MASTER'S THESIS

Exploring the Impact of Blockchain Technology on Data Sharing in the Energy Sector

Güngörmüş, Adem

Award date:
2024

Link to publication

Exploring the Impact of Blockchain Technology on Data Sharing in the Energy Sector

Degree program:	Open University of the Netherlands, Faculty of Science Master of Science in Business Process Management & IT
Course:	IM1803 BPMIT Graduation Assignment Preparation IM9806 BPMIT Graduation Assignment

Student: Adem Güngörmüş

identification number:

Date:	February 9, 2024
Thesis supervisor:	Dr. Ir. Roger W.H. Bons
Second reader:	Dr. Pien Walraven
Version number:	v26
Status:	Final

Open Universiteit
www.ou.nl

Abstract

This thesis investigates the potential for enhancing trustworthy data sharing in the energy sector through emerging technologies, such as blockchain. Navigating through the ethical and legal complexities of data sharing, this study examines how collaboration can unlock secure and mutually beneficial data exchanges, fostering trust and accessibility. Additionally, it examines how blockchain, with its inherent features of transparency, security, and interoptability, can address crucial challenges in trustworthy data sharing, such as privacy concerns and legal compliance. Utilizing an exploratory qualitative approach with semi-structured interviews and white papers, this study clarified the benefits, limitations, and potential transformative roles of these technologies. The findings suggest that while emerging technologies offer significant opportunities, technological hurdles and organizational resistance present real challenges. To fully unlock its potential, this study emphasizes the need for a holistic approach that embraces technological advancements, keeps pace with data initiatives and regulatory updates, and address organizational adaptation. This thesis concludes with actionable recommendations for stakeholders in the energy sector to maximize the benefits of these technologies and achieve trustworthy data sharing for a more sustainable and efficient energy future.

Key terms

blockchain, governance, energy transition, trustworthy data sharing

Summary

Research Focus
This thesis investigates how blockchain technology can be leveraged to improve trustworthy data sharing within the energy sector. Recognizing the disruptive potential of blockchain, the research primarily focuses on understanding the data sharing between stakeholders, the concerns they have, and how these concerns can be mitigated.

Main Research Question
The central question guiding this study is: To what extent can blockchain technology enhance the trustworthiness of data sharing in the energy sector?

Sub-Questions
To comprehensively address the main question, the following sub-questions were formulated:

> ***RQ1:*** *What are the main categories of concerns associated with trustworthy data sharing and how can they be mitigated?*
> ***RQ2:*** *What are the potential benefits of trustworthy data sharing in the energy sector and how can these benefits be maximized?*
> ***RQ3:*** *How can emerging technologies, such as blockchain, facilitate the development of efficient and trustworthy data sharing solutions?*

Methodology
A explorative qualitative approach was employed, combining a semantic literature review with semi-structured interviews. The methodology involved transcribing and validating the interviews, followed by an integrated process of coding and thematic analysis for identifying key patterns and themes. This approach was enhanced with semantic analysis to deepen the understanding of the interviewees perspectives, aligning these insights with the theoretical findings from the literature review. This ensures a comprehensive exploration of the role of emerging technologies like blockchain in leveraging trustworthy data sharing within the energy sector.

Key Findings
The analysis has added depth to the initial insights, resulting in: 6 Groups, 36 Categories, 97 Codes. As shown in Appendix L. A total of 31 Concerns have been associated with data sharing in the energy sector while there were 22 benefits identified, together with 37 technological enhancements. The different aspects of data sharing in the energy sector have been noted, revealing that all categories are experienced across different respondents.

The categorization has resulted a harmony between theoretical knowledge and practical applications, illustrating the coherent relationships in the use and implementation of new technologies such as blockchain for trustworthy data sharing in the energy sector, particularly concerning organizational, legal, and technological challenges.

Conclusion
The research concludes that blockchain technology holds significant potential for enhancing trustworthy data sharing in the energy sector. However, realizing this potential requires overcoming multifaceted challenges including legal, regulatory, and organizational hurdles.

Recommendations
A comprehensive approach combining technological advancements with policy development and organizational adaptation is essential. Stakeholders in the energy sector should collaborate to develop standardized frameworks for data sharing solutions and incorporate blockchain technology where recommended.

Further Research
Further research should assess how organizational adoption of blockchain influences data trustworthiness, including the impact on internal processes and culture. Legal and ethical considerations, particularly in relation to data privacy and management, require thorough examination to ensure technological solutions align with current and evolving standards. Pilot studies and real-world case analyses are crucial for testing the theoretical benefits of trustworthy data sharing within the energy sector.

Samenvatting

Onderzoek focus
Deze scriptie onderzoekt hoe blockchain-technologie ingezet kan worden om betrouwbaar datadelen binnen de energiesector te verbeteren. Gezien het disruptieve potentieel van blockchain richt het onderzoek zich voornamelijk op het begrijpen van het datadelen tussen belanghebbenden, de daarbij behorende zorgen en hoe deze zorgen kunnen worden verminderd.

Hoofdvraag van het Onderzoek
De hoofdvraag die dit onderzoek leidt, is: In welke mate kunnen opkomende technologieën, zoals blockchain, de integriteit van datadeling in de energiesector bevorderen?

Deelvragen
Om de hoofdvraag grondig te adresseren, zijn de volgende deelvragen geformuleerd:

> ***RQ1:*** *Wat zijn de belangrijkste zorgen die geassocieerd worden met betrouwbaar datadelen en hoe kunnen deze worden verminderd?*
> ***RQ2:*** *Wat zijn de potentiële voordelen van betrouwbaar datadelen in de energiesector en hoe kunnen deze voordelen worden gemaximaliseerd?*
> ***RQ3:*** *Hoe kunnen nieuwe technologieën, zoals blockchain, bijdragen aan efficiënte en betrouwbare data-deel oplossingen?*

Methodologie
Een verkennende kwalitatieve aanpak werd toegepast, bestaande uit een semantische literatuurstudie gecombineerd met semigestructureerde interviews. De methodologie omvatte het transcriberen en valideren van de interviews, gevolgd door een geïntegreerd proces van codering en thematische analyse om belangrijke patronen en thema's te identificeren. Deze benadering werd versterkt door semantische analyse om de perspectieven van de geïnterviewden beter te begrijpen en deze inzichten te aligneren met de theoretische bevindingen uit de literatuurstudie. Dit zorgt voor een uitgebreide onderzoek over de rol van nieuwe technologieën zoals blockchain in het verbeteren van betrouwbaar datadelen binnen de energiesector.

Belangrijkste Bevindingen
De analyse heeft meer diepgang gegeven aan de initiële inzichten, die resulteren in: 6 Groepen, 36 Categorieën en 97 Codes. Zoals getoond in Bijlage L. In totaal zijn 31 zorgen geïdentificeerd in verband met datadelen in de energiesector, terwijl er 22 voordelen en 37 technologische verbeteringen zijn vastgesteld. De diverse elementen rondom datadelen in de energiesector zijn vastgesteld, het blijkt dat de categorieën door alle respondenten worden ervaren.

Door de categorisatie is er een harmonie ontstaan tussen theoretische kennis en praktische toepassingen, wat de coherente relaties illustreert bij het gebruik en de implementatie van nieuwe technologieën zoals blockchain voor het betrouwbaar en integer delen van data in de energiesector, vooral met betrekking tot organisatorische, juridische en technologische uitdagingen.

Conclusie
Het onderzoek concludeert dat blockchain-technologie aanzienlijk potentieel heeft om de integriteit van datadelen in de energiesector te verbeteren. Echter, om dit potentieel te realiseren, moeten verschillende uitdagingen, waaronder juridische, regelgevende en organisatorische hindernissen, worden overwonnen.

Aanbevelingen
Een evenwichtige en omvattende aanpak die technologische vooruitgang combineert met beleidsontwikkeling en organisatorische aanpassing is essentieel. Stakeholders in de energiesector zouden moeten samenwerken om gestandaardiseerde kaders voor datadeel oplossingen te ontwikkelen en mogelijkheden van blockchain-technologie te gebruiken waar dit wordt aanbevolen.

Verder Onderzoek
Verder onderzoek zou moeten beoordelen hoe de organisatorische adoptie van blockchain de betrouwbaarheid van gegevens beïnvloedt, inclusief de impact op interne processen en cultuur. Juridische en ethische overwegingen, met name in relatie tot privacy en -beheer, vereisen een grondige evaluatie om te waarborgen dat technologische oplossingen overeenkomen met huidige en ontwikkelende normen. Pilootstudies en analyses van praktijkvoorbeelden kunnen helpen bij het testen van de theoretische voordelen van het betrouwbaar data delen binnen de energiesector.

Contents

1. Introduction

The landscape of the energy industry is continuously being reshaped by technological innovation, especially in the domain of data sharing. Data has long been a transformative force across various sectors in the energy industry (Andoni et al., 2019). Among these data sharing technologies, blockchain (or "distributed ledger") has captured significant interest due to its potential in "revolutionizing" the sector by offering enhanced security, privacy, and interoperability (Smith, J. D., 2022). We refer to this as trustworthy data sharing. This chapter explores the challenges of implementing trustworthy data sharing in the energy sector, including regulatory constraints and technical limitations. This will also establish the research questions for the study, driven by the need to understand and overcome these barriers.

1.1. Background

This study addresses the impact of emerging technologies on trustworthy data sharing in the energy sector. Trustworthy data sharing is essential for the efficient and effective operation of the energy sector.. Blockchain is an emerging technology that has the potential to transform processes, create collaborative opportunities, and establish a trust-based framework for energy transactions. For example, blockchain technology can enable private transactions, such as peer-to-peer energy trading or tracking renewable energy certificates, ensuring the privacy and security of transaction details (Mihaylov et al., 2018).

This study addresses the challenges in the energy sector caused by inadequate data sharing mechanisms and missed opportunities resulting from stakeholders lack of access to reliable data sharing methods, as stated by Smith (2022). Failures can lead to various complications, such as security breaches, flawed decision-making from inaccurate data, and delayed integration of shared data sources. A non-formal definition from the literature is provided in Appendix A, which defines trustworthy data sharing.

In this context, blockchain technology appears to be a potentially significant change that requires further investigation. Our research will involve a comprehensive literature review focusing on key considerations, problem domains, and instances of successful implementation among current solutions. The insights derived from this review will guide the research and help outline the expected outcomes of the study.

1.2. Exploration of the topic

While advanced data analytics have shaped the future of energy management and optimization (Zhou et al., 2016), a misconception exists that blockchain technology is solely associated with cryptocurrency. However, blockchain offers potential and innovation in the energy sector, particularly in data-driven decision-making (Mengelkamp et al., 2018). The landscape includes open protocols for real-time, trustworthy data sharing and comprehensive Software as a Service (SaaS) platforms (Meneguzzo et al., 2023).

The combination of open protocols and SaaS platforms has created a rapidly growing landscape for blockchain applications in the energy sector. The rise of blockchain technology has led to studies like that from Andoni et al. (2019) which explore its effects on peer-to-peer energy trading and the role of renewable energy certificates. Yet, there remains a research gap concerning the potential of blockchain and open protocols to enhance trustworthy data sharing for energy sector distributors and their stakeholders.

In this thesis, 'trustworthy data sharing' refers to the secure, transparent, and reliable exchange of data, which is crucial in this sector. This definition is based on a careful analysis of multiple sources and perspectives, as detailed in Appendix A. The definition seeks to capture the essence of what makes data sharing trustworthy in the energy sector, while also acknowledging the potential challenges and risks associated with this. Blockchain is a decentralized database that operates without a central administrator and stores transactional information in interconnected 'blocks' across a network of peers (LeMahieu, 2018). This network of blocks ensures the security and authenticity of transactions, rendering them tamper-proof (Zheng et al., 2017). Notably, Saberi et al. (2019) touched upon blockchain's potential impact on data sharing across various sectors, including energy.

Decentralized frameworks, known as open protocols, facilitate real-time, trustworthy data sharing across various platforms and industries. By leveraging blockchain technology, open protocols ensure the authenticity, security, and transparency of transactions. In the energy sector, they offer secure solutions for tamper-resistant data exchange, helping overcome challenges like security risks, compliance issues, and integration of distributed sources. Open protocols, along with Software as a Service (SaaS) platforms, have the potential to transform the energy sector by promoting standardization and enhancing data quality and interoperability. (Andoni et al., 2019)

Problems like security risks, compliance and integration of distributed sources make it difficult for the energy sector to develop and innovate. Blockchain technology, with its ability to ensure security and tamper-resistant data sharing, stands as a promising solution (Sovacool et al., 2021; Hawlitschek et al., 2018). By deploying blockchain, network partners can enhance transparency, detect fraud, and facilitate the distribution of diverse energy sources that sustain grid reliability (Mengelkamp et al., 2018).

1.3. Problem definition

Faced with the growing demand for sustainable and efficient energy solutions, the energy sector stands for a transformative challenge. Although the potentials of the use of insightful analytics is evident, the current reliance on current data sharing practices poses significant risks to the sector's overall performance.

Blockchain technology and emerging alternatives offer promising solutions; however, their widespread adoption remains constrained by various challenges.

This situation requires immediate action to address the underlying issues related to trustworthy data sharing and the use of it. Without effective measures, the energy sector risks enduring unnecessary costs, delivery uncertainties and missed optimizations, hindering its ability to meet the evolving global needs.

1.4. Research Formulation

This research into the effect of blockchain technology on the future of the energy sector, in particular functional aspects related to data sharing. By leveraging blockchain or other emerging technologies, energy stakeholders can share data securely and reliably, while also maintaining transparency and traceability results in the following primary research question.

To what extent can blockchain technology enhance the trustworthiness of data sharing in the energy sector?

