Innovating business models in the energy sector by using data

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Abstract

The energy sector is undergoing a significant transition, encouraging companies to innovate current business models (BM). The use of data is expanding to innovate BMs, but there is still a gap in how companies create business value from data. This research aims to examine how companies in the energy sector innovate their BMs by using data, and what internal and external barriers exist in terms of data, and how these affect the innovation of BMs. Findings from a study based on qualitative data from semi-structured interviews with industry experts indicate that implementation of new systems and initiatives is needed to identify, meet, and engage customer demands. Furthermore, investment in analytics is crucial for operation costs and production efficiency and is necessary with the shift from isolated data systems to an interconnected approach. There is a need to use analytics to leverage information from customer data to differentiate offerings, sensor data for maintenance efficiency and internal data for optimizing internal processes. Practical initiatives are vehicle-to-grid, second-life batteries, sensor data and computer vision with a need of enabling device interactions. Identified barriers to using data include understandability, accessibility, trustfulness, and measurability, as well as limitation of cross-sharing data for privacy reasons, the incorporation of data in the overall business and regulatory constraints of GDPR and accessibility of grid data. The research contributes to an extended understanding of how companies in the sector create value by implementing and increasing the use of data, as well as highlighting the various barriers to doing so.

Keywords: Energy sector, Business model, Business Model Innovation, Data, Data-driven Business Model, Barriers, Regulations

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Abstrato

O setor de energia está em transição, incentivando as empresas a inovar em seus modelos de negócio. A utilização de dados está se expandindo para impulsionar essa inovação, mas há uma lacuna na forma como as empresas extraem valor comercial dos dados. Esta pesquisa analisa como as empresas do setor de energia inovam por meio do uso de dados, identificando barreiras internas e externas que afetam a inovação. Conclusões de entrevistas qualitativas com especialistas do setor indicam a necessidade de implementar novos sistemas e iniciativas para atender às demandas dos clientes. O investimento em análise de dados é crucial para reduzir custos operacionais e aumentar a eficiência da produção, exigindo uma transição para uma abordagem interconectada de dados. É necessário utilizar a análise de dados para diferenciar ofertas com base nas informações dos clientes, otimizar a eficiência da manutenção com dados de sensores e melhorar os processos internos com dados internos. Iniciativas como a rede inteligente, baterias de segunda vida, dados de sensores e visão computacional são fundamentais, permitindo interações entre dispositivos. Os obstáculos à utilização de dados incluem compreensibilidade, acessibilidade, confiabilidade, mensurabilidade e restrições de compartilhamento de dados por questões de privacidade e regulamentações. Essa pesquisa contribui para a compreensão de como as empresas do setor de energia criam valor por meio do uso de dados, destacando os obstáculos nesse processo.

Palavras-chave: Sector da energia, Modelo empresarial, Inovação do modelo empresarial, Dados, Modelo empresarial baseado em dados, Barreiras, Regulamentação

Título: Inovar os modelos de negócio no sector da energia através da utilização de dados

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List of Abbreviations

BM	Business Model
BMI	Business Model Innovation
e.g.	for example,
DE	Data ecosystems
EDS	European Data Strategy
EU	European Union
GDPR	General Data Protection
V2G	Vehicle-to-grid
kWh	Kilowatt-hour
EV	Eletric vehicles
TSO	Transmission System Operator
ERP	Enterprise Resource Planning
DaaS	Data-as-a-service
AaaS	Analytics-as-a-service

1. Introduction

The energy sector is undergoing a significant transition with changed market conditions such as increasing prices, power crises and global pressure of meeting common global sustainability objectives by adapting to renewables (Aranda et al., 2023; Siuta-Tokarska et al., 2022). Stepping into a future with continuous digitalization, companies are encouraged to seize the opportunity of improving present processes to stay competitive and profitable in the market (Amit & Zott, 2012). Improving present processes, staying competitive and being profitable requires the development of business models (BM), and researchers purposed various conceptualizations of the definitions and components of BMs (Zott et al., 2011). As a part of developing BMs, innovation is a crucial part of staying competitive as studies show that innovation in BMs is a source of creating sustainable value (IBM Global Business Services, 2006). To innovate BMs in the sector, using data is an expanding source for creating real business value and gaining a competitive advantage (Davenport, 2006). However, there is still a gap in knowledge on how companies can create business value from data that can be caused by energy solutions (Paukstadt & Becker, 2019). These challenges establish questions regarding the concerns on *how* and *where* data provides value for companies (Hagen et al., 2013; Manyika et al., 2011). That being the case, this thesis pursues to answer the following research questions:

