as a mechanism for the equal provision of energy was mentioned by a few stakeholders. Others suggested more market based or regulatory mechanisms for achieving fairness, specifically taxation and subsidies to lower income groups or the elderly for example.

It is expected that new business propositions will grow and try to find new value in energy. Therefore new beliefs and cultural values are expected to be captured by firms in a competitive market. Some interviewees suggested that what is valued in the future energy system will be decided by the consumer, the end user, rather than a technology; *"I don't think blockchain as a technology per say dictates the world to be, it is very much determined by how people want to use it."* [R6]. For example, new business models will cater for how users want to use the new ability to trade energy, sending energy as a birthday gift was an example given.

### Blockchain and value

It is accepted that some kind of different 'value' will be expected to be provided to energy consumers in the future but different expectations surround what that might be. However, "*blockchain can be used in any manner*" [R3] and interviewees thought that experimentation is necessary to help work out what the end user will value. Blockchain as a technology is seen to be able to provide the architecture and platform where different value propositions can be experimented with; "*blockchain provides a technology that can create much more possibilities than previously, building apps and good propositions, with much lower barriers than before*" [R12].

The expectation of blockchain as a backbone architecture make models scalable which are then tailored to different contexts and uses. No one blockchain based application will be the same; the use of blockchain will be different in different contexts based on its functionality, and therefore the value it provides. Also the value that blockchain can deliver is not expected to just come from blockchain technology, development is needed on top of it, for example applications. This was concisely put by one stakeholder interviewed: "*blockchain is foundational - it is the core but part of others things that are needed for it to work properly*" [R17]. Further in the future an expectation is that a single or a few dominant blockchains will exist with innovation and variety created through applications with different functionalities and value generated off of them.

Another expected value blockchain can offer is trust which was mentioned by a number of stakeholders; "*we talk about trust - there blockchain really has got some advantages*" [R12]. This is seen as beneficial to end users, including energy communities, where there is currently a lot of distrust towards energy companies. This was remarked upon by one stakeholder: "*the distrust on a community level for the big companies - don't like being dependent on these huge million dollar companies. So people are looking for alternatives and blockchain could provide an alternative*" [R3].

Both trust and transparency are often associated with one another in the expectations of stakeholders in what blockchain can deliver. Different stakeholders listed the benefits of transparency through certificates for different parties. One stated that certificates are key for energy companies in order to validate the origin of energy, others stated the desire for end users to have proof they are using green energy; "*yes transparency, exactly. Certificates, definitely. This will definitely pass on down to the consumers because more and more consumers...want to identify their energy, they want to know where it comes from*" [R9]. This fits into the wider trend of local and green energy becoming more important to consumers. A few stakeholders acknowledged the regulatory advantage of blockchain and the transparency of certificates for regulation where "*you need to have a regulated blockchain, nodes for the government where they can watch along, regulate*" [R17]. As mentioned previously, blockchain is seen as a way of regulating a decentralised energy system in the future.

Blockchain is also expected to be able to deliver transparency in energy trading amongst parties whilst reducing the administrative burden involved in this. This was highlighted as particularly important for energy communities who do not want any added bureaucracy. For energy communities in particular blockchain has the potential to take a bureaucratic role for "*bookkeeping*" [R4] with smart contracts specifically being expected to bring administration to a decentralised level. With this are expected cost reductions which is also a common expectation which blockchain can provide in the future; "*it is a very logical conclusion that it should become cheaper*" [R10].

## Participation

> "*Everyone is going to have something to do with the energy transition" [R12]*

It is expected that the participation of different actors in the energy system in the future will change. The identity of actors is also expected to change, for example many consumers will become more engaged prosumers. New dynamics are also expected with one stakeholder remarking "*I think competition is going to shift*" [R12]. Partnerships between large incumbents and small new start-ups have already begun and are expected to become commonplace in the future. Consequently it is a widely held expectation that "*ecosystem collaboration*" [R7] will be key amongst all stakeholders in the future and not just amongst a few key players.

Technology, including digital devices and blockchain, are expected to change how energy markets will operate and how interactions amongst actors in the energy system will take place. The way the end user and energy communities will interact with their energy consumption, production and how it is managed will initially become more active with more end user choice through apps for energy management for example. However, it is also expected that technological automation will then reduce user interaction and become more passive in the long term.

### New players and roles

New roles and players are all present in the future expectations of the stakeholders; "*I think the market will be much more open than right now and all kinds of entrants will be possible*" [R12]. Some example expectations include end users having greater responsibility in their "*energy management*" [R11] with trading on behalf of consumers is most likely to happen through apps, agents, or community operators. Many stakeholders do not see energy companies in their current configuration as participating in the future energy market. One stakeholder explicitly expressed this: "*in our scenario energy retailers don't really exist*" [R16]. Government involvement in the future is seen in a regulatory capacity. One scenario sees the grid operator, a body governed by the state, as the gatekeeper to approving transactions within a blockchain. Energy communities are seen to have a new role with greater responsibility. Different expectations surround the amount of responsibility communities will be given. Some suggest energy communities or households should have the same responsibility as an energy supplier whereas others suggest that neither party would like this responsibility or extra bureaucracy associated with this role and instead service providers would assume this role on behalf of the community. Grid operators are expected to take on more roles including a role of trust to energy communities and other suppliers within the system.

One common expectation of blockchain is that its decentralised nature means that third parties will no longer exist. However, some stakeholders believe that third parties will still have a role but in new forms with the suggestion that expertise, and a service delivering this expertise, will still need to be provided somewhere; *"I think that third parties are not going to disappear"* [R11]. The expectation is not that, for example, energy communities have all of the resources to setup and maintain a blockchain based local energy trading platform, nor is this the desire of the energy communities interviewed. One stakeholder from a community energy development expressed this as: "*you need some party to assist the work and to do the billing on a yearly basis, or whatever, and we don't want to do this ourselves*" [R10]. Instead new roles are expected where companies provide the blockchain based platform and applications which can be used by energy communities or individuals. One business model surrounding this includes a subscription service where energy communities pay for the license to use a trading platform.

The energy community as an exemplar and group to learn from is an expected new role. Current energy communities as "*early adopters*" [R9] were frequently mentioned. Energy communities that exist now see themselves, and are seen by others interviewed, as existing in a niche. However, there is an expectation that these niche communities can be used to gain momentum to help scale energy communities to become majority players in the energy market. Some energy communities see themselves as more autarkic; they want to operate separately from the traditional system and other actors, and aspire to have their own blockchain based community market, for example. Whereas the expectations of software companies, grid operators and some of the energy communities interviewed see energy communities as active and key players in future scenarios; *"we have to go towards local communities...I see them as active players -they are not just the end user that has to obey whatever decision has been made above but actually the drive comes from them"* [R16]. Under this expectation energy communities will, and will want to, work with others within the system. For example to offer flexibility and help balance the energy mix in the grid.

Some expectations also see the role of energy communities beyond just being active players to adopting more dutiful roles; they are expected to help bring momentum to the scaling of energy communities as well as being principled and authoritative, groups. One stakeholder stated their role as: *"communities can be watchdogs - a community can be accountable - hold people responsible"* [R13].

### Autonomy

Blockchain is seen as fitting to matching the supply and demand of energy, which will become more complex in a more decentralised system. This is expected to be processed automatically. Moreover the matching of supply and demand is expected to be processed autonomously, by non human interventions; "*there is absolutely fact based evidence that more investment is moving in m2m economy. There is absolutely evidence that we are moving towards more autonomous assets*" [R7].