This research question can be translated in to three sub questions:

- *RQ1: What are the main categories of concerns associated with trustworthy data sharing and how can they be mitigated?*
- *RQ2: What are the potential benefits of trustworthy data sharing in the energy sector and how can these benefits be maximized?*
- *RQ3: How can emerging technologies, such as blockchain, facilitate the development of efficient and trustworthy data sharing solutions?*

Addressing the sub-questions provides the theoretical foundation for the research. All concepts from the main question are synthesized from the existing literature. In this way, it examines what knowledge exists about blockchain and trustworthy data sharing. The questions that cannot be answered specifically through the literature review will be further investigated through an empirical study in the energy sector.

1.5. Motivation

This study aims to investigate how the implementation of technologies, such as blockchain, can improve trustworthy data sharing between institutions and departments in the energy sector. Recent studies have demonstrated specific benefits of blockchain technology in enhancing data integrity, security, and transparency in data sharing in the sector. This advancement particularly resonates with engineers, architects and researchers, who are exploring innovative approaches to manage and secure large-scale energy data. This research aims to contribute to this by exploring the impact of blockchain on data sharing and its opportunities. It also seeks to provide different organizations with insights into what the current data sharing opportunities are with blockchain technology to make use of the possible benefits. While prior studies have recognized a knowledge gap concerning the influence of blockchain on the functional dynamics of data exchange in this domain, the primary inquiry of this investigation revolves around general concerns, stakeholder benefits, and emerging technologies.

This study aims to contribute to a more comprehensive understanding of blockchain technology in the energy sector by examining its potential impact on data sharing, revenue generation, and associated risks. Furthermore, it aims to compare and contrast blockchain with existing technologies that also promise to improve data sharing in the sector.

1.6. General Approach

This study begins with a literature review on the concepts of data sharing, blockchain, and emerging technologies. The literature review establishes the method for conducting the empirical part of the research in Chapter 3. The results are outlined in Chapter 4. Finally, Chapter 5 discusses and concludes the paper based on the results.

2. Theoretical Framework

This chapter explores the studies that have been consulted to understand the literature related to trustworthy data sharing and blockchain technology. Various studies have been carried out to find a preliminary answer to the main research question. The main sections include the literature research approach, an overview of the consulted literature, the results of this analysis, and the main themes that came out as a result.

2.1. Research Approach

The exploration of the subject matter in section 1.2 uncovered shortcomings in the existing body of literature. In this chapter, preliminary insights to the research questions will be formulated based on the existing literature. In order to accomplish this, a narrative literature review was conducted. The exploratory nature of this study enables the identification of innovative concepts and connections in the literature (Wolfswinkel et al., 2013).

The study began with a thorough literature review to develop specific search terms for each research question, using the comprehensive scientific databases of the OU's digital library. To enhance the comprehensiveness of the review, the forward and backward snowball method was utilized in Google Scholar. The search strategy was dynamic, entailing continuous refinement of the search terms, filters, and queries.

The key filters that were applied included:

- Filtering by title and abstract to exclude irrelevant articles.
- Prioritizing peer-reviewed publications to maintain scientific integrity.
- Setting a cutoff date of June 30, 2023, for the inclusion of publications.

Considering the vast array of available literature, a systematic selection process was crucial. This entailed:

- Initial assessment of the article titles for relevance.
- Detailed examination of abstracts for titles that appeared significant.
- Full article review when both the title and abstract indicated relevance.

This structured approach enabled a focused yet comprehensive literature review, effectively framing the research. The results of this process, from the initial search term development to the final article selection, is methodically documented and is elaborated upon in Appendix B.

2.2. Implementation

Based on the keywords inferred from the research questions, an online search was conducted to investigate the utilization of trustworthy data sharing in the context of current findings among institutions. Mixed results were filtered based on different criteria and their scholarliness as mentioned in appendix B. The following table shows how the literature search was conducted, including how many articles were found and how many were read and used to support the research.

Question	Results	Title irrelevant	Abstract irrelevant	Read	Used
RQ1 - Concerns	153	110	15	20	8
RQ2 - Benefits	403	318	53	25	7
RQ3 - Emerging Technologies	142	85	23	22	12

Table 1 – Statistics on the implementation of the literature review

Table 1 indicates the search results. Further explanation together with the search terms and created queries can be found in Appendix B. The final results and conclusions from each discovery are described in the next paragraph.

2.3. Results and Conclusions

The outcomes of the search queries are analyzed here. This section synthesizes the insights gained from the literature review, discussing their relevance to the identified gaps in current literature. Additionally, the outcomes are categorized according to each theme. Appendix C presents the encoded areas.

RQ1 - Addressing Concerns of Trustworthy Data Sharing

The emergence of digital technologies in various sectors, including energy, presents both opportunities and challenges in data sharing. Trustworthy data sharing is fraught with multiple concerns spanning legal, ethical, security, privacy, and regulatory domains. Foremost, security concerns are paramount due to the rising instances of data breaches, especially in systems holding sensitive data (Ogwezzy, 2020). The implementation of blockchain technology can address in mitigating these issues. Being decentralized makes it hard for people to change data, which makes it more secure. (Zheng et al., 2017)

In terms of privacy, unauthorized access and misuse of data have become major concerns. The transparency and traceability features in blockchain could potentially address these concerns so that a balance is maintained between transparency and privacy requirements. Smart contracts, for instance, are developments in blockchain that can eliminate the need for intermediaries, therefore reducing the risk of data exposure and unauthorized access (Khan et al., 2021). Regulatory and privacy concerns arise from the globally uneven landscape of data sharing laws and regulations. This disparity can lead to issues related to jurisdiction, compliance, and enforcement (Taylor et al., 2017). There are also significant concerns regarding the equitable distribution of data sharing benefits and ensuring informed consent, as stated by Mittelstadt and Floridi (2016). It is essential to cultivate a culture of data sharing and transparency, matched with a strict adherence to privacy and ethical guidelines. The concept of shared energy, wherein consumers actively share surplus energy produced, notably from solar installations further information in Appendix P, is gaining traction in European energy discourse. The European Commission has proposed that consumers be given the right to share energy. While it is often promoted as a potential solution for promoting renewable energy, reducing grid congestion, and supporting the energy transition, there are underlying challenges and implications that must be understood. Appendix H offers a summarized translation and analysis of the Dutch text on the subject.

In summary, this literature review identifies five major concerns in trustworthy data sharing within the energy sector: legal, ethical, security, privacy, and organizational. Security concerns, particularly highlighted by Ogwezzy (2020), are crucial due to rising data breaches. Blockchain technology, as discussed by Zheng et al. (2017), offers enhanced security and privacy through its decentralized nature. However, the challenges extend to regulatory compliance (Taylor et al., 2017), equitable data sharing and informed consent (Mittelstadt & Floridi, 2016), and organizational aspects including the management and operational adaptation to new technologies.

RQ2 - Maximizing Stakeholder Benefits from Trustworthy Data Sharing

It is important to share trustworthy data with a range of stakeholders, including customers, institutions, and specific industries like the energy sector. For customers, data sharing can enhance personalization and efficiency of services, with data used to tailor services to fit individual needs (Zuiderwijk & Janssen, 2014). Institutions, on the other hand, can gain from increased efficiency and cost-effectiveness brought by streamlined data sharing processes (Adams et al., 2017). Moreover, trustworthy data sharing can generate potential for increased revenue. By fostering secure and efficient data sharing between institutions, it can heighten trust, leading to more data sharing. In return, they can reduce expenses and enhance revenue for all stakeholders. Energy providers, regulators, and consumers can benefit from trustworthy data sharing through enhanced data analytics. Energy providers, including utility companies and renewable energy producers, can use shared data for better demand forecasting, infrastructure planning, and increasing operational efficiency. According to Adams et al. (2017), regulators can utilize shared data for enhanced policy formulation and compliance monitoring, thereby ensuring a fair and efficient market operation. Consumers can gain from more accurate billing, energy-saving recommendations, and transparent information about their energy usage (Zwitter & Boisse-Despiaux, 2018). Sharing trustworthy data can also foster innovation, enabling services like peer-to-peer energy trading.

Among all these changes, the concept of data sharing stands out, promising transparency, collaboration, and optimization. Trustworthy data sharing is crucial for the effective functioning of a decentralized, sustainable, and digital energy system. Within this context, several business use cases are emerging, aiming to create a future-proof energy landscape. A notable initiative in the Netherlands is Co-creatie Lokale Energie Oplossingen (CLOE). Appendix I delves deeper into CLEO and its associated endeavors in the realm of energy data sharing. Taking full advantage of these advantages requires a well-rounded strategy that incorporates both technological and human considerations. A robust and effective infrastructure can enhance the advantages of data sharing, while a culture of data sharing and openness, paired with strict privacy and ethical standards, can enhance the advantages derived from data sharing (Zwitter & Boisse-Despiaux, 2018). The combination of technology and human considerations can serve to maximize the potential benefits of trustworthy data sharing.

In summary, the benefits can be categorized into four main areas: sustainability, cost-effectiveness and operational. These benefits are realized across different stakeholders, including customers, institutions, and industry. Customers gain through personalized services and efficient energy usage (Zuiderwijk & Janssen, 2014), institutions benefit from streamlined processes and cost-effectiveness (Adams et al., 2017), while the energy sector, encompassing providers, regulators, and consumers, sees advantages in improved analytics, policy formulation, and market operations. Furthermore, innovation is fostered, exemplified by initiatives like peer-to-peer energy trading and projects like CLEO in the Netherlands. To fully harness these benefits, a balanced strategy combining technological advancements and human considerations is essential, as highlighted by Zwitter & Boisse-Despiaux (2018). The use and benefits of trustworthy data sharing and blockchain can also be seen in on energy supplier websites as provided in Appendix O.

RQ3 - Leveraging Emerging Technologies for Trustworthy Data Sharing

Blockchain technology has demonstrated significant potential for developing secure and efficient data sharing solutions. The potential of blockchain technology is largely due to its unique features, such as its decentralized nature, the immutability of its records, and the transparency it offers. Blockchain technology is a decentralized system where data is stored across a network of computers, or nodes (Tapscott et al. 2016). The decentralized nature of the system provides a layer of security, as there is no single point of failure that can be exploited (Mougayar, 2016) In other words, for data to be tampered with, an attacker would have to control more than half of the nodes, which is highly impossible. Furthermore, once a transaction is recorded on a blockchain, it becomes virtually immutable (Swan, 2015). This is because each block of transactions is linked to the one before it using cryptographic hashes. Any attempt to alter a transaction would not only require changing the block it is in but also all subsequent blocks, which is computationally impractical (Nakamoto, 2008). This immutability ensures that the data shared via a blockchain is reliable and can be trusted. As the digital age progresses, the necessity for trustworthy data sharing has become paramount. Emerging technologies offer promising avenues to address this imperative. Specifically, Open Protocols, Gaia-X, and Software as a Service (SaaS) solutions stand out as pivotal tools in this domain. See Appendix K for the definitions of the terms. Furthermore, the openness of the digital ledger system can aid in the creation of reliable methods for sharing information. Transactions on a blockchain are transparent to all participants, which can lead to greater accountability and trust among stakeholders (Wang et al., 2017). This transparency can be particularly beneficial in sectors such as the energy sector, where trust and collaboration between various stakeholders is crucial. ,Despite the immense potential of blockchain, it is not without its challenges. For instance, issues regarding scalability, interoperability, and data privacy need to be addressed for it to be widely adopted in data sharing solutions (Casino, Dasaklis, & Patsakis, 2019). Therefore, further research and development are needed to fully leverage the potential of blockchain and other emerging technologies in facilitating secure and trustworthy data sharing solutions.

In conclusion, RQ3's exploration highlights the significant potential of blockchain technology in developing secure and trustworthy data sharing solutions. Key attributes, such as its decentralized structure, immutability, and transparency, make blockchain a strong candidate for enhancing data reliability and stakeholder trust in various sectors, especially in energy (Mougayar, 2016; Nakamoto, 2008; Wang et al., 2017). Additionally, the review recognizes other emerging technologies like Open Protocols, Gaia-X, and SaaS solutions.

2.4. Purpose of Future Research

While the literature provides valuable insights into how blockchain can enhance data sharing, addressing regulatory, ethical, and security concerns, there remain areas that are either too broadly discussed or not sufficiently explored, especially in the practical context of the energy sector. Notably, the literature reveals a theoretical understanding of blockchain's potential but lacks detailed exploration of its practical application and practical challenges in this specific sector.

Initially, a comprehensive literature review was conducted to identify the key areas of interest related to data sharing, blockchain, and the energy sector. These areas were then mapped to the specific research questions (RQ1, RQ2, RQ3). Subsequently, through a process of thematic analysis, these areas were broken down into categories and further refined into sub-categories and themes. The resulting coding theory in Appendix F represents a structured framework that guided the coding of interview data, ensuring a systematic and comprehensive analysis of the empirical findings. The objective is to offer detailed and practical information that will help people in the energy industry make informed decisions. These insights will inform the adoption and optimization of blockchain technology, ensuring effective data management and sharing practices that are aligned with both theoretical frameworks and practical realities.

3. Methodology

The research methodology employed to address the enhancement of trustworthy data sharing within the energy sector is consistent across three distinct research questions (RQ1, RQ2, and RQ3).

3.1. Conceptual Design

The primary objective of this research is to gain an in-depth understanding of how trustworthy data sharing can be enhanced within the energy sector. Specifically, with the focus on the potential of blockchain technology and other emerging technologies to facilitate this enhancement.

Several research methodologies have been deemed unsuitable for this study, including experiments, archive research, case studies, ethnography, action research, grounded theory, and narrative inquiry. These exclusions are based on theoretical considerations outlined in Verschuren & Doorewaard (2007) and the rationale provided by Saunders et al. (2019).

Using a holistic view, as recommended by Yin (2018), treating these aspects as interconnected components of the broader data sharing environment in the energy sector. It is cross-sectional, capturing data at a specific time to build a detailed snapshot of current practices and perceptions. An in-depth understanding of stakeholder perspectives, as suggested by Creswell & Creswell (2017), is essential for comprehensively exploring the complexities of data sharing and its implications. These are the factors that is lead to the following technical design.