- How is the energy sector creating value by innovating its business model?
- What potential value does data have in the energy sector?
- How does the energy sector use data in innovating its business model?
- What are the potential internal and external barriers to innovating business models in the energy sector?

Innovation in BMs contributes to favorable impacts on operations and improved performance (Zott & Amit, 2007; Cucculelli & Bettinelli, 2015), as well as to a long-term sustainable competitive advantage (Economist Intelligence Unit, 2005; Foss & Saebi, 2017). There is an acknowledgment in the current energy sector, especially for traditional energy companies, of an experience of decreased margins, which pushes for a strong need to be able to use data in a valuable matter (Duncan, 2010; Sorescu, 2017; Demirkan et al., 2015; Hartmann et al., 2016). However, strikingly little is known regarding the way data impact innovation in BMs and extensive knowledge of the challenges of using data to innovate BMs is lacking (Sorescu, 2017:

Schüritz et al., 2017). Within this, internal (Chesbrough, 2010; Chesbrough & Rosenbloom, 2002) and external barriers (Mosig et al., 2021; Teece, 2018; Maine & Garnesy, 2006) also occur which creates additional obstacles.

To acknowledge this gap, this thesis examine how companies in the energy sector innovate their BMs by using data to create value, and what internal and external barriers exist in terms of data, and how these affect the possibility of innovating BMs. The research approach is an exploratory study based on qualitative data from semi-structured interviews with experts in the sector. This study presents a more extended understanding of how companies in the energy sector innovate their BMs with different initiatives by making use of valuable data. This understanding opens the knowledge of the various barriers companies face in the current market, and a discussion arises of potential actions that can be implemented to decrease these barriers. The dissertation contains the following parts: Chapter 2 begins with defining and presenting the components of BM and Business model Innovation (BMI), and continues with the definition and value of data. Chapter 2 ends with an industry overview, the current BMs in the sector, the use of data and the regulations and initiatives. Chapter 3 consists of an explanation of the used research and strategy, as well as a description of the data collection process. Chapter 4 presents the findings based on created sub-categories for each research question. Chapter 5 discusses the main findings and chapter 6 presents the key conclusions and recommendations. Lastly, chapter 7 discusses the limitations.

2. Theoretical discussion

2.1. Business model (BM)

2.1.1. Definitions and perspectives

BM is often described as an *architecture* (Osterwalder et al., 2005; Timmers, 1998), a *conceptual tool or model* (Osterwalder, 2004) and a *structural template* (Amit & Zott, 2001).

Timmers (1998) describes BM as the architecture of the product, service, and information flows which contains a description of the various business players and their responsibilities, as well as a description of the possible advantages for those actors. BM is described as the information, organization, and control of transactions that generate profit by taking advantage of potential business possibilities (Amit & Zott, 2001).

2.1.2. Components of BM

BM has created popularity among researchers and practitioners in recent years, as seen by the numerous articles that have appeared (Zott et al., 2011). Many publications have been made on the subject over the past years, making the study of BM a subject that is becoming more and more appealing (Zott et al., 2011).

As it seems to be a variety of BM definitions and classification methods, Zott et al. (2011) state that BM still have not formed a generally recognized language, which might make it difficult for researchers that study business models from different lenses to effectively draw on the work of others. These opinions represent the misunderstanding that has been affecting a meaningful debate on important issues regarding what the elements of BM actually are (Zott et al., 2011).

The categorization of value creation and value capture has been at the center of debates. Value creation identifies the consumer and how they are involved (McGrath & MacMillan, 2000), whereas value capture defines how value is provided and monetized (Teece, 2010). Value creation is also described as a business's capability to capture the created value for its customers and turn it into profits that can outcompete competitors (McGrath & MacMillan, 2000).