The use of autonomous agents to represent human interests is expected to happen in the future. This new player and role in the system is an inanimate device which will represent and trade according to preset human interests. For example, the user will set a series of parameters, or energy preferences; a user chooses to have solar as the source of their energy, which is produced no further than 2km away and for no more than 10 cents per KwH. These will be set by the user via an app and an algorithm will then match supply to the user's demand for energy according to their preferences. It is expected that most end users do not have the time or desire to monitor all of their energy use and transactions and so will be comfortable with a blockchain based agent to process and record these transactions.

Some stakeholders expect autonomy to be present on multiple levels within the future energy system. So within the household level, in the home non human agents will interact with one another and with higher level agents, for example an energy community operator which will match the supply and demand of all energy within a local market and then, if there is a shortage or surplus of energy, these operators will communicate with autonomous agents on a higher tier which deal with flexibility within the grid on a regional or national level. It is expected that multiple markets will be able to operate because they will utilise non-human interactions; "*I see that as an autonomous role. If it were a human role it couldn't scale*" [R12].

### Collaboration, negotiation and competition

Collaboration and competition are expected in the future energy system, by both small and large, traditional and new actors. Specifically in terms of the use of blockchain collaboration is seen as fundamental to how it is developed and used; "*there has to be some sort of collaboration. This is what blockchain has its strength in. You cannot have a blockchain on its own. Well you can but why bother?*" [R6]. However, there is resistance from some energy communities to collaborate with the larger incumbents in the energy system and instead preferring a grassroots collaborative approach amongst socially minded small companies or fellow community energy developments.

Competition will dictate future blockchain based business models. There are competing visions amongst stakeholders about some of the future functionalities and consequent business models of blockchain. Some expect P2P to remain and evolve into a dominant blockchain based business model in the future energy system as it is already established and is well known with pilots and use cases attached to its development. Other stakeholders strongly disagree with this future P2P business model as unsuitable to blockchain and see it creating competition amongst neighbours. The majority of other stakeholders see P2P as hyped but, nevertheless, see it as evolving in one form or another in the future in spite of the issues surrounding it; the potential social inequality it generates and legislative issues involved. One stakeholder expressed their expectation of P2P along these lines as: "*I think sharing, P2P, will happen but without people knowing so much that it is happening. It will happen that you will agree on the amount of energy you want and the time that you want it and you know that it will come from somebody else in the community*" [R9].

Non incumbents, such as blockchain software developers, see incumbents, energy companies for example, as wanting to stay competitive and will use their resources to buy up small, innovative companies so they are able to stay relevant in the market. It is also the expectation that different criteria will determine end users and their preferences; for example, if a service provider ensures transparency of transactions, or if another provider has an innovative dashboard which shows energy flow in real time. So future technological innovations and differences are expected to create competition and differentiation amongst competitors who currently are collaborating and learning from one another.

In the future it is expected that there will be more than one blockchain, they will exist in layers but also as competitors. Another expectation which takes this point further is that the current pilots which are formed from alliances with different actors across the energy system, will grow into the blockchains which will compete with one another in the future. The configurations of these blockchains and business models will be different and dependent on their functionality. In terms of energy communities they can have a role in designing how the blockchain based application will work for them based on functionality, i.e. how many members they have, what they would like to do with their data, if they using the platform just for tracking or exchanging energy transactions. There is also an expectation for further in the future that there will be only a single blockchain or a few dominant blockchain architectures in the future; "*in the next five, perhaps ten, years all these different aspects and features of all these blockchain technologies will come together and possibly merge into one standard technology or a handful or so*" [R6].

### From active to passive

The role of the end user in the future is expected to change to a more dynamic and active role. Consumers will have control over their data and what happens to it in blockchain based scenarios, leading to the empowerment of the consumer; "*if you share your data as a consumer you share your information, so someone can purchase it - even better. So everyone can benefit*" [R8]. However, it is expected that once the consumer has trust and assurance from a blockchain based app, they will not engage with it on a weekly, monthly or even annual basis. One stakeholder described this diminished participation of the end user as: "*you can see it happening that they will just have an application say on their phone, and it is easy for them to set it one time and that's it, and they don't really need to worry about it*" [R7]. So initially participation within the energy system will increase. However, once rules are established then end user interaction will reduce again.

The time and effort needed to manage energy consumption and production on a real time basis is expected to be too much for most users in the future. This was an expectation even for those actively involved in energy communities and prosumers themselves. Instead participation is expected to be determined by technology; algorithms were commonly referred to and also smart contracts which participate on your behalf via a blockchain. One stakeholder explained this passive participation via technological devices as: *"let's say you have this P2P marketplace for extra power, and the first thing you will do is trade with your neighbour, trade with your mother. That's really great but if you need to do that with every KWH you consume on a daily basis you will wear out. You will want some kind of machine or algorithm to do that for you."* [R6].

It is expected that over time, as innovation and the development of applications and value propositions develop, interaction will become more dynamic for the end user. However, what form these will take is too early to tell. Time is needed to allow the technology to develop and for participation to increase; as momentum gains so too will the number of people who participate. Branding and directing the narrative are seen as important for this to develop. One stakeholder claimed that "*we need to make it fashionable, to make energy fashionable*" [R7]. This idea was found in the expectations of other stakeholders who stated the need for a social acceptance of new ways of participating in the energy system, with many suggesting apps as a way of doing so.

There were many expectations from both energy communities and other actors, that see the need for energy communities to be scalable in the future. However, the approach to how this scaling will be achieved varies. Energy communities generally expect a grassroots approach where communities learn from one another. One stakeholder from an energy community expressed it as the following: "*it should be scalable of course. There will always be cooperation between the communities to exchange knowledge*" [R10]. The expectation is that a type of internal scaling amongst the communities will be conducted which takes more of an insular approach within the existing national energy communities network. Conversely other stakeholders envision more of a top down approach where a community model could be built and then implemented in different contexts. Blockchain is seen as an appropriate technology to do this and with the community scaled and accessed via an app or simple interface. One stakeholder described this expectation as the following: "*now you see communities doing it themselves. Some are the frontrunners and spend every free hour doing this. This is not going to be the way the masses are going to develop. So I am sure something is needed where you can download the app and get people together and say 'tomorrow we are a community'. This is how it must and will go.*" [R12]. Again the expectation is that participation will diminish with technology taking on an active role when the majority of the population are considered in the future energy system.

### Blockchain and participation

Blockchain will not dictate how it is used, instead people will. The general expectation of blockchain is that it could offer different degrees of participation from automation, to being able to own your data. An expectation is that blockchain will give transparency and empowerment to end users by giving them access, and according to some stakeholders, ownership of their energy data; "*we want to give consumers the key to our data - that is blockchain*" [R13].

Blockchain as a technology and its expected provision of trust is also seen in its potential use for identity management. "*Blockchain is a sure way of verifying agents and accounts*" [R11] and is therefore expected to create trust and an assurance of who you are "*talking*" [R11] to. This is especially useful for autonomous non human devices; an example given was that an energy supplier can easily identify an autonomous bot that is representing a household or consumer for example.

One popular expectation is the future use of blockchain for trading, in the processing of transactions between different parties. One stakeholder stated that: *"we think blockchain will be the trading system of the future"* [R13]. The use of blockchain for transaction based energy trading platforms was a commonly held expectation. However, a few alternate expectations amongst the stakeholders were given and actually refuted this dominant expectation with one stakeholder stating the future use of blockchain is "*probably not in transactions*" [R11].