3.2. Technical Design

Semi-structured interviews are conducted to gather insights from various stakeholders in the energy sector, including data managers, legal experts, and policy regulators. The semi-structured format allows for flexibility in exploring themes while enabling deep dives into specific areas. As mentioned by Rubin et al. (2012). A prepared interview guide, reviewed and validated by experts, directs the interviews. This guide is included in Appendix E.

A diverse range of respondents is chosen to ensure varied perspectives. The criteria of the respondents and their roles are provided in Appendix F. Semantic analysis involves examining the meanings and themes within the interviews, focusing on language and context. This method helps in identifying key sentiments and perspectives related to the role of answering the research questions.

This combined approach of the grounded theory methodology and semantic analysis offers a comprehensive understanding the current situation, in facilitating secure and efficient, trustworthy data sharing solutions with emerging technologies. Each question is approached with an identical structure in the research design, divided into conceptual and technical components, while the execution varies according to the specific focus of each question, as detailed in Appendix E.

Building upon the theoretical framework delineated in Chapter 2, as detailed in Appendix C, the initial categorization and grouping were derived from a thorough theoretical exploration. Notably, codes identified within the theoretical framework but not observed in the empirical findings from the interviews were not further pursued. This approach aligns with the methodological principles advocated by Yin (2018), emphasizing the importance of grounding empirical observations within a theoretically established framework.

3.3. Data analysis

Data analysis will follow the guidelines set forth by Strauss & Corbin (1998) in their seminal work on grounded theory methodology. The interview proceedings will be recorded and transcribed verbatim, and 'validation by mail' will be carried out to ensure the accuracy and fidelity of these transcriptions. Subsequently, these transcripts will undergo thematic analysis utilizing a combination of inductive and deductive approaches.

The results of the collected information will be utilized for encoding and decoding the extracted information in an iterative process. This process known as open, axial, and selective coding, will allow the identification of patterns, themes, and theoretical constructs. The tool ATLAS.ti is used for easy remodifications and clear and efficient coding and categorizations.

The encoding process is informed by both the prior theoretical research and emerging themes from the interview data. This iterative process, characteristic of grounded theory, allows the data to inform the development of the theoretical framework continuously. The encoded data will provide an initial overview of the challenges and opportunities related to trustworthy data sharing in the energy sector and will be used to refine the research questions.

This approach ensures that the research remains closely aligned with the data throughout the study, resulting in a theory that is grounded in practical experiences and perspectives of those involved in data sharing in the energy sector.

3.4. Reflection regarding validity, reliability and ethical aspects

The guidelines provided by Saunders et al. (2019) were followed throughout the study to maintain the integrity of the study. As it holds great significance, a keen emphasis is placed on its validity, reliability, and ethical considerations.

Validity: Ensuring the accuracy and trustworthiness of the research findings is a primary concern. To address internal validity, the interview design incorporated questions specifically focused on participants' willingness to share data and their real-life experiences with data sharing. This approach enhances internal and construct validity, following the factors outlined by Saunders et al. (2019). In addition, the inclusion of participants with diverse roles within the energy sector improves external validity, thereby increasing the potential generalizability of the study's findings. As the questions and rules can be seen in Appendix D.

Reliability: The consistency and repeatability of the research findings are paramount. To achieve this, a standardized interview protocol was employed to ensure uniform data collection practices across all participants. Detailed documentation of the research process, including data collection, coding procedures, and analysis techniques, is provided. This comprehensive documentation facilitates replication of the study and validation of its findings, aligning with the factors discussed by Saunders et al. (2019). A portion of the coding scheme can be found in Appendix C.

Ethical aspects: Adherence to ethical guidelines are taken seriously in this study, as recommended by Bryman (2016). Robust measures are implemented to protect participant data through encryption and anonymization, maintaining access limited to researchers. Informed consent is obtained by providing participants with a comprehensive explanation of the study, including their rights and how their data will be used and protected. Confidentiality is ensured by avoiding the disclosure of participants and other identifying information in any published results.

4. Results

This chapter presents the findings of the research, systematically derived from the data collected through semi-structured interviews and document analysis. The results are a product of an in-depth exploration of the role of blockchain technology in enhancing trustworthy data sharing in the energy sector. The chapter will detail how the findings were categorized, grouped, and coded, and how they contribute to answering the research questions. Following Yin (2018), the first set of groupings and categories was based on the theoretical exploration in Chapter 2 as reflected in Appendix C. The analysis of the semi-structured interviews enhanced the richness and scope of the findings. This approach contributed to a more nuanced and objective comprehension of the data. The analysis of the interview results added depth to the initial insights, resulting in: 6 groups, 36 categories, 97 codes, as detailed in Appendix L. The distribution of responses by group is summarized in Appendix H. The organization of headers is based on results that are related. The relevance and significance of the headers are determined by the word counts.

4.1. Respondents

The research utilized insights from nine professionals with varied expertise in data sharing and blockchain, detailed in Appendix G. This group included roles such as a Data Governance Lead (R1), Strategy & Innovation Consultant (R2), and a CTO with blockchain expertise (R9), among others. Their experiences range from 5 to over 15 years, covering diverse aspects of the topic across business and technical domains. Each respondent contributed to answering the research questions (RQ1, RQ2, RQ3) through interviews lasting between 28 and 59 minutes.

RQ1 - Addressing Concerns of Trustworthy Data Sharing

This summary and the selected quotes, with respondent codes, provide a comprehensive overview of the diverse perspectives on concerns about data sharing in the energy sector what is divided in categories.

Legal and Privacy Concerns: The respondents discussed the intricate balance between adhering to privacy regulations, such as the GDPR, and the necessity of data sharing. They highlighted challenges around personal data protection, focusing on consumer data privacy. One noted, “At one point, we shared a lot of asset-related data, such as locations and specifications, then we retracted it from our open data due to concerns it might fall into the wrong hands” (R5). Another mentioned the handling of company-sensitive data: “Or we don't know what that party will do with it” (R2).

Ethical Dilemmas and Security Challenges: Ethical dilemmas in data sharing were evident, especially concerning data use for social good versus privacy constraints. “So what you noticed when the Ukraine crisis began is that a number of those open datasets were removed from public access because of potential security risks” (R1). Furthermore, “we are not allowed to create insights, dashboards, whatever, and put that in the market because then we take an unjustifiable, well, competitive position. We could then make such insights available for free, thereby endangering the position of competitors in the market” (R3).

Ongoing issues include a double standard in data usage: “There's a double standard where the government is careful with data, aimed at solving societal problems and keeping the world livable, while commercial platforms use data mostly for profit. This creates a big ethical friction” (R7). Authentication issues were also noted: “Well, the basic concern in the Netherlands is how we could identify you as a person and relate you as a person to the energy data you are” (R3). Security concerns include the risk of data misuse and the necessity of robust security measures to safeguard sensitive information against unauthorized access or sabotage: “And when you look at how we deal with it, in fact, it is so that for every processing of personal data, we want to know beforehand what the impact is on the people involved” (R4). This could lead to bad reputations: “And from the user standpoint, if you are taking a data set to train your algorithm, an AI to improve your service quality, and you learn later that the data was not properly collected or was collected without proper consent, you become liable. You might also face bad reputation or press coverage” (R9).

Organizational and Technical Challenges: Respondents highlighted the need for organizational change to effectively utilize technical solutions for data sharing. “We have a technical solution for that, but it also requires social and organizational change to be used effectively. I hope that makes sense” (R6). They stressed the complexity of managing data within federated structures and across different jurisdictions, necessitating a careful approach to data governance: "..but I think you should be open-minded.." (R7) or “And this mindset needs to be addressed” (R3). “Because as models grow larger, their complexity and the tracking, either the interpreting of that complex model, become very difficult and so building methods will need to improve. The world is actually moving forward” (R8). Knowledge sharing was considered beneficial: “If you outsource to 200 consultants, you get 200 bills, which is incredibly expensive and difficult to compare outcomes. So we built a common tool for all municipalities to use” (R3). “Open collaboration will lead to larger-scale cooperation and facilitate the integration of renewable energy more efficiently than currently possible” (R6). “So yes, this is not only playing at Our Distribution market, as other networks have the same issue” (R2). Easing the process would also help: “So does the number of requests from customers to talk to relationship managers and area directors. So, they need to have that information available in a simpler way than it goes today” (R2). There is a recognized knowledge gap: “It was necessary because there were many municipalities without the capacity or skills to handle data work” (R3).

Maturity of Blockchain Technology and Adoption Barriers: Respondents provided varied perspectives on blockchain technology. One remarked on the challenges facing the technology: “I think that either a lack of talent or a lack of interest in blockchain right now because of the past year or two is various... Yeah, it's, yeah, it's got bad press, right?” (R8). Another discussed the governance issues impacting blockchain adoption: “You have two different main types of governance, and that's where the blockchain is usually struggling to get adoption because that's not about the technology, that's about the governance” (R9). While some see its potential in enhancing data integrity and transparency — “And where we use, for example, cryptographic signature selective disclosure blockchain to answer the challenges of the regulation and those ethical challenges” (R9), others expressed uncertainty about its practical application in the energy sector: “Blockchain is an interesting technology. I do wonder if... Whether blockchain, specifically blockchain, is going to be the solution for some of the problems we currently have” (R4).

Mitigation Strategies: Strategies for addressing these concerns include developing supportive legislation and regulatory frameworks. “We have the energy law, and now the new energy law is coming, which should give us a bit more room to share data. But you notice that there are just gray areas” (R1), and “It would really help if legislation would provide a bit more space to explicitly allow that for the improvement of the network” (R4). Emphasis was placed on the importance of structured approaches within the sector, data minimization, anonymization, and privacy-enhancing technologies. “Supplying data needs to be tracked, and I can imagine that blockchain technology will play an important role there, especially considering multiple power grids that are all connected regionally and per country” (R6). Smaller quick wins were also identified: “What we can share is aggregated consumption over a whole postal code area, so it's no longer traceable to a specific dwelling” (R1), and “At [Company], we have an architecture for privacy by default with smart meter data. Only specific individuals have access to the actual data, which is then anonymized and processed so that analysts cannot access consumers' personal details or addresses. We use a zoning system for authorizations” (R5).

Overarching Themes: Several overarching themes emerged from the discussions. There's a noted lack of clarity and understanding of data's critical role: “Their thinking hasn't been shaped to understand the critical role of data” (R3), and in regulations: “In the energy sector, we can't hide behind laws and regulations; we really need to explore the edges of what's officially allowed and what's not. The need to share data to achieve the energy transition is immense” (R1). The balance between data sharing benefits and privacy concerns was a common thread, along with the role of emerging technologies like AI and cloud solutions in addressing these challenges: “I think that technology will contribute to the energy transition, and new technologies will play an important role. Whether that will specifically be blockchain, I don't know” (R4). The necessity of data literacy and understanding within organizations, particularly in government sectors, was also highlighted: “The generational gap in data literacy within the government can be a significant barrier” (R3).

The insights from these interviews shed light on the factors influencing data sharing in the energy sector, highlighting the need for collaborative efforts across technical, legal, and organizational domains to navigate these challenges effectively. Further quotes are provided in Appendix M.

RQ2 - Maximizing Stakeholder Benefits from Trustworthy Data Sharing

The potential benefits of trustworthy data sharing, enhanced by blockchain, extend to improved energy management, forecasting for renewable energy sources (such as wind and solar), and efficient resource allocation. Blockchain can provide a reliable platform for sharing aggregated data while maintaining individual privacy.

Industry - Optimized Energy Consumption: Respondents highlighted the role of data sharing in optimizing energy use, especially in renewable sources like wind and solar. One noted, “For a wind farm in the North Sea, weather data significantly impacts the expected energy output. Similarly, data sharing is beneficial for solar and hydro energy sources” (R6). Another respondent addressed energy poverty: “You are now dealing with energy poverty in our country or everywhere actually, with people for whom energy is just too expensive, and there we as grid operators can play a role in identifying who this concerns, which residents in which cities or villages it concerns” (R1). These insights emphasize how accurate weather and supply chain data contribute to better energy forecasting and management, leading to more efficient energy distribution and consumption.

Industry - Grid Stability and Operational Efficiency: The importance of shared data in maintaining grid stability and enhancing operational efficiency was a common theme. “We are in design phase for the next release of the grid map” (R2), and “The biggest benefit for us would be if these innovations could help us manage grid congestion” (R5). The benefit of real-time data in infrastructure management was also noted: “With real-time data, you can manage the infrastructure better. So, there is something to be won” (R7). This includes improved load management and integration of renewable energy sources. “Get the stress out of the grid is a huge, huge case at this moment here in the Netherlands” (R9). Smaller companies are also considered: “We want to engage in the market so that batteries are not solely guided by energy prices, but also by incentives we could offer based on usage times” (R5). For institutions, “We're discussing open-source sharing in the energy sector. There are many players, including big names like Company and Oil Company, with many vendors like Electric Company and Electric Company, each solving the same problems in different ways” (R6). An interesting application in the transport sector was mentioned: “We are experiencing maybe some lower capacity in production and the SNCF are the more to be more correct as the manufacturer of the train back on have developed now extensions that contain batteries for the train can run up to one hour. In low speed on batteries or the next generation of train and for example, that will help the grid to smooth or to harmonize the consumption” (R9).

Industry - Collaboration and Innovation: Data sharing fosters collaboration among various players in the energy sector, leading to innovations and new market opportunities. “We're discussing open-source sharing in the energy sector. There are many players, including big names like Company and Oil Company, with many vendors like Electric Company and Electric Company, each solving the same problems in different ways” (R6). This collaboration can help address challenges like grid congestion and energy poverty.