By taking a look at Amit & Zott's (2001) view of BM, value creation is described as a component that explains how the organization's resources are coordinated to optimize its operations. Value creation can be focused on gaining higher efficiency by reducing expenses or increasing revenues. Examining the research even further, Baden-Fuller & Haefliger (2013), describe BM which includes four components of customer identification, customer engagement, value delivery, and monetization. Chesbrough & Rosenbloom (2002) describe the idea of BM and argue that it outlines a company´s value chain, identifies a market sector, and communicates its value proposition.

Hedman & Kalling (2003) are defining BM as a concept including customers and competitors, the offering, activities and organization, resources and input market merger. Hedman & Kalling (2003) are also highlighting the importance of value creation and value proposition in their definition. The value proposition is a preliminary outline of the product's possible uses and its planned format and the customers´ advantage from using the product/service. The offering, also known as the value proposition, is the core component of all BM frameworks (Chesbrough & Rosenbloom, 2002; Osterwalder, 2004; Johnson et al., 2008).

An extended view of BM is being made by Osterwalder & Pigneur (2002), explaining the business model as a description of the value a company provides to its customers, the organizational structure of the company, and its partnerships for developing and providing its value to generate profitable and sustainable revenue streams. Osterwalder & Pigneur (2002) are including value creation, value capturing, and value proposition as components in the definition. Johnson et al. (2008) are also discussing a framework for BM, which includes the customer value proposition, a profit formula, and key resources and processes for delivering the profitability of the value proposition. Similarly, Teece (2010) defines BM as how the firm produces and gives value to its customers and turns received payments into revenues.

Some standards allow one to judge whether or not someone has created a strong BM, regardless of the industry. A successful BM produces value propositions that are attractive to customers, creates beneficial cost and risk structures, and allows the company that creates and provides goods and services to increase value capture. The major challenges in building BMs are understanding how to provide value to customers and achieving profit while doing so. It is not sufficient to achieve one without the other (Teece, 2010).

However, in recent years a transition of attention has been made from the research of BM to Business Model Innovation (BMI) in the area of management studies (Spieth et al., 2014; Zott et al., 2011). Given the rapidly expanding field of BMI research, it is important to recognize that BMI is an important development that requires independent analysis and theorizing. Therefore, even while research indicates that BM and BMI are related, research on BMI also takes innovation into account, which creates a lot of important theoretical and empirical circumstances (Foss & Saebi, 2017).

Table 1. Definitions and components of BM

Author (s), Year	**Definitions**	**Value Creation**	**Value Capture**	**Value Proposition**
Amit & Zott, 2001	A structural template that describes the information, organization and control of transactions intended that generate profit by taking advantage of potential business possibilities.	✓		
Hedman & Kalling, 2003	Defined as a concept including customers and competitors, the offering, activities and organization, resources and input market merger	✓		✓
Baden-Fuller & Haefliger, 2013	Including four components of customer identification, customer engagement, value delivery and monetization.	✓	✓	✓
Chesbrough & Rosenbloom, 2002	Outlines a company´s value chain, identifies a market sector and communicates its value proposition.	✓	✓	✓
Osterwalder & Pigneur, 2002	A description of the value a company provides to its customers, the organizational structure of the company and its partnerships for developing and providing its value to generate profitable and sustainable revenue streams.	✓	✓	✓
Johnson et al., 2008	A framework that includes the customer value proposition, a profit formula, and key resources and processes for delivering the profitability of the value proposition.	✓	✓	✓
Teece, 2010	Defined as how the company produces and gives value to its customers and turns received payments into revenues.	✓	✓	✓

2.2. Business Model Innovation (BMI)

2.2.1. Definitions of BMI

Given the importance of BMI, the topic should be included in an extensive literature study on BM (Wirtz et al., 2016). The literature originally considers BMI as a standalone part, and as defined by Johnson et al. (2008), BMI is the total reimagining of the present BM in a way that is innovative for the market or sector. Gambardella & McGahan (2010) describe BMI as the implementation of a fresh strategy for companies when marketing their assets. Taking it one step further, in comparison to the ongoing discussion of BM, BMI generally takes a more extensive approach and has greater groundbreaking impacts (Wirtz et al., 2016). As well as Johnson et al. (2008) and Gambardella & McGahn (2010), Wirtz et al. (2016) is also examining the BM concept by using a conceptual guide and include innovation in its structure.