The participation of energy communities and blockchain solutions was specifically addressed by some of the stakeholders. The obstacles of administration and scaling of communities was highlighted with blockchain being noted as a possible technological solution; "*there is also an administrative burden on it [energy communities] and I really think that if you had a white label* *blockchain for a community it would really help them*” [R6]. A ‘white label blockchain’ was not directly referenced but also alluded to by other stakeholders as creating a blockchain based platform which could be used and adapted in different contexts or markets. A set or rules, some stakeholders referred to smart contracts specifically, could be created on this blockchain and then reuse the same rules again on another market, for example for another energy community. The core blockchain architecture is expected to remain the same but there is “*the option for a community to tweak, to impose some extra value*” [R3]. The expectation is that community participation comes after an off the peg blockchain ‘product’ has been purchased and can then be tailored to their specific needs. This model, which utilises blockchain, is seen as a cheap and easy way to scale energy communities in the future; “*the only reasons for using blockchain is one, it is cheap, it can be duplicated for other markets quite easily*” [R3].

# 6. Discussion

This research has mapped stakeholder expectations with the previous section showing those expectations of the dynamics of blockchain and energy communities in the future. The theoretical framework of expectations and imaginaries, and the methodological approach of interactive interviews, were used as a guidance tool to gather relevant data. The connection between energy communities and blockchain has not previously been investigated in-depth and so this research has specifically explored the future expectations of this potentially important technology for the energy sector. The results of this research add to the discussion of the role of energy communities in the energy system specifically in terms of their scalability. The key findings from this research show potential areas of interest and tension, specifically in the potential use of blockchain technology. Namely how energy communities are scaled, the role of intermediaries in this, and the framing of expectations of blockchain and the energy transition. Blockchain affords a multiplicity and choice for energy communities and enables their scaling, potentially from the meso to niche. This will be discussed in the scaling energy communities section below. However, for this scaling to happen support is needed; support which enables encouragement whilst maintaining the freedom and choice of communities. This is outlined in the need for intermediaries section below. Finally, the expectations of the energy transition are discussed; the specificities and practicalities of how blockchain can be implemented need to still be decided but in light of the energy transition.

## Scaling Energy Communities

The results from this research found that energy communities are seen to play an important role in the future energy system. In the past, energy communities have worked independently, are seen to have a distrust of the energy system with a desire to move away from the current centralised production of energy to a more equitable and green system (Hoppe et al., 2015). Many of these communities have been formed through local activism with Seyfang and Smith (2007) conceptualising community energy initiatives as ‘grassroots innovations’ (p.585). These are bottom up initiatives, are a response to the local situation, and have historically had little support from government or other actors. Hoppe et al. (2015) outline the counter movement found in many energy communities where alternative visions to the mainstream can be practiced. These alternate visions include individuals generating and using local renewable energy for example. Blockchain can help facilitate these visions, it has the potential, and expectation, to enable more local and decentralised green energy in the future and at low cost. However, what is also key for blockchain to be developed and to be used to potentially scale such initiatives in the future is collaboration amongst different actors within the energy system. For energy communities to fully utilise blockchain technology they cannot work alone; a grassroots approach is useful in encouraging other people to join communities however it is not enough to use and implement this technology. Communities will need to work within a system and depend on other actors, for example software providers, to utilise blockchain for energy communities to scale. This is a potential area of tension as communities are primarily self starting and governing initiatives, working in isolation rather than in collaboration with partners.

Conversely other actors within the energy system need to acknowledge that not all energy communities are the same. Ambiguities surrounding what is defined as a community have been elaborated on before; Walker et al. (2007), Van Der Schoor and Scholtens (2015), and Seyfang and Smith (2007) denoted the different values, aims and ethos' of communities.  Not all communities are likely to want to scale or work with certain partners; a stakeholder from one of the energy communities interviewed stated that they did not want to work with large corporate energy suppliers for example.

So it is likely that flexibility will be needed in the future to accommodate different 'versions' of communities. There is room for different types of communities to exist, they are all needed to help the energy transition, and blockchain could play a role in the scaling of these different communities. However, to avoid tensions between different group's objectives and beliefs understanding differences is necessary. As such, the framing of this is important as energy communities are seen as important actors in the future energy system and are key in many future blockchain based visions. An open and competitive environment is needed for these new roles to be filled and suited to create choice for energy communities. One way that this could happen, and was mentioned by the stakeholders interviewed was the use of open source for technological developments which could help develop this environment and provide an opportunity to let new collaborative relationships form. Secondly, negotiation and compromise is likely to be needed to help foster these partnerships and to use this technology to fits the needs of different communities. Discussions about what a 'community' is also need to be had with communities and other actors within the system to prevent tensions and to aid their scaling.

## The Need for Intermediaries

The imaginary of a fully decentralised energy system will not be realised in the future and instead a less decentralised system is expected. However, it is expected that blockchain can help facilitate a more decentralised system than the present. Part of aiding the creation of a more decentralised system is the reduction in the use of intermediaries, also known as third parties. Blockchain has commonly been associated with the ability to eradicate the need for these intermediaries (Gupta, 2017). Instead the technology and its configuration providing the transparency of transactions and security to ensure that transactions cannot be tampered with which previously was the role of large central intermediaries (Mengelkamp et al., 2018). Catalini (2017) shows that blockchain's initial use for Bitcoin did negate the need for intermediaries with the technology replacing the need for this centralised role.

However, the use and role of blockchain will not be the same in the energy system and instead intermediaries will exist and be needed in the future. For example, transactions need to be overseen and regulated; the matching of the supply and demand of energy needs to be processed. These processes are most likely to be automated and undertaken by technology, with an expectation that blockchain could fulfil this role, however, ultimately this technology needs to be created and regulated by an institution. This is especially true in the energy sector which has strict regulation and must adhere to EU policy. As such the use of blockchain does not negate the need for intermediaries rather the role of intermediaries will not be eliminated but will instead change.

Specifically in terms of energy communities intermediaries are key for them to be able to use blockchain based mechanisms or applications. In actual fact, intermediaries can be seen as a necessity for energy communities to scale with blockchain. The expertise, time, or effort within energy communities means that another party are needed for communities to use blockchain, most likely blockchain based applications, in the future. Energy communities do not commonly have skilled blockchain or software developers for example. This is where an intermediary becomes necessary. Moreover intermediaries could provide the support energy communities previously needed to scale and blockchain could enable a cost effective means of doing so.

Hargreaves et al. (2012) showed the often neglected role, and power, of intermediaries. This can be reflected in the potential uses of blockchain in its use to suit the different values of energy communities which could be met and fostered by the use of intermediaries. As such the use of intermediaries could be an opportunity. However, it is uncertain who will take on this role but some likely options include: incumbent energy suppliers, blockchain software developers or a national energy community association.

Existing incumbent energy suppliers are already well established within the system and are expected to move toward providing service oriented business models. Therefore are likely to, and expected to, try and assume this new intermediary role even though there is a level of distrust toward them (Hoppe et al., 2015). Partnerships between blockchain software developers and energy communities have already been established through current pilot projects many of which provide the service platforms based off of a blockchain. These projects could help foster the needs and wants of communities and be directly fed to and learnt from the software companies. A national association for energy communities already exists within the Netherlands and, unlike energy suppliers or software developers, this organisations already represents the interests of energy communities, for example through lobbying on their behalf, and is well established within the national communities network. As such it could be an important intermediary to enable collaboration, nurture grassroots activity, and to coordinate the needs of energy communities in their possible scaling in the future.