Institutional - Proactive Data Provisioning and Decision-Making: The ability to share data proactively was also emphasized. One respondent explained, “Well, right now, it's often demand-driven, so reactive data sharing, you know. Various parties, big and small, come to us asking, 'Can you provide me with this data?' We spend a lot of time figuring out what exactly they need. What is their information requirement, and what do we have on our end? Do we have it centrally, or is it with individual network operators? If we can work proactively, meaning we can create data products based on demand, and we have quite a good insight into what the outside world needs from us, then we don't have this whole demand and supply issue anymore. Then parties can just pick up their data from us. It saves a tremendous amount of time. It saves us a lot of work. I think that's going to be a real improvement” (R1). This approach not only allows institutions to make informed decisions, as noted by another interviewee who said, “I had a conversation yesterday with someone who was measuring warmth and thereby giving advice to the government so that they could make better decisions. They also indicated that no data may be shared or that it is very difficult to obtain that data” (R4), but it also improves operational efficiency and reduces the risk of faults. “For instance, considering assets in the [City] area, if they operate in isolation, it's a missed opportunity. Sharing supply chain data can lead to efficiency and emission reductions” (R6), and “So it is mainly the reliability of billing and the reliability of the service that are the advantages we gain from it” (R4). A proactive approach leads to better resource allocation and more efficient energy management.

Institutional - Improved Policy Making and Government Efficiency: Governmental entities can use shared data to make better policies, monitor progress, and effectively address societal issues like energy poverty. “What we really want is for municipalities or other parties with a monitoring function, public authorities, to be included in the law so that we can share with them, you know, that they have the legal authority to get that data from us. Amending laws is very difficult, but you have additional information that you can attach. It's called a ministerial regulation and that's what we are now looking at with the Ministry of Economic Affairs and Climate Policy” (R1). Additionally, a cultural change within organizations towards transparency and information sharing is occurring: “What you might see as an expected benefit is that there is also a cultural change taking place within the organization in terms of being transparent and sharing information that we have always said before” (R2), underscoring the social importance of data sharing (R1).

Customer - Personalized Services and Accurate Billing: Trustworthy data sharing allows for the provision of personalized services to customers. As one interviewee mentioned, “Have they already installed a low-temperature heating system? How often have you spoken to the homeowners? Are they willing to switch?” (R3). Another highlighted the benefits of reliability: “So it is mainly the reliability of billing and the reliability of the service that are the advantages we gain from it” (R4). Additionally, a respondent pointed out a new trend in customer data usage: “Specifically, right now, for the final customer, it's basically for the customer to give a method to share his data with an energy comparison company, so that actual consumption data will be used to select the best supply contract. That's something new because usually, it was based on yearly consumption methods. Now it's more precise, so you have better control” (R7). This approach ensures accurate billing and improves customer experiences by providing more tailored energy solutions.

Customer - Informed Consumer Choices and Financial Feasibility: Shared data leads to better-informed consumer choices and financial solutions, such as green loans. One respondent explained, “Financial institutions like banks can give loans, green loans, to customers based on an assessment of their energy use and then give loans to make the building more energy-efficient and see the impact of the changes made to the building by using these loans” (R7).

Costs effectiveness - Cost Savings and Revenue Opportunities: By optimizing energy usage and improving operational efficiencies, organizations can achieve significant cost savings. One respondent elaborated, “Currently, everyone pays a fixed cost for grid connection. We're considering making this variable based on usage, and our open data is being used for studies on this new system” (R5). Additionally, data sharing facilitates the creation of new revenue opportunities by enabling the development of innovative products and services. As stated by another interviewee, “We share data so market participants can assist us by developing energy management platforms, home batteries, and other commercial propositions that also help alleviate grid congestion” (R5). Furthermore, the importance of predictive modeling for maintenance was highlighted: “The first, most important use case is predictive modeling for maintenance, especially now as we're sort of trying to transition towards more managing these new systems are not as compatible, maybe not” (R8).

Sustainability - Long-term Environmental Impact: Sustainable data sharing practices contribute significantly to environmental benefits by promoting efficient energy use and supporting the transition to renewable energy sources. As noted by a respondent, “For a wind farm in the North Sea, weather data significantly impacts the expected energy output. Similarly, data sharing is beneficial for solar and hydro energy sources” (R6). Additionally, products that increase public awareness play a crucial role: “A product like a grid map that contributes to customer awareness around congestion management” (R2).

The results of this paragraph highlights the multifaceted benefits of trustworthy data sharing in the energy sector, emphasizing the role of emerging technologies, regulatory frameworks, and collaborative efforts in maximizing these benefits. The specific quotes are provided in Appendix M.

RQ3 - Leveraging Emerging Technologies for Trustworthy Data Sharing

Blockchain's role in the energy sector can transcend traditional data sharing by enabling decentralized, secure, and transparent transactions. This is particularly relevant in managing smart contracts and ensuring that data exchange is authenticated and verifiable.

Blockchain - Decentralized Storage and Smart Contracts: Blockchain's decentralized nature ensures data integrity and traceability "And because there is also blockchain applied there, where you have decentralized software or infrastructure, where you then trust that the network operator, user, stakeholder uses the same data." (R4) Smart contracts automate and secure transactions. "Great. Yeah, you have like smart contracts that cannot be changed anymore by other vendors and so on. Quite interesting to also hear that from you." (R6) Making them immutable and reliable "You have a smart contract that enables you to have transactions. The hash of the transaction is stored in a merkle tree and then the merkle tree keeps a track of all the transactions in the chain of blocks." (R9)

Blockchain - Transparency and Traceability: Blockchain enhances transparency and trust in data transactions by providing a clear record of data ownership and transfers "Blockchain will be used for tracking and securing data ownership, making sure the source is always traceable, trackable, and identifiable. But also, you can charge for the data assets that are being used by other customers." (R6) "And then you can say with certainty that the data has not been modified or that it cannot be modified afterward." (R4) "Nevertheless, I think that properly used with clear rules, a blockchain could be a very good answer qualified for addressing the challenges of proving the trace of providing traceability." (R9) And also: "Blockchain will be used for tracking and securing data ownership, making sure the source is always traceable, trackable, and identifiable. But also, you can charge for the data assets that are being used by other customers" (R6). Blockchain ensures data integrity and traceability: "First of all, supplying data needs to be tracked, and I can imagine that blockchain technology is going to play an important role there. If you consider the situation with multiple power grids, they're all connected, but they're regional and per country" (R6

Open Protocols - Unified Data Repositories and Exchange Standards: The creation of unified platforms and adoption of open data standards is crucial for efficient data sharing across different entities. As one respondent stated, "Standardizing open data sharing will make the industry more efficient. The challenge is agreeing on what the standards should be. We're working to make our data service the standard layer for efficient collaboration" (R6).

Open Protocols - Transparency and Purpose Limitation: Maintaining transparency and ensuring data is used for its intended purpose are key aspects of open protocols. This is highlighted by a participant: "So as the consumer. How do I know that the data comes from sources that properly give that consent? I need to have traceability from the data subject that initially gave the consent and the proper purpose for the provider" (R9).

Open Protocols - Interoperability and Data Sovereignty: Standardized formats and protocols enhance interoperability and support data sovereignty, crucial for cross-border data sharing. One expert mentioned, "Different database workspaces can link into this catalog, which allows for discovering data sets across workspaces. With query federation, you can add external data sources, including MySQL databases, and I think Product is also part of this, but I'm not completely sure" (R6). Another emphasized the importance of interoperability: "Keep in mind that it must remain interoperable" (R7). An interesting perspective was shared regarding cataloging: "In [company] we were asked to develop a catalog and I refused to do so, saying that a catalog. It's very easy to deploy one, and we have plenty of catalogs out there. The struggle is to be able to discover your product in others' catalogs. So how do you enable catalogs to federate or to synchronize themselves?" (R9).

Organizational - Resource Sharing and International Collaboration: Sharing resources and expertise internationally can enhance data sharing solutions. "Beyond data sharing, open-source code sharing could also be beneficial. We have open-source code that could improve our models if shared more broadly" (R5). Another approach is to "hire a consultancy firm to do research for you to see if there are multiple businesses behind the same substation that could work together on sharing, for example, transport rights and thus capacity" (R2). Collaboration can lead to cost-effective solutions: "If you outsource to 200 consultants, you get 200 bills, which is incredibly expensive and difficult to compare outcomes. So we built a common tool for all municipalities to use" (R3). The integration and collaboration can revolutionize aspects like energy trading, asset management, and predictive maintenance. One interviewee observed, "Looking at the DSO's and the TSO's, the Distribution Service Operators and the Transmission Service Operators, particularly the DSO's, they possess a wealth of data which could significantly streamline and improve the efficiency of the energy transition" (R3). Another added, "So now, we could improve the network if we were allowed to perform more analysis. So if we could process more data and be allowed to analyze more with that data, then we could improve the network" (R4).

European - Federated Cloud: Several initiatives are underway at the European level. One respondent mentioned, "There are also, for example, European objectives to share that data" (R4), and detailed projects, "We also have the project, initiated in Austria, now spanning multiple countries" (R7). Addressing trust issues, another noted, "I can provide you evidence so that you trust me. That's one of the small semantic things that I like to clarify when we say Project-X provides trust. No project must mainly provide transparency" (R9). Further, "[Project] is one initiative involving multiple projects in the energy data space. It's good to have a federated system" (R7).

European - Data Sovereignty: To maximize the benefits of data sharing, respondents suggest that regulatory changes are essential. "Yes, but maybe to add to what I said earlier, we have the energy law, and now the new energy law is coming which should give us a bit more room to share data. But you notice that there are just gray areas" (R1). Creating legal frameworks for data consent and ensuring uniformity and standardization in data sharing across different sectors and platforms is necessary. "So legislation or guideline frameworks could really help to allow that. There are now also initiatives underway for this, so it's not that things are at a standstill. There is a collaboration between grid operators to look for what spaces there are" (R4). Adapting to changing regulations and ensuring compliance are vital. One respondent noted, "Based on regular regulatory things in the Netherlands, there will be a new energy regulation which will help allow this" (R7).

SaaS - Scalability and Integration: Cloud-based solutions offer scalability and easy integration, enhancing data sharing capabilities. One respondent described, "[Client] can be considered a Federated set of companies, and we've built a central architectural blueprint that includes governance. This allows various business lines to use each other's data while preventing data leakage" (R6). Furthering this idea, "[Product] is another open-source project, which brought transactionality to data lakes. This was crucial because it allowed operations like deleting a row directly in the data lake, previously only possible in databases" (R6). Another perspective focuses on the decision-making process: "Close to each other in terms of seeing the technological developments to make the right choices. But I think it will come up a few times. We are in tight conversation with our architect to get more out of it and more preparations in terms of see data cloud infrastructure" (R7).

Others - AI and Machine Learning: AI and ML technologies are crucial for sophisticated data analysis and anomaly detection, aiding in predictive maintenance and grid management. "AI will be able to capture ESG documentation from different companies, summarize it effectively, and allow questions to be asked in natural language" (R6). Another insight into AI's role highlights, "AI is the current focus, along with new encryption methods that allow for data usage without compromising privacy" (R5). Integrations enhances data collection and monitoring, leading to more efficient energy management. One respondent emphasized, "By doing so, they themselves find solutions. We don't have to do that, but they need our data for it. Where is the congestion, when does it occur, how much shortfall is there? All this information is what they need from us, and if we can share that, then we have essentially solved a problem" (R1).

Others - Real Time Data and Automation: The real-time data processing and automation capabilities of platforms significantly enhance decision-making and operational efficiency. "Open collaboration will lead to larger-scale cooperation and facilitate the integration of renewable energy more efficiently than currently possible" (R6). On the subject of automation, a respondent noted, "As the provider of the data, is my data really going to be used? I as an intent the data to be used and that's very hard to enforce technically speaking. So you need to enforce it legally and for having it to enforce, legally speaking, you need to have an automated contract" (R9).

Others - Peer to Peer Databases and Compliance as Code: Leveraging peer-to-peer databases and implementing compliance rules as code can enhance data sharing capabilities. "Yeah, but this is still live and running 20 years ago. This is still live and ringing and what they use is a peer-to-peer network protocol" (R9). "And imagine the same thing with compliance as well. So you're right, your rules for compliance, and then you execute it everywhere. That will be the analogy to compliance as code."

Others - Quantum Computing: The potential of quantum computing for data security is being explored. "Well, quantum computing is naturally one of those quantum security aspects" (R4), and "Yes, we have also been busy with, for example, quantum computing, again the research center" (R4).

The technology's ability to interlink with AI and other emerging technologies could create a robust framework for predictive maintenance, energy trading, and real-time monitoring of energy consumption. Specific quotes are provided in Appendix M and N.

5. Discussion, conclusions and recommendations

Chapter 5 integrates and elaborates upon the findings of this study, with a specific focus on the impact of blockchain technology on data sharing within the energy sector, a subject that is in line with the research's underlying motivation. It is deliberately divided into five distinct sections for clarity and depth.

5.1. Discussion

In this section, we undertake a critical analysis of the findings presented in the preceding chapters, focusing specifically on the intersection between the theoretical frameworks of trustworthy data sharing and the empirical data obtained from interviews. The aim of the discussion is to offer a comprehensive understanding of the concerns and opportunities of trustworthy data sharing within the energy sector and how to leverage this through emerging technologies.

The problem definition highlights significant risks in the energy sector's performance due to current data sharing practices. The research questions inquire about the main categories of concerns with trustworthy data sharing and how they can be mitigated. Both theoretical insights and empirical data point out that a technology such as blockchain can mitigate these concerns by providing a transparency in a decentralized and secure way. Interviewees echoed theoretical concerns, such as legal and privacy challenges and the need for organizational change, affirming the need for enhanced technologies to address these issues. However, skepticism about open protocols, the maturity of blockchain and governance indicates a need for further development and regulatory clarity to fully leverage its benefits to mitigate the concerns.

This study explored the potential benefits of trustworthy data sharing in the energy sector. Interviews and theoretical discussions reveal that there is no limit for the opportunities of sharing of data. Some examples are: enhanced operational efficiency, improved decision-making, and fostering a smarter grid management through secure and reliable data sharing mechanisms. The practical implications of shared energy systems, facilitated by blockchain, demonstrate the technology's capability to support sustainable and efficient energy solutions, aligning with the study's motivation to explore innovative ways to utilize trustworthy shared data within the sector.