Continually, in recent BMI research, which is defined as the commercial launch of a BM that is different from the market for products where the main company competes (Snihur & Zott, 2020), a perspective has been developed further by looking at BM themselves as the foundation of innovation and value creation. With this, BMI research has emphasized the issues of value creation and value capture (Zott et al., 2011) , revealing the advantages of BMI for customers and users (Priem et al., 2018).

2.2.2. Value of BMI

The idea of BMI relates to rethinking the BM by developing or creating whole new BMs, instead of just making gradual implementations over time (Voelpel et al., 2004). As a result, recently developed BMs may be related to the creation of whole new businesses or even sectors as a result of the introduction of new technologies. It may also apply to companies that already exist and have fully reinvented their identities and business strategies (Voelpel et al., 2004).

Voelpel et al. (2004) continue with the thought that the fast changes in the market, sources of sustained competitive advantages can be created through BM transformation that depends on disruptive innovation, rather than gradual transformation.

Studying companies as a whole, BMI has shown to have a beneficial impact on the operations of entrepreneurial enterprises (Zott & Amit, 2007) and for established businesses that choose to reinvent their BMs, improved performance is experienced (Cucculelli & Bettinelli, 2015). It can as well be a source of long-term competitive advantage (Economist Intelligence Unit, 2005) and can create a sustainable competitive edge (Foss & Saebi, 2017).

2.2.3. Expanding perspectives on BMI

The idea of BMI has lately been used from different perspectives. One of the perspectives, on a firm level, is by using BMI to create economic value by meeting customer demands in new ways. A recent literature review demonstrates that BMI is positively related with financial performance on a firm level, which is typically measured based on measures of companies' growth in revenue, return on equity, operating profits, or stock market values (Zhang et al., 2021).

Researchers interested in the societal implications of BMI are beginning to think about how BMI might provide value on various levels, including economic, social, and environmental (Snihur & Bocken, 2022). Over the past year, in particular, the attention on BMI in connection to sustainability has increased (Foss & Saebi, 2017).

2.2.4. Barriers of BMI

In current literature, different types of barriers are being identified connected to the implementation of BMI. One of the discussed barriers is the internal one, which includes aspects connected to the culture within the company, as well as the composition of the internal processes (Chesbrough, 2010). In the framework of academic literature, individual capacities and behavioral habits, as resistance to changing already existing behaviors or with negative attitudes to ideas that are coming from outside, are creating cognitive challenges (Chesbrough, 2010; Chesbrough & Rosenbloom, 2002).

It is not only the internal barrier that has been recognized in the academic literature but also external barriers such as technology-related (Mosig et al., 2021). Connected to BMI, Teece (2010) is pointing out that innovation of technology does not essentially contribute to BMI. Teece (2018) acknowledges technology advancements as an encouraging but also a limiting aspect when companies seek to innovate their BMs, and also draws a connection between technological barriers and regulatory restrictions.

The discussion continues by Teece (2018) with an inclusion of the extensive amount of data that is being generated by the technology in the networks of companies. Mosig et al. (2021)

demonstrate that there is a notable connection between the technology-related barrier, but with a lack of detail and with a need for further research within the topic, especially of the challenges with data and use of data-driven business models for innovation (Schüritz et al.,2017).

2.3. Data

2.3.1. Definitions of data

2.3.1.1. Big data

When discussing the enormous quantity of data that we are currently dealing with, many people use the term "big data". Big data can refer to several data attributes, including "variety," "velocity," "veracity," "variability," and "value," in addition to the "volume" (Chen & Zhang, 2014). Even if the phrase "big data" has gained popularity, there is evidence that there is a lack of a clear definition of “big data” as it may have several meanings. Big data is frequently stated in terms of data volume (Manyika et al., 2011), although there is growing recognition that this perspective is constrained (Schroeck et al., 2012). As a result, players that have recently started working with data and distributed systems may have quite different understandings of big data than companies with well-established data-driven business models (Demirkan et al., 2015). As a result, we shall only refer to data as opposed to big data.