However, which actor or actors will fill this role of an intermediary in the future comes down to a much broader question; what type of actor is appropriate, how should it be decided how this role is assumed, and whether policy and regulation should be used to enable certain actors to take on this role. Many of the stakeholders interviewed agreed that regulation should not be introduced yet in order for blockchain technology and pilot projects to develop without interference.

However, if no regulation also comes with consequences. Ultimately the energy sector is still a competitive market and dictated by market forces; if there are business opportunities companies will want to benefit off of those. This can already seen in the large investments in blockchain in the energy sector (World Energy Council, 2018), in the blockchain pilots of large energy incumbents (for example Alliander, Eneco, and Vattenfall in the Netherlands), alongside the influx of tech companies investing in blockchain projects, exemplified by IBMs energy Blockchain Development Lab (IBM, n.d.b). The increasing presence of tech companies suggests they could assume the role of intermediaries as providers of software and service platforms for energy communities, and potentially push out the need for many of the current energy incumbents. Something which was also found during this research. However, that is not to say that the presence of large tech companies is problem free. Instead this brings up many potential problems associated with large tech, as seen recently in issues over data privacy for example (Dearden, 2018). Alternatively, third sector or more socially oriented organisations, like a national association, could assume this intermediary role. This would be more in line with the grassroots ethos held by many energy communities.

The benefits and difficulties, and how to enable different actors to take on this role cannot be debated within this research. Moreover the issues with regulation, and when or how it is best to regulate is beyond the bounds of this research, and a complex topic in itself. However, what can be derived from this research is that intermediaries are key to facilitating energy communities in their implementation and application of blockchain related applications and that these roles need to be assumed by actors who will be responsive and supportive to these communities.

## Energy Transition Expectations: In search of technofixes

Expectations contain a 'script', that is how a future vision is described and framed (Van Lente & Rip, 1998, p.203). The challenges of the energy transition dominated the 'script' of the stakeholder expectations in this research. Specifically a common framing of expectations and future visions was the suitability of technologies in accordance to the challenges facing the energy system as part of the wider sustainability transition. The framing of the expectations of the stakeholders was that the challenges of the energy transition come first, then followed by technologies and how they are suitable in helping to overcome these challenges. This is commonly referred to as a technofix, where a technological solution is found to an existing problem.

As such the applicability of blockchain within the future energy system should be understood in relation to energy transition challenges. The applicability of blockchain and energy communities should not be understood as an isolated development but instead viewed in the context of the wider discourse of the energy transition. This is necessary in order to determine what the most relevant use and functionality of this technology could be for energy communities. This adds a new dimension to how expectations for blockchain can be viewed in the context of the future energy system. As such moving forward in the potential development of blockchain and energy communities there is a need to move away from what this technology has potential to do, to what it is suitable in doing, to fit with the future vision of the energy system.

This is interesting in terms of blockchain specifically which has been hyped as a revolutionary technology with the potential to dramatically change society (Reijers & Coeckelbergh, 2006) and whole industries (Gupta, 2017; Mulligan et al., 2018) as well as providing the foundation to uptopic visions of democratic and completely decentralised structures within the energy system (Lyons, 2018; Woodhall, 2018). As such, many of the associations and rhetoric which surround blockchain are not applicable or longer relevant to its potential uses in the future energy system. The example was given above in the necessity of intermediaries. This also includes debates around technical details such as the benefits of a permissioned or permissionless blockchain, as outlined in the blockchain background section of this paper, which will not help develop the potential use of this technology in the energy sector. Instead a practical approach is needed which moves past many of the common associations of blockchain and its potential, toward its specific functionality and the social aspects of this. Addressing what people want and then whether blockchain can fulfil that. Conversations need to open up to understand whether blockchain is best suited to say, processing P2P transactions amongst neighbours, or whether it is better suited to an administrative role for energy communities or its ability to provide a secure and transparent mechanism to track the origin of renewable energy from multiple sources.

However, determining what people what and whether blockchain is best suited to that is no easy feat. This research has shown that the applicability of blockchain within the future energy system should be understood in relation to energy transition challenges. However, what that also means is that the developments of blockchain and energy communities sit within the wider and discourse of the energy transition. A discourse which is well established, complex and highly political (Bosman et al., 2014). This could mean there may be multiple barriers which will needed to be overcome in order to show the opportunities blockchain and energy communities could offer, for example in its ability to scale communities from the niche to regime.

## Further Research

Energy communities are seen to have an important role in the future as energy consumption and production is expected to become more local. If they are to scale and help create momentum to the meso then more research is needed to investigate the expectations of these energy communities themselves. Discussions with more energy communities across the country and the national network many of the communities are associated with are needed. A potential area of tension could arise as some energy communities are grassroots organisations which were set up to be autarkic and remove themselves from the energy system as much as possible. Conversely some energy communities have been set up for primarily economic purposes and would like the opportunity to participate in new business ventures. Therefore researching the different dynamics and perspectives amongst energy communities is a key step to understanding the differences in these groups and whether energy communities are willing to assume a more dominant role in the future.

Another interesting area for further research in terms of communities is how they are formed in the digital age. Research has been conducted on how social participation and engagement has changed since digital devices have become commonplace, in many instances a necessity, in how we now live in the modern developed world. Does this impact how we participate locally, within our neighbourhoods and specifically for the scalability and role of blockchain in energy communities, how we form communities? Can digital technologies help or in some ways hinder participation in energy community developments? This is a key area of research given the large expectations surrounding the local and community in the future energy system.

Collaboration and crossovers from other industries are an expected development in the future energy system. Housing developers and IoT were mentioned in the results section as key areas of development in the future. Research into potential crossovers with other industries and blockchain's development in IoT could therefore be fruitful. Taking a multidisciplinary approach to looking beyond the energy sector could be valuable and in accordance with the expectation of collaboration between these industries in the future.

# 7. Conclusion

This research has investigated future expectations of the use of blockchain technology for energy communities. The aim of this research was to find out relevant stakeholder expectations of this emerging technology and its use for energy communities. Specifically in mind of the role this new technology could give energy communities and their possible scaling. Emphasis was placed on drawing out a social perspective rather than focusing on the technical details of this technology, the latter of which has been investigated in other literature. Instead how blockchain technology might be used and is seen by relevant stakeholders was the focus of this research. As such the theory of expectations and imaginaries were deemed appropriate to analyse this topic as they investigate futures, help analyse the relationship between society and technology and how they influence one another. Multiple methodological steps were taken to collect different types of data, the primary of which were interactive interviews with relevant stakeholders. Scenarios were presented during the interviews and used as a meditative tool to seek out expectations and other relevant information from the stakeholders being interviewed. This was a methodological tool used to try to generate new insights and follows the process of creating positive futures in terms of the energy transition originally outlined by Hajer & Pelzer (2018).

This research has found that blockchain is hyped; blockchain will not fulfil all its promise, nor is it unanimously expected to play a large role in the future energy system. However, it has innate characteristics which make it suited to some of the challenges facing the energy system and energy communities.

Specifically the use of blockchain to scale energy communities was found as a promising expectation amongst relevant stakeholders. There has been difficulty in the past in scaling these communities beyond the niche. However, this research has found that blockchain could offer certain characteristics to help overcome these problems and to give momentum to these communities. As such the role of energy communities is seen as important in the promotion and provision of local green energy in the future. Moreover the role of intermediaries will be important to help the scaling of energy communities if blockchain technology is to be used. This is an important insight from this research and differs from the general expectation that blockchain does away with the need for intermediaries. It will be interesting to see the future development of energy communities given that blockchain can offer momentum to their scaling. However the use of blockchain will also require communities to change their practices and outlook with collaboration and partnerships, and most likely negotiation, as a necessity with this technology.