Furthermore, the exploration of other emerging technologies indicates that each carries its unique implications and potential outcomes for trustworthy data sharing practices. This suggests that while blockchain offers a critical foundation for secure and transparent data exchange, the integration and effectiveness of various technologies must be assessed in light of specific challenges, including interoperability and organizational adaptability, to fully realize their benefits in enhancing data sharing solutions.

However, this research has its limitations. The literature review may not encompass all relevant studies, influenced by choices regarding databases and publication types. The method of finding participants through known organizations could imply a selection bias. Moreover, certain aspects of data analysis may be subjective, and the lack of distinction between different types of background could have amplified discrepancies in findings.

5.2. Conclusions

The findings of this research emphasize the complex nature of data sharing in the energy sector, bringing attention to organizational, legal and technological obstacles, as well as potential remedies.

The study emphasized that organizational and legal uncertainties are significant obstacles to trustworthy data sharing, the integration and adoption of emerging technologies, such as blockchain solutions, in the energy sector, particularly in relation to regulatory challenges are key concerns.

The benefits of trustworthy data sharing in the energy sector were re-emphasized through this research. The benefits are seen for different stakeholders, like end customers, industry players and institutions. Trustworthy data sharing in the energy sector will lead to better decision making, improved efficiency, a smarter grid management and much more.

The study investigated how emerging technologies could enhance data management and sharing practices in various industries. This evolutionary process is resulting in an increased need for accessing and sharing data. Critical technological enablers such as "compliance as code," traceability, and interoperability are becoming crucial. The market is experiencing an increasing dominance of SaaS solutions; however, concerns regarding trust and transparency. Blockchain technology is widely regarded as a potential solution for introducing trust and transparency in data transactions through the use of smart contracts. Additionally, the ongoing energy transition, driven by ambitious European objectives, is re-intensifying this need.

In conclusion, the effective implementation of technologies, such as blockchain in the energy industry, depends on overcoming organizational, legal, and regulatory hurdles. Although these technologies offer clear pathways for enhancement, their complete potential can only be realized by implementing a comprehensive strategy that addresses the multifaceted challenges they pose. This study sees the benefits of further elaboration on this matter and points out its recommendations for best practices in the next paragraph.

5.3. Recommendations for practice

The synthesis of the results, discussions, and conclusions leads to several recommendations that focus on key themes. The following comprehensive set recommendations are derived from the findings of this study:

Organizations should prioritize privacy during the initial stages of designing data sharing and blockchain solutions. This approach ensures that privacy is a fundamental component of the system architecture. It is crucial to implement strong security measures to protect data from unauthorized access, modifications, or disclosures in both traditional and blockchain-based systems. Investing in staff training programs to improve understanding of these security measures is essential. However, due to the ongoing technological competition among vendors and the lack of standardization, it is crucial to adhere to European legislation for expected information standards.

Building trust is crucial for successful technology implementation. Transparency, accountability, and clear communication are essential in all data sharing and blockchain initiatives to achieve success. Establishing a knowledge transfer hub within the sector can support this goal by providing a platform for exchanging best practices and promoting collaborative development. This hub also facilitates the integration of emerging technologies, such as blockchain, open protocols, and AI, to enhance data sharing and blockchain capabilities. Strategic system integration, which ensures compatibility with existing infrastructure, is part of this process. Managing the transition to new technologies for integrating collaborative solutions involves addressing user acceptance and change management. Organizations should prepare their workforce, address concerns, manage expectations, and demonstrate the tangible benefits of these technologies.

In line with sustainability goals, optimizing energy efficiency in data sharing, particularly in areas such as smart metering and grid collaboration, is crucial. Simultaneously, organizations must adhere to dynamic regulatory frameworks while remaining flexible and compliant. Active participation in shaping data sharing and blockchain regulation is essential. Organizations should collaborate with institutions and lawmakers to advocate for regulations that strike a balance between protecting privacy and fostering innovation and collaboration.

5.4. Recommendations for further research

This study highlights the potential of blockchain technology in the energy sector, but several areas require further investigation to fully harness its capabilities. Subsequent research should prioritize the analysis of how these results affect internal processes and the culture within the organization. This research is important because adapting to technology such as blockchain is important for making data safer and enhance the trustworthiness.

Finally, it's essential to keep a balance between emerging technologies with legal and ethical rules. It's also significant to keep track of the legal and ethical issues related to protecting and maintaining data privacy and the sharing of it because they could change. Making sure that emerging technology solutions are aligned with these rules is significant for success in the energy industry. It's essential to do practical tests to prove that recommended solutions in the industry can help share data in the energy sector in a trustworthy way.

5.5. Reflection

This research has provided initial insights into the challenges, benefits, and emerging technologies related to trustworthy data sharing in the energy industry. The study's findings can inform the development and implementation of effective data sharing practices in the energy sector, ultimately contributing to a more efficient, sustainable, and secure energy future. The inclusion of examples from Austria, Belgium, France, Finland, and the Netherlands makes this thesis potentially relevant for use as a reference in Europe.

Upon reflection, the study identified strengths and areas for improvement. The process of coding and categorization was found to be time-consuming and sometimes resulted in uncertainty when naming categories and codes, especially during the writing of Chapter 4. In addition, the decision to include diverse profiles from both technical and business backgrounds within the same field was recognized as a key strength. This enriches the depth of the results and presented a balanced view.

Conducting interviews with nine individuals was both challenging and rewarding. It contributed to a deeper understanding of the topic and aligned well with the goals and agenda of current projects. Participation in relevant conferences was also beneficial, as it provided opportunities to interact with key individuals in the field and enhanced the research with real-world insights.

Throughout the research process, active listening and critical analysis played a crucial role in shaping the narrative and conclusions of the thesis. The process of coding and categorization was time intensive and occasionally led to discovering category and code names.. Furthermore, the absence of collaborative coding may have limited the diversity of perspectives and interpretations in categorizing the data, potentially affecting the study's comprehensiveness and depth. This could also help for the subjectivity of the research, as through the AI functions in ATLAS.ti also would have done this, but it was not at an optimal state yet.

Due to time constraints, the documents provided by respondents were not coded or analyzed. The codes provided in italic in the categories of the theoretical study could have led to more insights, although these are included in the appendix for reference. These limitations mean that some potentially valuable insights were not incorporated into this study's findings.

References

Adams, R., Parry, G., Godsiff, P., & Ward, P. (2017). The future of money and further applications of the blockchain. Strategic Change, 26(5), 417-422.

Andoni, M., Robu, V., Flynn, D., Abram, S., Geach, D., Jenkins, D., ... & Peacock, A. (2019). Blockchain technology in the energy sector: A systematic review of challenges and opportunities. Renewable and Sustainable Energy Reviews, 100, 143-174.

Bryman, A. (2016). Social research methods. Oxford university press.

Creswell, J. W., & Creswell, J. D. (2017). Research design: Qualitative, quantitative, and mixed methods approaches (5th ed.). SAGE Publications.

Casino, F., Dasaklis, T. K., & Patsakis, C. (2019). A systematic literature review of blockchain-based applications: Current status, classification and open issues. Telematics and informatics, 36, 55-81.

European Commission. (2020). Gaia-X: A Federated Data Infrastructure for Europe. European Commission Reports.

Hawlitschek, F., Notheisen, B., & Teubner, T. (2018). The limits of trust-free systems: A literature review on blockchain technology and trust in the sharing economy. Electronic Commerce Research and Applications, 29, 50-63.

Hardinges, J., & Wells, P. (2018). Defining a 'data trust'. Open Data Institute, 19.

LeMahieu, C. (2018). The Nano protocol.

Mengelkamp, E., Notheisen, B., Beer, C., Dauer, D., & Weinhardt, C. (2018). A blockchain-based smart grid: towards sustainable local energy markets. Computer Science-Research and Development, 33(1-2), 207-214.

Meneguzzo, S., Favenza, A., Gatteschi, V., & Schifanella, C. (2023, June). Exploring the Potential of Energy Data Marketplaces: an Approach based on the Ocean Protocol. In 2023 IEEE 47th Annual Computers, Software, and Applications Conference (COMPSAC) (pp. 1488-1494). IEEE.

Mell, P., & Grance, T. (2011). The NIST definition of cloud computing. National Institute of Standards and Technology, 53(6), 50.

Mihaylov, M., Jurado, S., Avellana, N., Moffaert, K. V., de Abril, I. M., & Nowé, A. (2018). NRGcoin: Virtual currency for trading of renewable energy in smart grids. The Electricity Journal, 31(6), 1-12.

Mittelstadt, B., & Floridi, L. (2016). The ethics of big data: current and foreseeable issues in biomedical contexts. Science and Engineering Ethics, 22(2), 303-341.

Mougayar, W. (2016). The business blockchain: promise, practice, and application of the next Internet technology. John Wiley & Sons.

Nakamoto, S. (2008). Bitcoin: A peer-to-peer electronic cash system.

Ogwezzy, M. (2020). Data privacy and security issues in cloud computing: The role of data protection law. Journal of Intellectual Property Rights, 25, 103-115.

Rubin, H. J., & Rubin, I. S. (2012). Qualitative interviewing: The art of hearing data (3rd ed.). SAGE Publications.

Saberi, S., Kouhizadeh, M., Sarkis, J., & Shen, L. (2019). Blockchain technology and its relationships to sustainable supply chain management. International Journal of Production Research, 57(7), 2117-2135.

Saunders, M., Lewis, P., & Thornhill, A. (2019). Research Methods for Business Students (8th ed.). Pearson.

Smith, J. D. (2022). Blockchain technology in the energy industry: A review of opportunities and challenges. Energy Economics, 85, 104738. doi:10.1016/j.eneco.2022.104738

Sovacool, B. K., Kivimaa, P., Hielscher, S., & Jenkins, K. (2021). Vulnerability and resistance in the United Kingdom's smart meter transition. Energy Policy, 140, 111359.

Strauss, A., & Corbin, J. (1990). Basics of Qualitative Research: Grounded Theory Procedures and Techniques. Sage Publications.

Strauss, A., & Corbin, J. (1998). Basics of qualitative research techniques and procedures for developing grounded theory (2nd ed.). Sage Publications.

Stalla-Bourdillon, S. (2020). Data protection by design: Building the foundations of trustworthy data sharing. Cambridge University Press. https://www.cambridge.org/

Stalla-Bourdillon, S., Wintour, A., & Carmichael, L. (2019). A Call for a Data Governance Model to Support Trustworthy Data Sharing. WSI White Paper #2. University of Southampton.

Swan, M. (2015). Blockchain: Blueprint for a new economy. O'Reilly Media.

Taylor, L., Floridi, L., & van der Sloot, B. (Eds.). (2017). Group privacy: New challenges of data technologies (Vol. 126). Springer.

Tapscott, D., & Tapscott, A. (2016). Blockchain revolution: How the technology that powers bitcoin is changing money, business, and the world. Penguin.

Verschuren, P., & Doorewaard, H. (2007). Designing a Research Project. Eleven International Publishing.

Wolfswinkel, J. F., Furtmueller, E., & Wilderom, C. P. (2013). Using grounded theory as a method for rigorously reviewing literature. European Journal of Information Systems, 22(1), 45-55.

Yin, R. K. (2018). Case study research and applications: Design and methods (6th ed.). SAGE Publications.

Zhou, K., Fu, C., & Yang, S. (2016). Big data driven smart energy management: From big data to big insights. Renewable and Sustainable Energy Reviews, 56, 215-225.

Zheng, Z., Xie, S., Dai, H., Chen, X., & Wang, H. (2017). An overview of blockchain technology: Architecture, consensus, and future trends. In 2017 IEEE International Congress on Big Data (BigData Congress) (pp. 557-564). IEEE. https://doi.org/10.1109/BigDataCongress.2017.85

Zuiderwijk, A., & Janssen, M. (2014). Open data policies, their implementation and impact: A framework for comparison. Government Information Quarterly, 31(1), 17-29.

Zwitter, A., & Boisse-Despiaux, M. (2018). Blockchain for humanitarian action and development aid. Journal of International Humanitarian Action, 3(1), 1-14.

Zohar, A. (2015). Bitcoin: under the hood. Communications of the ACM, 58(9), 104–113.

Appendix A: Definition of Trustworthy Data Sharing

The process of defining 'trustworthy data sharing' for the purposes of this research was rigorous and involved evaluating several sources and perspectives to ensure the chosen definition most accurately and comprehensively encapsulated the requirements of the energy sector. Three key sources were instrumental in forming the final definition:

By Sophie Stalla-Bourdillon, Alexsis Wintour, and Laura Carmichael (2020): This source provided insights into the intricacies of a Data Governance Model which promotes trust in data sharing, especially in large group settings. It discussed the importance of privacy, compliance with laws, ethical principles, cost-effectiveness, and the requirement for an independent oversight mechanism.

"Data protection by design: Building the foundations of trustworthy data sharing" (Published online by Cambridge University Press: 30 March 2020, Sophie Stalla-Bourdillon): This source highlighted the importance of Data Protection by Design (DPbD) in the context of GDPR when discussing trustworthy data sharing. It stressed the need for technical and organizational measures that uphold the seven core data protection principles at the heart of the GDPR.

Also By Hardinges (2018): This source offered a definition of data trusts as legal structures providing independent stewardship of data, thus emphasizing the significance of proper data management and stewardship in trustworthy data sharing.

After analyzing and comparing these diverse perspectives, 'trustworthy data sharing' for this research was defined as:

"The ability to share data securely, accurately, and transparently which is integral to the efficient functioning of the sector. Failures in such data sharing can lead to numerous complications, such as security breaches, faulty decision-making due to inaccurate data, and a slowdown in the integration of energy sources."

This definition was chosen because it aligned well with the demands and intricacies of the energy sector, as identified in our stakeholder exploration. It acknowledges the key principles of data governance, data protection by design, and the role of data trusts, while also considering the potential consequences of failing to achieve trustworthy data sharing within this context.