2.3.1.2. Digital infrastructures

To identify the meaning of data in this paper, a focus is set on explaining digital infrastructures, which is a classification of IT artifacts, presenting a new area of the development of IT and resembles the integration of social aspects (Tilson et al., 2010). Through expansive digitalization, *a sociotechnical process*, the phenomenon of generativity is developing. Generativity refers to the capacity of a self-contained system to build, develop and generate new output. For a digital infrastructure to be generative it needs to be recursive, scalable, flexible and with a variety of characteristics of the data (material) being transported. With this, digital infrastructures transport bits, which is a single universal substance that can take a range of meanings (Tilson et al., 2010). Data plays an important role in digital infrastructures and are the special characteristics missing in physical infrastructures (Kallinikos et al., 2010). With digital infrastructures, business models are changing as separate infrastructures emerge, and with the increased use of digital infrastructures various stakeholders need to collaborate to decide the meaning and context of the exchanged information. This creates a shared understanding of how the bits of data are interpreted and creates an effective way of using the digital infrastructure (Tilson et al., 2010)

2.3.2. Value of data

Businesses are engaged in generating real business value, not only gathering, keeping, and evaluating data and, in a similar vein, Davenport (2006) provides several, primarily empirical, examples of businesses gaining a competitive edge through the use of data and analytics. Furthermore, according to research by McAfee & Brynjolfsson (2012), businesses that use data for making decisions are more often productive and profitable. There is access to several professional papers from consulting firms (Hagen et al., 2013; Manyika et al., 2011) that address the concerns of where and how data provides value. Data may provide value to businesses in two major ways: It can be leveraged to gradually improve and optimize existing company procedures, operations, and offerings, or, the usage of data may be used to create new goods and business strategies (Hartmann et al., 2016). Zolnowski et al. (2016) discuss the incorporation of data into the BM as well, declaring, similar to Hartmann et al. (2016) that businesses may utilize data to pursue a company-focused agenda trying to increase internal efficiency, or they use data to pursue a customer-focused agenda pushing for a greater service orientation by developing innovative value propositions.

As the usage of data in organizations increases, analytics technology will become increasingly important. Analytics may now gather insights, not just about the organization itself, but also about other firms, industries, and even other sectors thanks to the increasing availability of data. Such analysis has the effect of changing company operations, influencing business strategies, and changing BMs, all of which take precedence over more isolated, tactical improvements (Chen et al., 2011).

Chen et al. (2011) found that today's corporate decision-making would need data assembled from numerous sources using analytics to generate insights, as opposed to past isolated business strategic planning, which is based on segmented and limited data sources. Analytics that can process large amounts of different data will be able to have a far bigger effect than segregated tasks. At the highest strategic level, it may assist in making decisions that will drive complete business changes and innovation in BMs, as well as enable changes to business processes (Chen et al., 2011).

Chen et al. (2011) define two perspectives that can be used to analyze the effects of this analytics trend: Analytics built on data will produce keen insight from the viewpoint of each organization, which will result in high value and competitiveness for businesses. From the standpoint of the whole analytics ecosystem, widespread use of analytics technology across a wide range of business processes would promote a healthy analytics atmosphere and assure the ecosystem's long-term sustainability (Chen et al., 2011).

2.3.3. Data-driven business models

Hartmann et al. (2016) continue the discussion and focus on the data-driven business model and its definition, which is a business strategy that uses data as a primary resource. Companies are identifying a range of types of data that can possibly be used as they become more aware of the value of data and its potential in creating new BMs (Sorescu, 2017). Data from these sources differ from *internal* to *external*. Internal data can be *existing data* generated from, e.g., ERP data and *self-generated* data as e.g., web-navigation and sensor data. External data can be described by *acquired data*, e.g., purchased from data providers or *customer-provided* data (Hartmann et al., 2016). Data-driven business model also includes businesses that are *collecting data*, as well as businesses that are engaged in *analytics*. Fayyad et al (1996) are dividing the *offerings* of businesses into *data* and *information/knowledge*, with data sole being the (raw) data without meaning. Information/knowledge is created when data has been interpreted, e.g., the product of any analytical activity. Lastly, the inclusion of the *customer segment* is another part of data-driven business models and includes *B2B* and *B2C* (Morris et al., 2005; Osterwalder, 2004).