## Limitations

Fully engaging in futures is a difficult and resource intensive process (Jasanoff, 2015). A larger sample size of stakeholders would also have allowed for more insight across different stakeholders and possibly given weight to dominant visions or expectations of the futures of blockchain and community energy initiatives. However, the sample size was large enough that a saturation point was reached. An iterative process should be used when analysing futures as they are temporal and adapt and change over time. This research has not allowed for an in depth study over a long period of time and instead a small-scale research has only assessed the current landscape of futures. Further research would allow for the findings to be reanalysed and compared at a different point in time to see if the expected futures have changed and the implications of this.

As is common in many research projects, resource constraints brought limitations. Individual interviews were chosen as the main data collection method. However, ideally a series of interactive group workshops amongst stakeholders would have been conducted to generate discussion, crossovers and enable more design led participation.

Scenarios were used as an interactive tool during the interviews with stakeholders. This is an innovative research method which when used created a few problems. The scenarios used catered to a wide range of stakeholders. They were accepted very easily and with excitement by some interviewees, some of whom had created their own future visions, however, they were also met with hesitation and confusion by others. In retrospect, the scenarios could have been designed with cues or prompts which would have guided the interviewee through the scenarios more. This would hopefully have prompted those that were more hesitant to engage and to discuss their reactions to the scenarios, and ultimately reach the goal of opening a discussion about their expectations toward different futures. Alternatively, more creative techniques which are far removed from any of the stakeholders' use of scenarios could have been used. For example objects placed in front of the interviewee to begin a discussion. This technique has been used in the research of the Urban Futures Studio where an interactive installation was used an object to engage with different stakeholders (Hajer & Pelzer, 2018). The creation of an object would need more time and resources from the researcher, which was not appropriate to this research but could be useful for more extensive research processes.

The use of an axis within the scenario design had both positives and negative effects. It gave participants a clear and easy way to read the four extreme futures being presented to them. As such many participants engaged well with this diagram. However, some participants critiqued it and tried to optimise or 'correct' it. This was not the intended purpose of the scenarios exercise with none of the futures being presented as 'correct'. This was stated in the explanation of the scenarios and during the interviews. However, to avoid these discussions or corrections in further research different visual cues could be used. Rather than using an axis other ways of representing relationships could be used. A simple table with a list of scenarios could be an easy change to make for future research.

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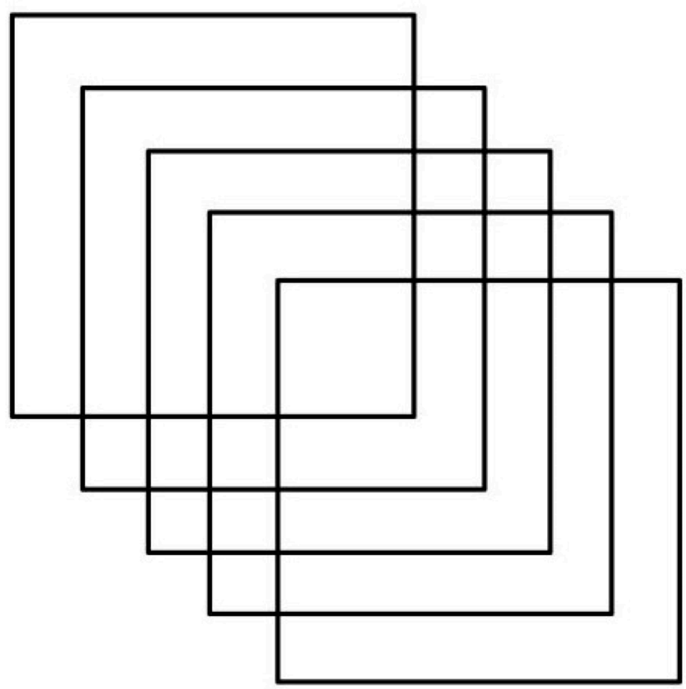
All other images are the author’s own

## Appendix I

# BLOCKCHAIN AND ENERGY

## A VISUAL DISCOURSE ANALYSIS



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# CONTENTS

# SUMMARY

## WHAT IS A VISUAL DISCOURSE AND WHY DOES IT MATTER?

A visual discourse analysis uses visual sources as objects which can be critically analysed. It leans on semiotics, where signs and symbols are studied with the suggestion that there is a reason why certain images or references have been chosen for what they communite or symbolize.

A visual discourse analysis can therefore show us how a technology is being envisioned, and how it could be potentially be used in the future.

## HOW?

Grey literature from the internet were the main sources used for this analysis. Websites specifically dedicated to blockchain activites were a key insight for the broader visualisations of this technology. Company reports and white papers helped identify the visual language designed to explain how the blockchain works. Media coverage, company advertisements and promotions were used to reveal the possible future uses of the blockchain in the energy market.

# VISUAL REPRESENTATIONS OF BLOCKCHAIN

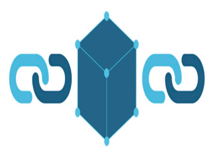
Generally visual representations of blockchain are still heavily associated with cryptocurrencies; Bitcoin is still a common symbol. A visual language specific to blockchain has also evolved both in terms of symbols and icons but also in its structural representations. These have been put into two categories, icons and symbols, and structural representations and will be explained further below.

## ICONS AND SYMBOLS

Recurring symbols are commonly used in the technical explanations of blockchain. Icons are used tohighlight what the important attributes of this technology are. Motifs and icons are an easy and accessible way to communicate these new qualities of blockchain. For example, a padlock is a recurring motif to suggest the high security blockchain can provide.

BLOCKCHAIN

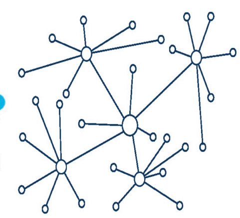
Source: LO3 Energy



Source: Coin Sutra

DECENTRALISED

Source: Block Geeks



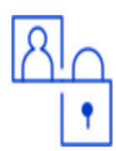
Source: Blockchain

TRADABLE

Source: We Power

Source: Trade IO

SECURE



Source: IBM

Source: Ledger

# BLOCKCHAIN AND ENERGY

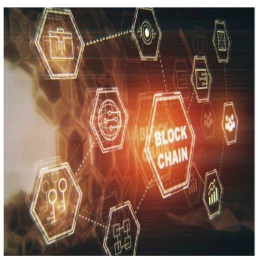
Much of the visual language specifically describing the energy sector is borrowed from general blockchain visualisations and motifs. Comparisons can be drawn in terms of the graphics which are rectilinear in form with similar rendering; dark back-grounds with bright, often blue, graphical representations.
Blockchain architectures and networks are structural in their visual representation. They are typically abstract, rectinlinear andinterconnected  in their form. These networks are often global in scale and show the tractions between differnet parties through interconnected linear forms.