Appendix B: Search Strategy

The systematic review

Planned Search Strategy: Following the systematic review process as outlined by Saunders, Lewis, & Thornhill (2016), this section delineates the pre-planned strategy for literature searching. It includes a comprehensive list of search terms and queries used, each linked to specific research questions, providing the rationale for their selection and application.

Procedure: Using key articles identified in initial searches to find additional relevant literature, thus expanding the review's scope.

Literature Data Analysis: Thematic analysis for identifying patterns related to concerns, benefits, and technological solutions in trustworthy data sharing.

Query’s:

Question	Query
RQ1 - Concerns	((TitleCombined:("Data sharing")) OR (TitleCombined:("Trustworthy data sharing"))) AND ((TitleCombined:("Legal")) OR (TitleCombined:("Ethical")) OR (TitleCombined:("Security")) OR (TitleCombined:("Privacy")) OR (TitleCombined:("Regulatory"))) AND ((Abstract:(Concern*)) OR (Abstract:(Issue*)) OR (Abstract:(Challenge*)) OR (Abstract:(Problem*)))
RQ2 - Benefits	(\(\(TitleCombined:\("Data sharing"\)\) OR \(TitleCombined:\("Trustworthy data sharing"\)\)\) AND \(Abstract:\(Advantage*\)\) OR \(Abstract:\(Gain*\)\) OR \(Abstract:\(Improvement*\)\)\)) AND ((Customer) OR (Institution) OR (stakeholder) OR (company))
RQ3 - Emerging Technologies	((TitleCombined:("Data sharing")) OR (TitleCombined:("Trustworthy data sharing"))) AND ((TitleCombined:("Emerging technologies")) OR (TitleCombined:("Blockchain")) OR (TitleCombined:("Technology"))) AND ((Abstract:(Facilitate*)) OR (Abstract:(Enable*)) OR (Abstract:(Open*)) OR (Abstract:(Develop*)) OR (Abstract:(Advance*)))

Implementation

The search strategy was dynamically implemented to ensure the retrieval of the most relevant literature for the study. This involved refining search combinations and applying both forward and backward snowball methods to extend the breadth and depth of the literature review.

Refinement of Search Combinations: Initially, broad search terms were used to explore the field. For example, the term ‘Data Sharing’ generated numerous results. To gain a focused understanding of the topic, a preliminary review of about ten articles was conducted. This initial exploration resulted in the identification of different relevant articles. The insights gained from this preliminary review led to a more specific search term, 'Data Sharing Concern*', to delve deeper into the nuances of 'Data Sharing Concern* Privacy'.

Application of the Snowball Method: To capture the most recent and relevant literature, the forward snowball method was employed. This involved examining which other articles cited the initially identified relevant articles. Google Scholar was utilized for this purpose due to its comprehensive database and ability to track citations effectively.

In parallel, backward snowballing was also conducted. This process involved tracing back through the references of the initially found articles to uncover additional relevant literature, including those that used different synonyms or terminologies related to the same topic.

Evaluation and Selection of Articles: Each identified article underwent a thorough relevance assessment. This started with reading the abstract to understand the core topic of the study. Subsequently, the research questions, sub-questions, and conclusions of each article were reviewed to determine their relevance to this research. Articles that merely mentioned the searched terms without conducting substantial research on them were deemed irrelevant.

Those articles deemed relevant were read in their entirety and included in this research. This thorough process ensured that only literature that significantly contributed to understanding the research questions was considered.

Appendix C: Coding Scheme Theory

Research Question	Category	Sub-Categories/Themes
RQ1: Concerns	Legal	Data privacy regulations, Data ownership, *Data breach risks*
	Ethical	*Fairness*, Data minimization, Informed consent
	Security	Data integrity, Authentication, *Malware and cyberattacks*
	Privacy	Data misuse, Data anonymization, Data subject rights
	Regulatory	Adherence to evolving regulations, Legal compliance
	Ethical	*Alignment with ethical principles*, Impact assessments
	Maturity of the Technology	Technical maturity, Adoption barriers
RQ2: Benefits	Customer	Personalized services, Improved efficiency, Accurate billing
	Institutional	Decision-making, Operational efficiency, *Reduced fraud*
	Industry	Grid stability, Renewable energy integration, *Peer-to-peer trading*
	Cost-effectiveness	Financial feasibility, Cost savings, Revenue opportunities
	Sustainability	Environmental impact, Long-term sustainability
RQ3: Emerging Technologies	Blockchain	Decentralized storage, Smart contracts, Transparency
	Open Protocols	Data exchange standards, Standardized formats, Interoperability
	European	European data infrastructure, federated cloud, Data sovereignty
	SaaS Solutions	Cloud-based platforms, Scalability, Integration
	Privacy Enhancement	Access Control, Encryption, anonymization
	Other	AI and Machine Learning, *IoT*, Anomaly detection

The recursive codes where not found or mentioned by the respondents, and is not used in the general coding as seen in Appendix L.

Appendix D: Interview Rules and Questions

Introduction

Hello, I'm Adem Gungormus, deeply immersed in exploring the intersections of technology and data within the energy sector. I'm excited to engage with you today and unravel your unique insights on this subject. Before we delve deeper, I hope your day has been going well?

Interview Goals

The compass guiding this research points towards understanding how the energy sector perceives the opportunities presented by trustworthy external data sharing, alongside the potential of technologies like blockchain. Through engaging conversations with experts like yourself, and weaving together your thoughts and requirements, we aim to sketch a potential solution.

I trust you have received and reviewed the list of subjects and the consent form for today's discussion. May I confirm your consent for this interview to be recorded and the data to be utilized for the thesis? Please remember, your participation is voluntary, and you may withdraw at any moment.

Today's discussion will navigate through Data Sharing Barriers, Regulatory and Legal Frameworks, Technological Solutions, Cost-Effectiveness, and Potential Benefits and Use Cases.

Informed Consent & Communicative Validation

Informed Consent:

Before the interviews, participants received a brief outline of the study's objectives, methods, and potential risks and benefits. They were made aware of their right to withdraw at any time. Each participant provided signed consent, confirming their understanding and agreement to participate.

Communicative Validation:

To ensure accuracy, key points from participants were summarized and confirmed during the interviews. This validation process helps in representing their views authentically.

Data Confidentiality:

All collected data, including interview recordings, are securely stored and password-protected. Personal details are anonymized to protect participant privacy. Data usage is strictly limited to this study's objectives, and its retention and disposal align with the university's guidelines.

Participant Rights:

Participants were informed about their rights, including withdrawal, omission of questions, and confidentiality. Open communication is maintained to address any concerns.

This approach maintains transparency, ethical consideration, and the validity of the research.

General Questions:

1. Could you please share your current role and position?
2. How many years of experience do you hold in trustworthy data sharing?
3. Are there specific areas within this domain where your expertise particularly shines?

RQ1 - Concerns: What are the main categories of concerns associated with trustworthy data sharing and how can they be mitigated?

1. Can you describe any legal concerns encountered with data sharing in your sector, and how these were mitigated?
2. What ethical challenges related to data sharing have arisen, and how were they addressed?
3. Have you faced any security-related concerns during data sharing, and how were these resolved?
4. Can you discuss instances of privacy concerns in data sharing and the measures taken to address them?
5. What regulatory issues have been a concern for data sharing, and how have these been mitigated?
6. Are there additional thoughts or concerns related to these topics that you would like to share?

RQ2 - Benefits: What are the potential benefits of trustworthy data sharing in the energy sector and how can these benefits be maximized?

1. Can you identify any benefits your organization has experienced from trustworthy data sharing? Additionally, could you elaborate on why your organization initially decided to share this data, what the initial expectations were, and whether those expectations have been met?
2. How have customers or other stakeholders benefitted from your organization's data sharing practices?
3. In what ways can these benefits be maximized?
4. Are there any unexplored benefits of data sharing that you think should be considered?
5. Are there other things that you would like to add about this topic?

RQ3 - Emerging technologies: How can emerging technologies, such as blockchain, facilitate the development of efficient and trustworthy data sharing solutions?

1. Do you have information of your organization or any affiliated networks that delve into the application of blockchain, open protocols or similar emerging technologies for data sharing?
2. Based on your expertise, how do you predict emerging technologies, especially blockchain, will transform data sharing in the energy sector?
3. Are there any practical implementations or projects you can reference that underscore these potential changes?
4. Could you discuss the key benefits and challenges you've witnessed or foresee in harnessing emerging technologies like blockchain for data sharing in the energy domain?
5. Have any specific events or instances informed your views on this?
6. Have you come across any specific strategies or mechanisms either in your organization or elsewhere that utilize emerging technologies to enhance the security and efficiency of data sharing?
7. Could you highlight any success stories or examples that demonstrate the effectiveness of such approaches?

Appendix E: Example Invitation for Interviewees

Subject: Invitation for Participating in Research Study on Data Sharing in the Energy Sector

Dear [Interviewee's Name],

I hope this message finds you well. I am Adem Gungormus, a researcher conducting a study aimed at improving trustworthy data sharing within the energy sector. Your expertise and experience in this field would offer invaluable insights, and I am writing to cordially invite you to participate in a semi-structured interview. This would take approximately 60 minutes of your time and focus on your experiences and perspectives regarding data sharing, its challenges, benefits, and the potential impact of emerging technologies.

Ethical Considerations & Data Protection:

Your participation is entirely voluntary, and you have the right to withdraw from the study at any point. We prioritize ethical research conduct, and as such, this study does not involve personal experiences that would necessitate a detailed ethical review (CETO). The conversation will primarily revolve around your professional insights and expertise.

All information shared during the interview will be kept strictly confidential. We will use teams for conducting and recording sessions, and any transcription will be done using approved tools, ensuring data security and enabling detailed engagement with the text.

Data collected will be stored securely on approved drives, complying with data protection regulations. I will be responsible for safeguarding the data, and any relevant files will be stored on secured drives within the organization, adhering to established agreements on data protection.

Further Queries & Scheduling:

Should you agree to participate, I will follow up to arrange a suitable date and time for the interview. If you have any questions, require more information about the study, or have concerns about data handling and ethical considerations, please do not hesitate to ask.

Thank you for considering this request, and I look forward to the possibility of your valuable contribution to this research.

Kind Regards,

Adem Gungormus

Appendix F: Criteria for roles

This combined criteria aims to ensure the selection of participants with a comprehensive understanding of data sharing issues, benefits, and technological advancements in the energy sector.

For RQ1 - Concerns

Criteria	Description
Role	Legal experts, security officers, data managers, institutional representatives, policy makers
Experience	Experience in dealing with legal, security, privacy, and regulatory aspects of data sharing; identifying, evaluating and maximizing the benefits of data sharing for various stakeholders; and working with or understanding emerging technologies like blockchain and their application in data sharing
Sector	Energy sector
Knowledge	Deep understanding of the challenges and risks, as well as the potential benefits associated with data sharing and knowledge about the functionalities, benefits and challenges of emerging technologies in data sharing
Involvement	Direct involvement in data privacy, security, and compliance issues; data sharing processes and initiatives; exploration or implementation of emerging technologies for data sharing in their organization
Influence	Ability to influence or implement changes to mitigate data sharing concerns, maximize data sharing benefits, and influence technology adoption for data sharing

For RQ2 - Benefits

Criteria	Description
Role	data managers, institutional representatives, IT professionals, technology strategists, digital innovation officers, enterprise architects
Experience	Experience in identifying, evaluating and maximizing the benefits of data sharing for various stakeholders
Sector	Energy sector
Knowledge	Understanding of the benefits associated with data sharing, and how these can be optimized
Involvement	Direct involvement in data privacy, security, and compliance issues; data sharing processes and initiatives; exploration or implementation of emerging technologies for data sharing in their organization
Influence	Ability to influence or implement changes to mitigate data sharing concerns, maximize data sharing benefits, and influence technology adoption for data sharing

For RQ3 – Technological Enhancements

Criteria	Description
Role	IT professionals, technology strategists, digital innovation officers, solution architects
Experience	Experience in understanding and working with emerging technologies like blockchain and their application in data sharing
Sector	Energy sector
Knowledge	Knowledge about the functionalities, benefits, and challenges of emerging technologies in data sharing
Involvement	Direct involvement in the exploration or implementation of emerging technologies for data sharing in their organization
Influence	Ability to influence technology adoption for data sharing

Appendix G: Respondents

Person	Function	Experience	RQ's	Duration
R1	Data Governance Lead – Data Office	10+ Years	RQ1, RQ2, RQ3	31 min
R2	Strategy & Innovation Consultant	5+ Years	RQ2, RQ3	41 min
R3	Program Manager	15+ Years	RQ1, RQ2	28 min
R4	Privacy Officer	10+ Years	RQ1, RQ2, RQ3	37 min
R5	Data Science Manager	10+ Years	RQ1, RQ2, RQ3	44 min
R6	Strategic Architect	10+ Years	RQ1, RQ2, RQ3	59 min
R7	Business Consultant	10+ Years	RQ1, RQ2, RQ3	59 min
R8	Legal Engineer	5+ Years	RQ1, RQ2, RQ3	59 min
R9	CTO + Blockhain Engineer	5+ Years	RQ1, RQ2, RQ3	40 min

Appendix H: Response Distribution

	R1	R2	R3	R4	R5	R6	R7	R8	R9
RQ1 General Concerns	9	13	25	18	6	2	32	5	18
RQ1 Legal Concerns	15	18	12	37	21	0	29	2	15
RQ1 Mittigations	3	0	0	3	1	5	6	0	1
RQ2 Benefits of Blockchain	0	0	0	0	0	4	1	3	2
RQ2 Sectoral Benefits	12	15	16	8	12	9	12	12	15
RQ3 Helpful Methods	0	6	1	5	1	2	12	3	29
RQ3 Helpful Technologies	10	11	4	10	3	27	23	11	31

Appendix I: Concerns in Sharing Energy Data

Context and European Propositions

Shared energy aims to allow consumers (households, SMEs, and public bodies) the right to share electric energy, which should be sustainably produced. This energy could also come from a storage facility.