Data is also increasingly driving the innovation of the BM process (Demirkan et al., 2015; Hartmann et al., 2016). The relevance of the data-driven business models is growing for both newly established businesses, creating new BMs, and for established businesses modifying features of their current ones (Foss & Saebi, 2017).

There are some examples of how businesses use data to innovate their BMs. E.g., a value proposition can be created by using external data to satisfy customer needs by building BMs that can gather, package, and sell data. Regarding internal data, it can deliver value by gathering customer data and creating customized products (Lokitz, 2015).

In data-driven business models, data has developed to be a resource that is a fundamental part of one, or possibly for all, of the innovation of the business operations (Sorescu, 2017; Schüritz

& Satzger 2016; Hartmann et al., 2016). There are limited academic papers that analyze BMs, but an increase of new service types as data-as-a-service (DaaS) and analytics-as-a-service (AaaS) can be observed (Delen & Demirkan, 2013; Stipic & Bronzin, 2012). Even with the highlight of the significance of data for innovation of BMs, in-depth knowledge of the obstacles to the innovation of data-driven business models still needs to be improved as remarkably little is known regarding the way data impact innovation in BM (Sorescu, 2017; Schüritz et al., 2017).

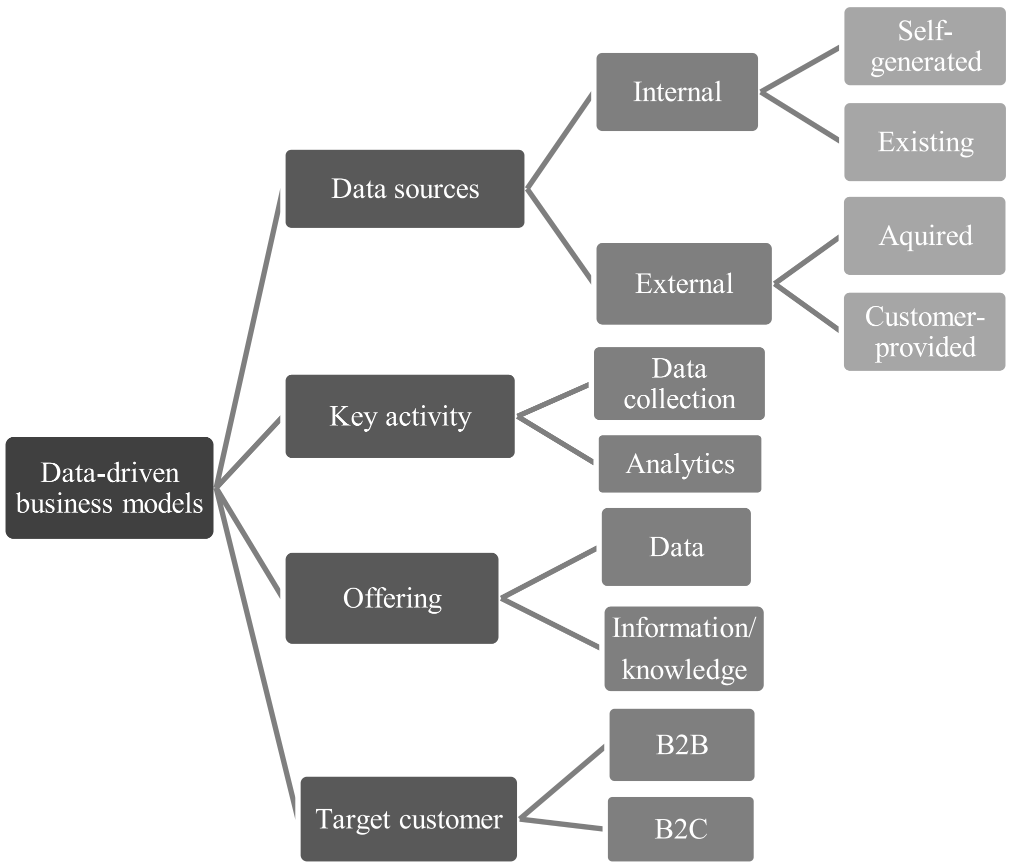

Figure 1. Data-driven business models framework

2.4. The energy sector

2.4.1. Industry overview

The energy sector is undergoing a major transition. There are several aspects to consider: A steady shift away from traditional power plants to alternative power sources as a consequence of the politically intended energy transition. This means switching to energy from sustainable sources, decreasing the economy's carbon footprint, and improving energy efficiency (Siuta-Tokarska et al., 2022). Energy prices have also reached record highs as a result of the recent disruption of the market for energy brought on by the COVID-19 outbreak and the war in Ukraine (Aranda et al., 2023). On the other hand, these circumstances are encouraging innovation regarding construction energy management on both a technical and commercial level. Instead of blocking innovation, the excessive price instability aids in redirecting an otherwise conservative sector (Aranda et al., 2023). The energy sector's transition fosters a competitive marketplace that affects sales. Focusing on automation and upgrading current procedures are unsustainable to serve effective company sectors in the more digitalized future (Amit & Zott, 2012).

2.4.2. Business models in the energy sector

Extended research has been done on how BMs are constructed in energy companies (Burger & Luke, 2017), but there is still a lack of knowledge on how companies can create business value from the data that is generated from energy solutions (Paukstadt & Becker, 2019).