BLOCKCHAIN (GENERAL)

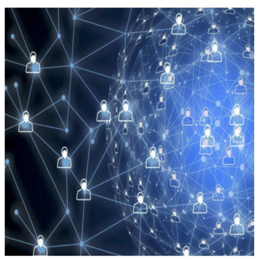
Source: Ethnews

BLOCKCHAIN + ENERGY

Source: IB Times

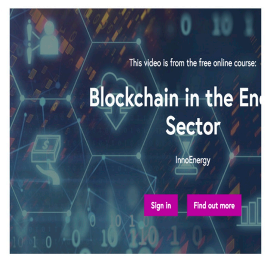



Source: Harvard Business Review



Source: The Blockchain


Source: Exergy




Source: Future Learn

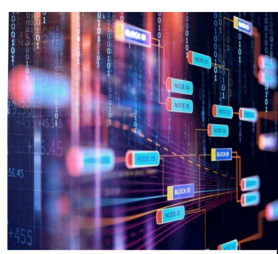
## EVOLVING THEMES AND SYMBOLISM

Certain visual representations specifically describing energy and blockchain are emerging. This is especially interesting when looking at companies and their advertising. A departure can be seen from the futuristic abstract representations of block-chain and replaced by common and familiar features from our everyday lives. For example, washing machines,

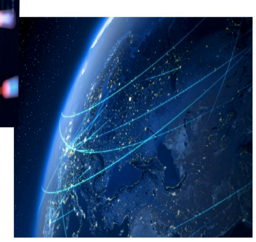
## EFFICIENCY

Efficiency and speed are present. This is seen through the rep-resentations of energy flows, presence of data and tracking devices which measure energy inputs and outputs.

Bright blue is a recurring colour and is frequently used to rep-resent energy flows. This colour choice is symbolic of speed and efficiency perhaps deriving from blue light which is char-acteristic of electronic devices and high speed wavelengths.



Source: Smart Cities NY



Source: LO3 Energy 5

## THE URBAN

Urban contexts prevail, it seems this has been chosen as the landscape for this new technology to begin its developments.

Connectvity within urban environments is also a theme.

Source: LO3 Energy

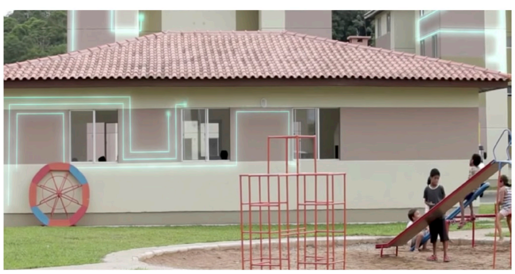

Source: Siemens


Source: Medium


Source: Greentechmedia

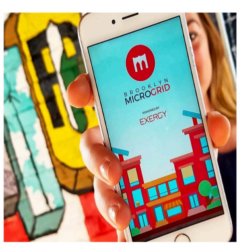

Source: PwC

## THE EVERYDAY

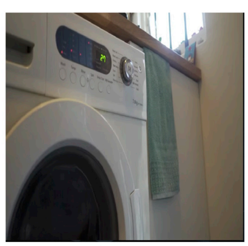

Source: Exergy, LO3 Energy

Humans are involved. This is a personal technology.  Reinforced by the graphical motifs of networks and connectors.

This personal connection to this technology is especially interesting in its developments for community initiatives.



Source: The Brooklyn Microgrid


Source: Power Ledger


Source: Power Ledger


Source: The New York Times

## WHAT DOES THIS TELL US?

The images within familiar and real settings, such as urban environments, houses and those with human figures, are interesting. They use current and recognisable elements but in a 'future' use, the 'what could be' world. As such these representations are steering the discussion of blockchain and energy to:
-the urban
-efficiency
-the individual: personal connections, in people's houses
-connected and networked

The new visual language and motifs surrounding blockchain are also interesting. Often with the introduction of a new technology, new languages are adopted. Icons are often developed alongside the creation of new digital technologies, for example the shopping cart on e-commerce websites.
A few icons or motifs recur throughout blockchain imagery, explanation and use. These use rectilinear forms, and links, often representing a connectedness.

Connectivity is a frequent reference with lines connected buildings and objects to oneanother. It is also worth  mentioning that Bitcoin sysmbols, a 'B', were frequently usedin contexts which were not related to Bitcoin nor cryptocurrencies. There is still a strong association between Bitcoin and blockchain regardless of the use of blockchain.


Source: Medium

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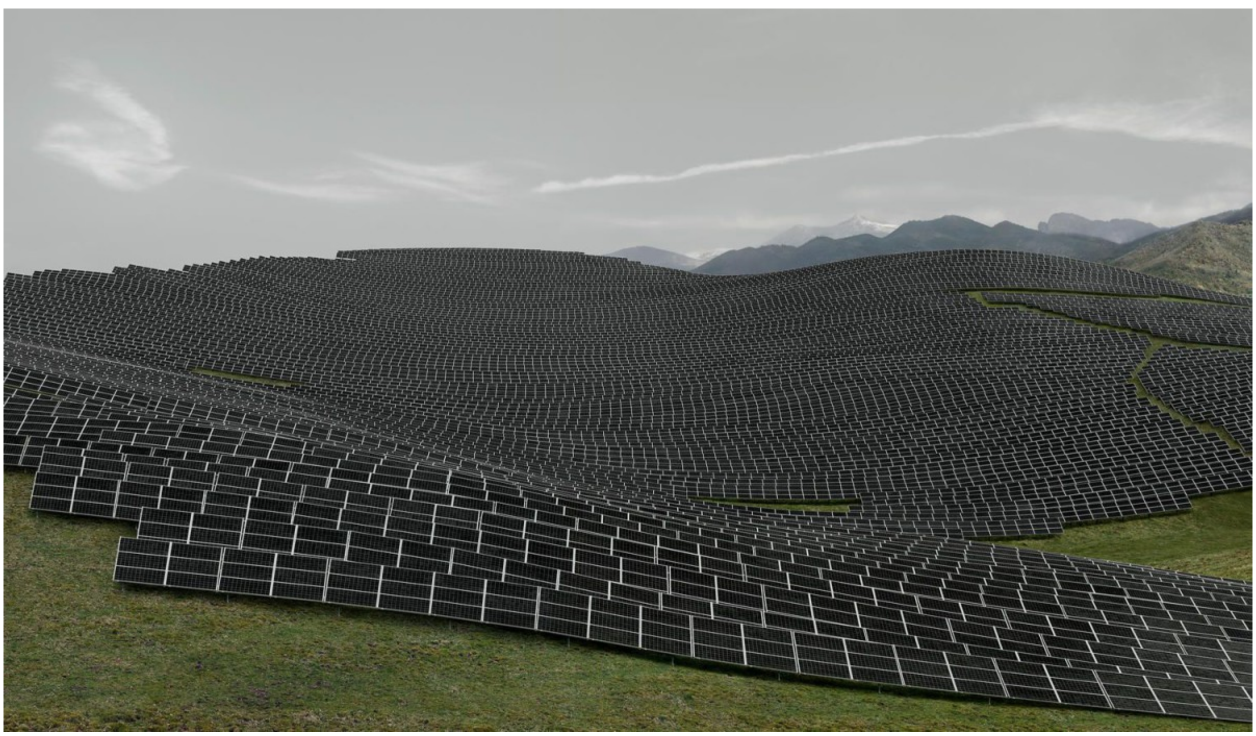
## Appendix II

# Exploring the Futures of Blockchain and Energy Communities

## 4 Scenarios



Source: Andreas Gursky *Les Mées, 2016*

## Introduction

The aim of this research is to gain an insight into the perspectives of stakeholders on the possible futures of blockchain and energy communities. 4 Scenarios have been created based off of research and the different imaginaries for blockchain and the energy sector. These will be presented in the following pages. These scenarios have been created using two variables: configuration and value, which have been presented in polarised forms.