Sharing is perceived as balancing production and consumption but must occur within the same quarter-hour. Thus, offsetting production during a sunny afternoon with consumption later in the evening is not possible.

Active consumers shouldn't be unfairly treated by suppliers and their responsible entities. Network operators must facilitate the sharing process, ensuring data validation and tracking energy-sharing parties.

Mechanics of Energy Sharing

Energy sharing involves selling surplus electricity produced by solar panels between two consumers without requiring the same electricity supplier. Transactions depend on actual energy flow rather than pre-agreed volumes. For instance, if Mrs. Adema feeds back 0.5 kWh within a quarter-hour and Mr. Boersma consumes more than this, the shared energy is accounted for as 0.5 kWh.

Challenges and Financial Implications

When consumers with surplus energy, such as from solar panels, share their energy during low market prices, it could undermine supplier pricing strategies. Suppliers might have to raise their supply tariffs, affecting all households. Estimating the imbalance risk becomes more intricate. Suppliers need to predict not just their consumers' consumption but also the energy input from non-clients.

Energy taxes and VAT present complications. With energy sharing, it is uncertain who would bear the tax obligations. If suppliers handle this tax for both shared and directly supplied energy, administrative costs will increase, leading to potential hikes in tariffs.

The European Commission's framing of energy sharing as "distant self-consumption" may inadvertently promote a form of legalized tax avoidance. If one party benefits from tax breaks by generating their energy, sharing allows another party to access the same benefits, even if they don't produce energy.

4. Network Tariffs and Operational Costs:

Beyond the challenges faced by suppliers, network operators will also encounter operational costs to facilitate energy sharing. Tracking, validating, and managing the energy-sharing process, especially in real-time, requires substantial infrastructure upgrades and investments.

Conclusion

While energy sharing offers promising avenues for consumer empowerment and renewable energy integration, its practical implementation presents complex challenges, both financial and operational. As Europe moves forward with its energy transition, a comprehensive understanding and analysis of such propositions are critical to ensure equitable, efficient, and sustainable outcomes.

Appendix J: Benefits Data Sharing in the Energy Sector

CLEO (Co-creatie Lokale Energie Oplossingen)

A collaborative venture working on local energy solutions that are widely applicable in the Netherlands. Projects focus on rapid development and implementation with stakeholders, serving as a launchpad for both new and existing initiatives. A collaborative initiative focusing on the future energy system: sustainable, decentralized, and digital. It aims to provide standardized solutions which can be easily applied and customized for a regional approach, ensuring an efficient utilization of the energy network.

De Metrokaart

The Metrokaart offers insights into local network situations, topology, network load, and consumption profiles, enabling stakeholders to unite and design solutions to match local energy supply and demand. This platform is set to undergo a Beta Release for a select group before its Gold Release for a broader audience. An update from May 2023 reflects on the progress made in the previous quarter concerning the Metrokaart.

De Coöperatieve Energiebeurs

A New Energy System and Changing Customer Needs: The energy transition is leading to a change in the current energy system, becoming more decentralized and weather-dependent. The shift results in new needs among consumers, businesses, and market parties. Collaboration Towards New Solutions. As a network company, the focus is on facilitating and stimulating local energy exchange with market parties. Possible solutions include new tariff models, new contract forms, and digital trading platforms.

The first quarter of 2023 was dedicated to establishing a project team and overall preparations for the Coöperative Energiebeurs. This quarter will involve work on the cooperative principles and technical requirements for its development.

From Concept to Realization

CLEO's approach involves active participation from the conceptualization stage to actual implementation. The initial co-creation trajectory in November 2022 saw more than 90 ideas emerge, out of which three propositions were developed. Two concepts, namely the Metrokaart and the Coöperatieve Energiebeurs, were chosen for implementation.

Source: https://www.alliander.com/content/uploads/dotcom/CLEO-Visiedocument-download-16-11.pdf

Appendix K: Emerging Technologies

Open Protocols

At their core, open protocols are decentralized frameworks that facilitate transparent and reliable data sharing across various platforms and industries. By relying on a distributed approach, they foster an environment where data can be exchanged with confidence in its authenticity and integrity. Such protocols promise a standardized mechanism for data exchange, emphasizing interoperability and reduced reliance on central intermediaries (Zohar, 2015).

Gaia-X

Initiated as a European endeavor, Gaia-X aims to develop a federated data infrastructure that is both secure and transparent, aligning with European values and standards. Gaia-X emphasizes data sovereignty, ensuring that individuals and organizations retain control over their data, dictating who can access it and for what purpose. Its architecture is designed to operate in synergy with open protocols, providing a foundation for trusted data sharing in compliance with regulations such as the General Data Protection Regulation (GDPR) (European Commission, 2020).

Software as a Service (SaaS) solutions

SaaS platforms, operating in the cloud, enable users to access software applications over the internet. They offer scalability, flexibility, and cost-saving advantages. More pertinently, certain SaaS solutions are now integrating blockchain and open protocols to offer enhanced data sharing capabilities. These platforms emphasize security, ease of integration, and streamlined data management, presenting them as valuable tools in the quest for trusted data sharing (Mell & Grance, 2011).

Conclusion

In conclusion, as the need for reliable data sharing solutions intensifies, the exploration of Open Protocols, Gaia-X, and SaaS solutions becomes imperative. Their collective potential to revolutionize the landscape of data sharing, especially within the confines of trust, positions them as central players in future digital endeavors.

Appendix L: Thematic Analysis / Encoding

Group	Category: Code	Count	Root
RQ1 General Concerns	Ethical: Commercial sensitivity	10	Interview
	Ethical: Informed consent	7	Theory
	Ethical: Lack of transparency	3	Interview
	Maturity of the Technology: Adoption barriers	10	Theory
	Maturity of the Technology: Blockchain	8	Interview
	Maturity of the Technology: Critical infrastructure vulnerability	7	Interview
	Maturity of the Technology: Technical maturity	14	Theory
	Organizational: General	27	Interview
	Organizational: Lack of Data Literacy	16	Interview
	Organizational: Security Procedures	10	Interview
	Organizational: Technical Knowledge	17	Interview
	Security: Consulting relevant stakeholders	8	Interview
	Security: Procedures and guidelines	16	Interview
	Security: Risk of sabotage	4	Interview
RQ1 Legal Concerns	Ethical: Different goals	10	Interview
	Ethical: Ethical dilemma	8	Interview
	Legal: Data ownership	1	Theory
	Legal: Data privacy regulations	21	Theory
	Privacy: Data anonymization	5	Theory
	Privacy: Data misuse	14	Theory
	Privacy: Data subject rights	7	Theory
	Privacy: In-house confidentiality obligations	8	Interview
	Regulatory: Adherence to evolving regulations	14	Theory
	Regulatory: Legal compliance	16	Theory
	Regulatory: Non-Disclosure Agreement	4	Interview
	Regulatory: Unclarity	20	Interview
	Regulatory: Risk Assessment	4	Interview
	Security: Authentication	9	Theory
	Security: Data Integrity	10	Theory
	Security: Informed consent	6	Theory
	Security: Legacy systems	6	Interview
	Security: Measures	8	Interview
RQ1 Mitigation	Ethical: Data minimization	1	Theory
	Mitigation: Filtering per zone	1	Interview
	Mitigation: SaaS Solutions	5	Interview
	Mitigation: Supportive legislation	8	Interview
	Mitigation: New Technologies General	4	Interview
RQ2 Benefits of Blockchain	Blockchain: Assistance	1	Interview
	Mitigation: Blockchain	9	Interview

RQ2 Sectoral Benefits	Cost-effectiveness: Cost savings	6	Theory
	Cost-effectiveness: Financial feasibility	10	Theory
	Cost-effectiveness: Revenue opportunities	4	Theory
	Customer: Accurate billing	9	Theory
	Customer: Improved efficiency	20	Theory
	Customer: Optimized and Efficient Energy Consumption	16	Interview
	Customer: Personalized services	17	Theory
	Industry: Commercial value	5	Interview
	Industry: Grid stability	16	Theory
	Industry: Operational efficiency	17	Theory
	Industry: Peer 2 Peer trading	2	Interview
	Industry: Proactive Data Provisioning	9	Interview
	Industry: Renewable energy integration	9	Theory
	Industry: Unexplored	6	Interview
	Industry: Effective energy distribution	13	Interview
	Institutional: Decision-making	14	Theory
	Institutional: Operational efficiency	15	Interview
	Sustainability: Environmental impact	5	Theory
	Sustainability: Long-term sustainability	13	Theory
RQ3 Helpful Methods	European: Authentication	13	Interview
	European: Data sovereignty	2	Theory
	General: Regulatory updates	8	Interview
	General: Open-source code sharing	6	Interview
	Organizational: international	3	Interview
	Organizational: Resource sharing	9	Interview
	Other: AI and Machine Learning	4	Theory
	Other: Centralized	7	Interview
	Other: Peer 2 Peer database	7	Interview
RQ3 Helpful Technologies	Blockchain: Decentralized storage	12	Theory
	Blockchain: Smart contracts	13	Theory
	Blockchain: Transparency	15	Theory
	Emerging Technologies: Data Portal	13	Interview
	European: European data infrastructure	2	Theory
	European: Federated cloud	7	Theory
	Methods: Design thinking	2	Interview
	Open Protocols: Data exchange standards	13	Theory
	Open protocols: Interoperability	11	Theory
	Open protocols: Purpose Limitation	2	Interview
	Open protocols: Standardized formats	8	Interview
	Open protocols: Transparency	13	Interview
	Open protocols: Unified Data Repository	4	Interview
	Other: Automatization	7	Interview
	Other: Compliance as a Code	5	Interview

	Other: Distributed Streaming	2	Interview
	Other: Quantum Computing	2	Interview
	Privacy Enhancement Encryption	5	Theory
	Privacy Enhancement: Access Control	1	Theory
	Privacy enhancement: Aggregated and De-Identified data	6	Interview
	Privacy Enhancement: Anonymization	5	Theory
	Privacy enhancement: In Development	3	Interview
	SaaS Solutions: Cloud-based platforms	10	Theory
	SaaS Solutions: Integration	3	Theory
	SaaS Solutions: Scalability	4	Theory
	Technology: Real-time data	1	Interview

Appendix M: Sample results

Group RQ1: Legal Concerns

Legal: Data Privacy Regulations
R1: "Well yes, rules that we have to comply with. We have, first of all, of course, the [Privacy Regulation] privacy legislation."

Privacy: In-house Confidentiality Obligations
R1: "In addition, we have our own confidentiality obligation of company-sensitive data."

Regulatory: Non-Disclosure Agreement
R2: "Or rather, the purpose limitation must be recorded, for example, in an NDA with the recipient of that information."

Ethical: Ethical Dilemma
R1: "It has a very big social importance that we share that data, but we are not allowed to."

Group RQ1: General Concerns

Industry: Commercial Sensitivity
R1: "We are not allowed to create insights... thereby endangering the position of competitors."

Security: Security Procedures and Governance
R6: "[Client] can be seen as a Federated set of companies, and we've built a central architectural blueprint that includes governance."

Maturity of the Technology: Critical Infrastructure Vulnerability
R1: "During the Ukraine crisis... Suddenly, the location of your gas pipelines, basically your energy conduits, become very sensitive."

Group RQ1: Mitigations

Data Minimization Strategies
R4: "So data minimization is often deployed. Anonymization is sometimes done but not very often."

Supportive Legislation for Data Sharing
R1: "The new energy law is coming which should give us a bit more room to share data."

Group RQ2: Sectoral Benefits

Customer: Optimized Energy Consumption
R1: "If companies...can agree among themselves on when to use energy, spreading their usage throughout the day...we have essentially solved a problem."

Industry: Proactive Data Provisioning
R1: "If we can work proactively, meaning we can create data products based on demand...It saves a tremendous amount of time."

Industry: Renewable Energy Integration
R6: "For a wind farm in the North Sea, weather data significantly impacts the expected energy output."

Group RQ3: Helpful Technologies

Privacy Enhancement: Aggregated and De-Identified Data
R1: "No, we can't share usage data... but we can share aggregated consumption over a whole postal code area."

Unified Data Repository & Transparency
R6: "We have a unified catalog for sharing data within a single cloud provider's region...delta sharing enables data asset sharing across different locations."

Blockchain Technology: Decentralized Storage & Smart Contracts
R6: "Blockchain will play an important role...for tracking and securing data ownership."

Open Protocols: Data Exchange Standards & Interoperability
R6: "Standardizing open data sharing will make the industry more efficient."

Emerging Technologies: Data Portal
R2: "By having a data portal available...it saves a tremendous amount of time."

Group RQ3 Helpful Methods

European Initiatives: Data Sovereignty
R4: "We are aware that legislation changes...sometimes the situation changes faster than legislation."

Organizational Methods: Resource Sharing
R1: "The Chief Information Security Officers are coming together to create a central data platform."

Appendix N: More Results

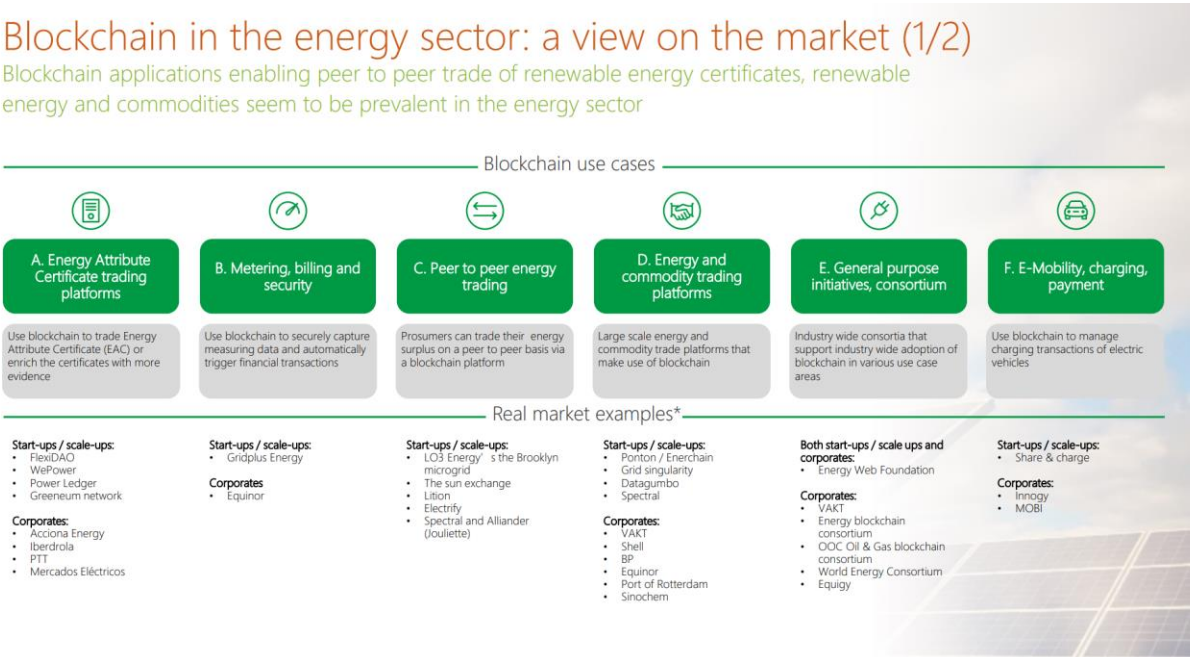
RQ3 - Emerging Technologies

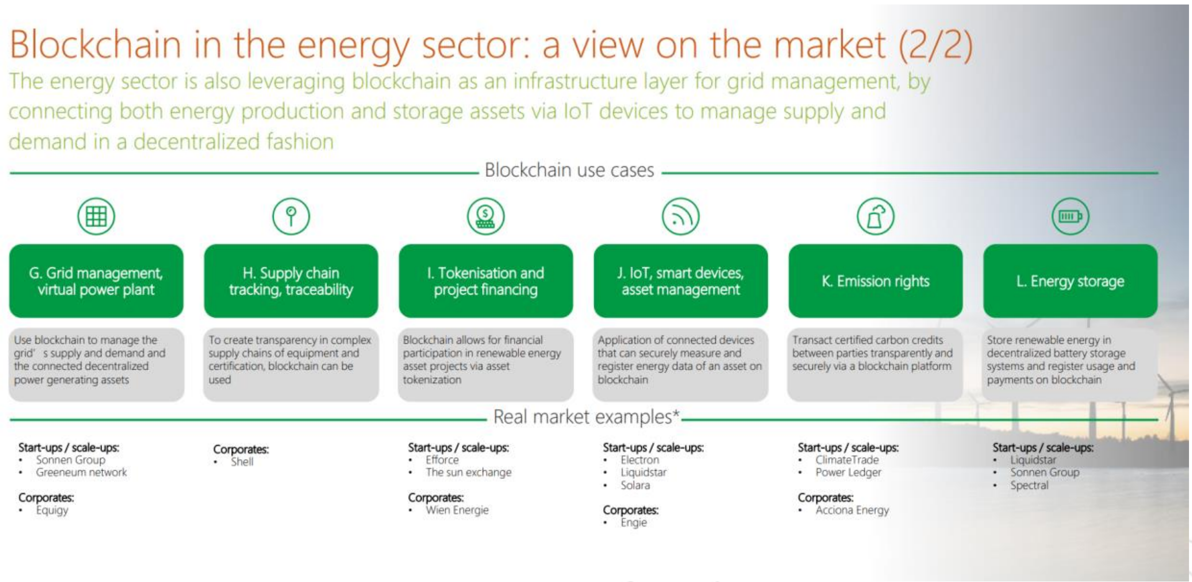
Privacy Enhancement Techniques - Aggregated and De-Identified Data: Techniques like aggregation and anonymization are essential in maintaining privacy while sharing valuable data insights. For instance, one respondent shared, “But what we can share is aggregated consumption over a whole postal code area so that it's no longer traceable to a specific dwelling” (R1). Another explained, “It's designed so it cannot be traced back to individual users because we always maintain an aggregation level of at least 10, among other measures” (R5).

Privacy Enhancement Techniques - Encryption and Access Control: Implementing advanced encryption methods and stringent access controls are key to ensuring data privacy and security. As one interviewee mentioned, “Yes, that's right. Because I've seen some interesting examples where we put data into a central cloud where no one specifically knows about the data, but then analyses are performed and only the results that are not price-sensitive are then made available again” (R4). Discussing identity verification, another stated, “..something in Belgium. Yes, it's Itsme, something. And in the Netherlands, we have DigID and it's now Itsme, and you have DataKeeper. DataKeeper is mostly for the financial institutions, basically the banks, I think” (R7). Additionally, the importance of identifying individuals was noted: “This handwriting signature can be in if go a bit, we step from this very far manual type of contracting” (R9).

Appendix O: Specific Documentation

Slides of Blockchain Use-Cases provided by Respondent 2 (Strategy & Innovation Consultant)





Acciona launches blockchain to trace green hydrogen used as energy

February 10, 2021 • by Ledger Insights

Blockchain used for major Australian renewable energy market trial

September 2, 2021 • by Ledger Insights

Vodafone, Energy Web to link power grid assets with blockchain, IOT

May 26, 2020 • by Ledger Insights

Energy Web, VW partner to explore blockchain, EV batteries for energy storage

March 4, 2021 • by Ledger Insights

Energy web in blockchain project with German energy agency DENA

October 13, 2020 • by Ledger Insights

Germany uses Energy Web blockchain to store wind energy in batteries

March 13, 2020 • by Ledger Insights

Wien Energie, RIDDLE&CODE tokenize renewable energy installations

June 7, 2021 • by Ledger Insights

ENGIE to use DeFi to crowdfund rural solar panels in Africa

June 17, 2021 • by Ledger Insights

Slides of Blockchain comparison provided by Respondent 2 (Strategy & Innovation Consultant)

Comparison of centralized vs distributed systems

Whether a centralized vs a distributed solution brings the most value is dependent on whether collaborating parties are willing to trust one party with their data

	Regular database	Blockchain
Architecture	Centralized systems	Distributed systems
Ownership over system and data	One party	Sometimes a consortium, never a single party
Governance	To be set up and maintained around the database	Build into the system after agreement
Immutability of data	Not immutable, flexibility needed	Immutable, since you don't trust others
Censorship resistant	No, data can be changed / deleted or user access denied by owner of database	Yes, very difficult to change data or deny user access
Who should users trust	One party	The system, or a consortium behind the system
Typical use	1-2 parties read and make updates and changes to a ledger	Many parties read and write the append-only ledger

Bitcoin ethereum vechain HYPERLEDGER

Blockchain @ Stedin (Dutch Energy Distributor) provided by Respondent 2 (Strategy & Innovation Consultant)

Rotterdam, May 10 – Stedin is joining forces with nine international energy companies in the Energy Web Foundation (EWF). Founded by the American Rocky Mountains Institute and startup company Grid Singularity, EWF aims to make energy exchange between consumers and renewable energy producers more efficient through the use of blockchain technology.

David Peters, Director of Strategy and Innovation at Stedin, says, "The application of blockchain technology in the energy sector is still in its infancy but has a disruptive character. EWF will explore where this can add the most value. Think of new business models that involve consumers, lower transaction costs, and more efficient use of our network."

Exchanging energy locally with more ease

Peters continues, "There are global examples where energy exchange between producers and consumers is more efficient. Ten organizations are now joining forces to research these international examples, optimize them, and determine which regulations need to be adjusted to make this legally possible. We believe in partnerships. As a network operator, you can never do this alone." The partners collaborating with Stedin within EWF are Centrica plc, Elia, Engie, Royal Dutch Shell plc, Sempra Energy, SP Group, Statoil ASA, TWL (Technical Works Ludwigshafen AG), and Tokyo Electric Power Co (Tepco).

What is blockchain technology?

Blockchain technology reduces transaction costs because only one copy of transaction data is stored, making coordination and settlement unnecessary. Potentially, it can play an important and even revolutionary role in the energy sector. It is important because it can reduce the costs of energy bills and the need for working capital in wholesale gas or electricity transactions. Revolutionary because it enables interaction at the interface between distribution systems and consumers. This interaction involves millions of energy installations, such as heating, ventilation, and air conditioning systems, boilers, electric vehicles, batteries, and solar energy systems. It also aids energy providers and network operators in integrating more variable renewable energy capacity on a large scale at much lower costs.

The use of blockchain technology in the energy sector is still nascent but can become very significant.

David Peters, Director of Strategy at Stedin

Automating energy demand

Hervé Touati, President of EWF, states, "The biggest challenge for the energy sector in the 21st century is to integrate more sustainable energy into the grid in a cost-effective manner with a largely stable or declining demand. The only way we can achieve this is by automating the demand side. This could lead to a significant increase in the number of participants accessing the grid, which requires automation at the interface between distribution systems and consumers and the integration of this automation with wholesale markets. We are very excited about the potential facilities that blockchain technology offers to realize this vision. Blockchain will not be the only building block of the 21st-century grid, but it will be one of the most important. Additionally, it offers a much higher level of cybersecurity at no extra cost, addressing one of the key concerns regarding distributed energy sources as a side effect."

How does EWF operate?

EWF is a collaboration between the Rocky Mountain Institute and Grid Singularity. The Rocky Mountain Institute, an independent non-profit organization from the United States, focuses on promoting efficient and restorative resource use. As a developer specialized in blockchain technology applications for the energy sector, Grid Singularity, together with partner Parity Technologies, will provide the most advanced blockchain technology. This will address the limitations of speed and transaction costs of currently available blockchains.

In parallel with the development of an open-source IT infrastructure, EWF focuses on analyzing use cases. Task forces will convert the most promising cases into so-called proof-of-concepts and commercial applications. There will be a network of application developers, and collaboration with regulatory authorities and standardization institutes will facilitate implementation. EWF actively seeks collaboration with other technology providers who support the open-source approach to removing barriers to entry into the energy market.

About Stedin

Stedin works daily towards sustainable energy for everyone, so that over two million customers in the Netherlands can live, work, and thrive in the most urban and industrial regions of Utrecht and the majority of South Holland. The energy infrastructure is complex, and the dependency on energy is significant in their service area. With about 3,000 employees, they are working towards a sustainable energy system with increasing local generation, one that is reliable and affordable for future generations.

About the Rocky Mountain Institute

The Rocky Mountain Institute (RMI) is an independent non-profit organization established in 1982 that globally transforms energy consumption for a clean, prosperous, and secure low-carbon future. It engages businesses, communities, institutions, and entrepreneurs in accelerating the adoption of market-based solutions that shift from fossil fuels to efficiency and renewable resources. RMI has offices in Basalt and Boulder (Colorado), New York City, Washington, and Beijing.

About Grid Singularity and Parity Technologies

Grid Singularity is a technology company developing an open-source software platform for blockchain-based energy applications, as well as decentralized applications enabling automated, secure, and more efficient energy applications. Grid Singularity's

Source: https://www.stedin.net/over-stedin/pers-en-media/persberichten/stedin-sluit-zich-aan-bij-de-energy-web-foundation-een-wereldwijd-energie-blockchain-initiatief

Appendix P: Analysis of Solar Power Surplus in The Netherlands

Introduction The evolving Dutch electricity market showcases a notable increase in renewable energy, particularly solar power. This growth, while beneficial for sustainability, has occasionally led to a surplus. This appendix delves into this surplus's dynamics, the stakeholders involved, and potential flexibility strategies amidst negative day-ahead prices.

Magnitude of Dutch Electricity Surpluses On days with substantial wind and sunshine, renewable energy sources like wind turbines and solar panels often function at peak capacity, leading to a potential overgeneration of electricity. Such conditions create a situation where producers might even pay to distribute their generated electricity. A representation of the situation indicates a national surplus of about 12 GW on specific peak days, requiring the curtailing of about 4 GW after maximal export.

Must-Run Power Plants These are plants in the energy system that operate independently of electricity prices. They can be gas power plants offering balancing reserves, CHP plants essential for industrial processes, or plants with high operational costs. They also contribute to the electricity surplus.

Response to (Negative) Prices The balance achieved, even with peak production from renewable sources, suggests active demand responses and production curtailing. However, not all renewable energy sources respond to negative prices due to subsidies from the SDE+(+) scheme. Still, many large-scale renewable farms are beginning to adapt to these negative prices.

Flexibility and Incentivization Dutch Wind Production: Data indicates offshore wind energy is fully integrated, but onshore wind sits at about 30%. Patterns suggest market price-driven adjustments, notably in offshore wind. EU Subsidies and Negative Pricing: The EU restricts subsidies during negative price hours. The Netherlands implemented a subsidy stop for projects submitted after December 1, 2015, when there are six consecutive negative hours. Current trends suggest a need to revisit these regulations for projects facing negative market prices.

Unlocking Flexibility Solar PV for Small Consumers: Due to net metering regulations, these consumers lack incentive to modify their production. However, with growing solar panel installations, change is imminent. A legislative proposal under review suggests phasing out net metering by 2031. Conventional Must-Run Production: A sustainable energy system transition necessitates reducing this production type. Despite the reliance on these for reactive power compensation, newer renewable sources could fill this role with the right configurations. Demand Response: A trend towards more electricity consumption during surplus periods is emerging. The Netherlands has suppliers offering dynamic contracts, pointing to an electrification wave in the system. However, its full realization is still pending.

Conclusion While market incentives ensure balance, shielding rooftop solar owners through net metering is problematic. The debate around this hasn't fully considered the potential risks. Adjustability is crucial for small consumer solar installations. Present incentives might deter future investments. Contract structures that struggle to adapt to market shifts need reform. The renewable energy sector has vast potential to provide system services during peak periods, presenting an optimistic outlook for the Dutch energy landscape.

https://energeia.nl/trilemma/40107711/de-nederlandse-zonnestroomboterberg