Variables:

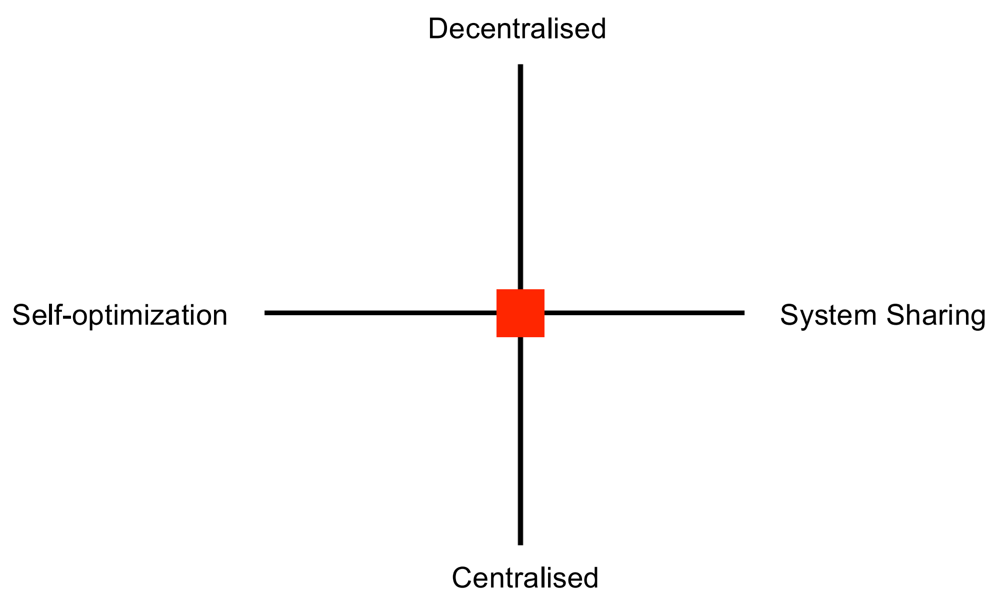
- **Configuration:** Decentralised vs. Centralised
- **Value:** Self-optimization vs. System Sharing

*Scenario 1:* Decentralised, Self-optimization: Machine Autonomy

*Scenario 2:* Decentralised, System Sharing: Libertarian Utopia

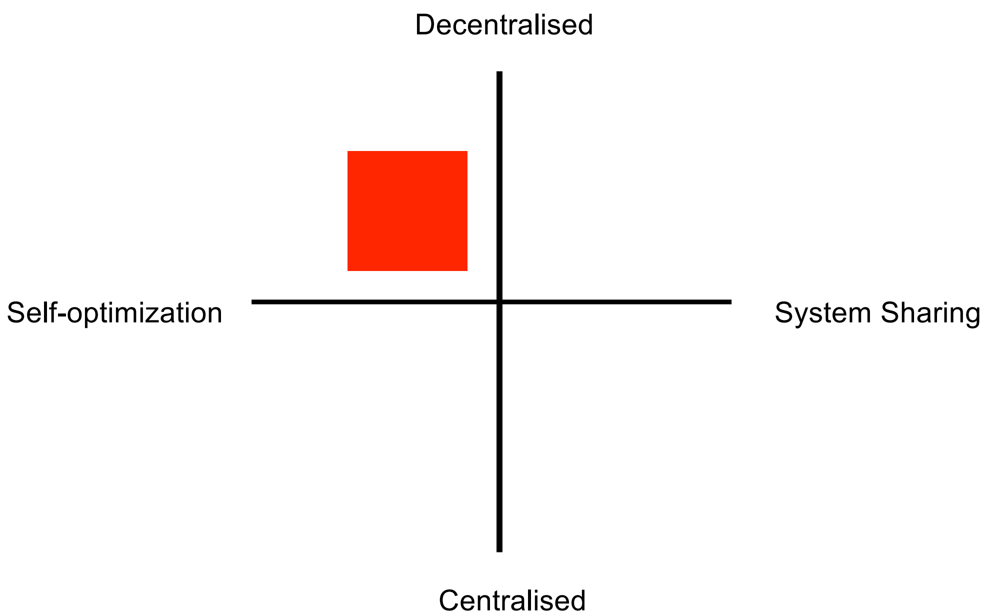
*Scenario 3:* Centralised, System Sharing: Enclave Communities

*Scenario 4:* Centralised, Self-optimization: Green Markets




The aim of this exercise is not to look for the 'correct' scenario, as these are extreme futures, they are fanciful and not true to life. Instead these scenarios have been developed to be meditative, as a point of interaction to generate wider ideas or opinions. Therefore I encourage you to use them as a tool; your expectations, hesitations, emotional or practical reactions are all valid and insightful for this research.

# Machine Autonomy



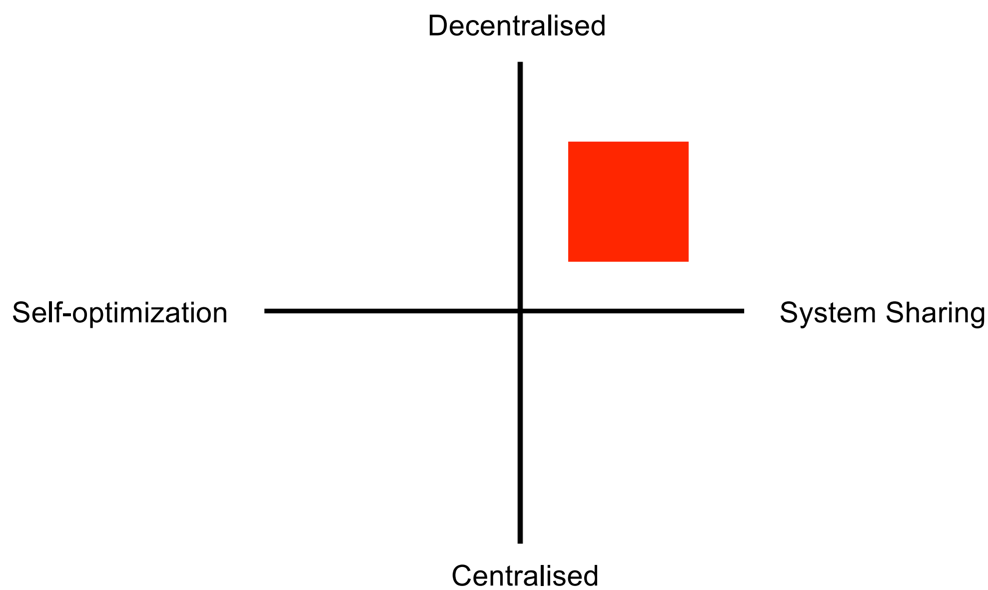

A completely open decentralised energy market exists where anyone can choose to supply energy

Machine to Machine interaction is used - smart meters in people's homes directly match the supply and demand of energy with meters in their neighbour's homes

Energy is marketed based on preset criteria: price and distance

Energy is traded across borders

# Libertarian Utopia

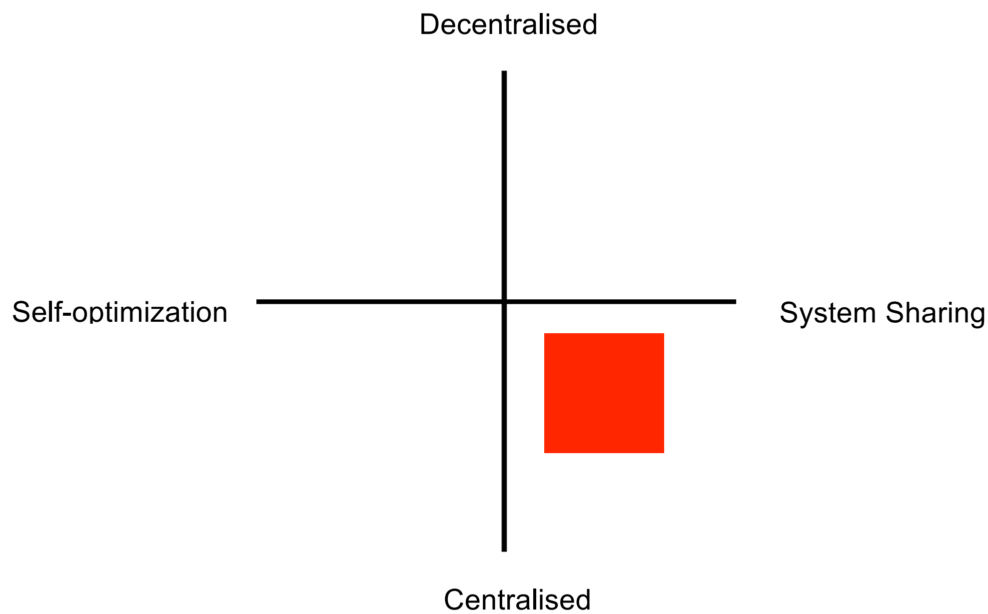



Energy has been completely democratized with everyone participating in a global community - suppliers, prosumers (energy consumers that produce energy) and energy communities trade alongside or with one another

To ensure everyone has fair access to clean energy, a basic daily kWh of energy is provided to households and businesses

The social and human side of energy is important. When exchanging energy you have to write about yourself in a profile which includes: where your energy come from, what activities you enjoy doing

# Enclave Communities



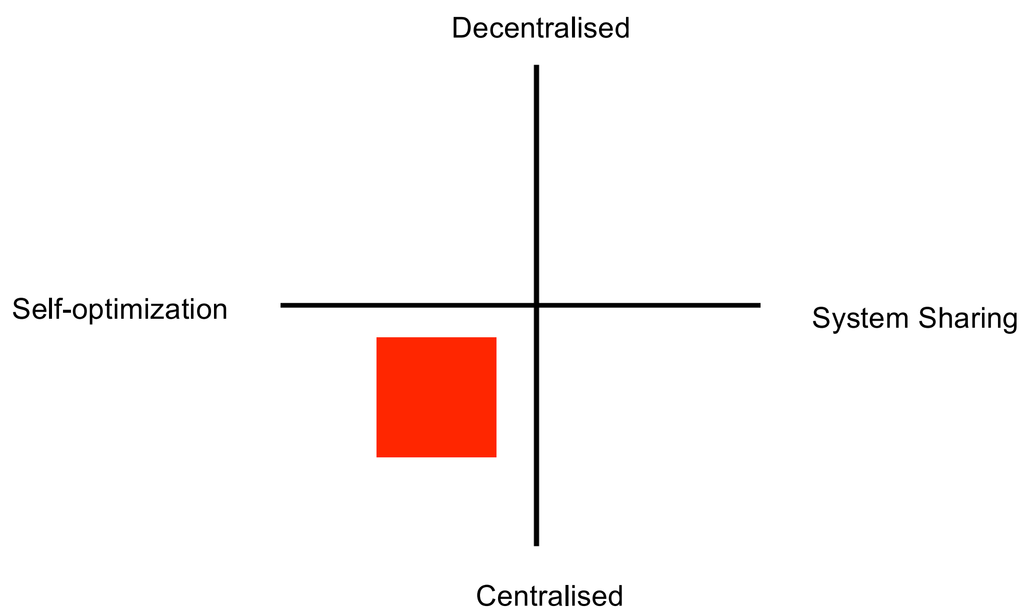

The energy system is polarised – centralized renewable energy mainly comes from offshore wind farms. Energy communities only exist off-grid having cut themselves from the centralized grid

Energy communities are self sufficient using storage to match supply and demand differences

There are tense divisions between the off-grid energy communities and grid users. Grid users have submitted many formal complaints to the municipality over the 'visual pollution' of the community's solar panels

Energy is a right of all members of the community and therefore isn't monetized – community board members oversee the blockchain which facilitates the trading of energy between neighbours

# Green Markets




Large scale energy producers and smaller energy communities both feed into the centralized grid

Community energy developments have to meet government rules – they have the legal status of a business and have to have at least 500 members

The consumer can filter their energy: source of energy, a ceiling price, a % they are willing to pay extra when there is high demand

# Appendix III - Interview Topic Outline

**Who**

*Actors:*

- Where is momentum for change coming from within the actors of the energy system?
- How much input is there from citizens? What are they incentivized by?
- Will actors outside of the energy sector become important?

*Social Acceptability:*

- How will consumers interact, encounter blockchain?
- How do you see blockchain being visualized, or what applications will be used?

**What**

*Policy and Regulation*

- Is there resistance, or hesitation, from policymakers for blockchain to be used? Specifically in P2P energy trading?
- What are the main changes in policy which are needed to facilitate decentralized energy production/consumption?

*Configuration*

- What type of network is likely to be used (e.g. direct P2P exchange or via a third party)?

**How**

*Size and Scalability*

- Can decentralized production/consumption of energy fit into the energy system of the future? If so what are the barriers and drivers of this?
- Are urban areas more attractive for blockchain and decentralized energy production?

*Market:*

- What scope (Dutch, European, global) is the future energy market likely to have?

*Barriers, Opportunities and expectations:*

- What do you see as barriers to community energy developments in the future?
- What do you see as opportunities for community energy developments to grow or strengthen in the future?

# Appendix IV - List of Interviewed Stakeholder Categories

| Stakeholder Category | Description and Relevance |
|---|---|
| **Blockchain Energy Company** | These companies will actually build the blockchain and or associated applications. Therefore what value propositions they offer and how they are configured, for example their design interface, could be an important consideration. |
| **Energy Company** | Blockchain challenges their current incumbent position within the energy system but they also dominant the market, if they choose to adopt this technology, how they do so will be significant to the wider system. |
| **Energy Community** | The communities contacted were specifically interested or involved in blockchain pilots. The people interviewed were active members within the community initiatives. |
| **Energy System Expert** | These were people working within the energy system, with consultancies and data experts as examples. They have knowledge of the different actors within the system and new technological developments, such as the potential uses of blockchain. |
| **Grid Company** | They are currently key in how energy is distributed, balanced and regulated. Therefore their role in the future is also likely to change with the use of blockchain. |

# Appendix V – Stakeholder Interview List

| Interview Number | Stakeholder Description |
|---|---|
| **1** | Energy System Expert |
| **2** | Energy community |
| **3** | Energy System Expert |
| **4** | Energy Community |
| **5** | Energy Community |
| **6** | Energy Company |
| **7** | Blockchain Energy Company |
| **8** | Energy Community |
| **9** | Energy Community |
| **10** | Energy Community |
| **11** | Energy System Expert |
| **12** | Grid Operator |
| **13** | Energy Company |
| **14** | Blockchain Energy Company |
| **15** | Blockchain Energy Company |
| **16** | Blockchain Energy Company |
| **17** | Blockchain Energy Company |