Connected to the discussion regarding the components of BM, Küfeoğlu et al. (2019) examine the BMs in the energy sector and point out the importance of value creation, value capture, value proposition and target customers. Innovation in BM in the energy sector can also be distinguished in the following ideas of peer-to-peer (P2P), electricity trading, virtual power plants (VVPs), flexibility management, local energy market, and the vehicle-to-grid concept (Siuta-Tokarska et al., 2022).

As mentioned, the development of the data has increased further pressure, raising challenges about how businesses provide value to customers and how they may profit from providing new information services for customers. Large volumes of data and information have been made easily accessible to people and businesses (Teece, 2010). According to research, businesses that deal with end consumers on the retail part of the energy value chain are expected to gain the most from the new data-driven opportunities (Shomali & Pinkse, 2016). In addition, the customer market, which is competitive and the final link in the energy value chain, can make it more flexible to innovative approaches (Weiller & Pollitt, 2013).

BMs that are being explored in the energy sector, are a result of the pressure of the development of the digital economy. With the use of digital technologies gives the energy sector the potential to increase efficiency and productivity, as well as decreasing costs. One of the most valuable parts is for energy companies to create added value for the whole energy system (Trzaska et al., 2021).

2.4.3. Use of data

For participants in the energy sector, it is beneficial to acknowledge the market situation with decreasing margins of traditional energy companies, with a need for a strong capability to use data while offering innovative data-driven business models (Duncan, 2010).

Studying the complete value chain, physical tools are being replaced by connected products, starting with energy generation to consumption from the customers. Porter & Heppelmann (2014) discuss the replacement of new devices, such as sensors, software, interfaces and network modules that makes it possible for devices to interact with each other and collect and analyze different data types (Newman, 2018). Data can as well be used in the development of management instruments, intelligent energy transmission networks and to lead complete energy systems (Siuta-Tokarska et al., 2022). By studying electric utility businesses, a digital level is necessary to implement in their infrastructure, and adaptions of BMs need to be made to capitalize on possible investments in smart technology. It is predicted that data analytics and prediction software will be the foundation of the utility sector, but stakeholders in the sector lack expertise and ownership of entire grids. However, this contributes to the possibility for IT businesses to provide services of business intelligence for utility businesses (Frost and Sullivan, 2013).

An expanding perspective is to study the data and information exchange of data between separate parts of the energy system of producers, distributors, and customers (Siemens, 2022). Sharing data across value chains and outside the sector is not as easy and it is currently no easy way of sharing data (Marinakis et al., 2021). One of the reasons is the shortage of energy-customized data ownership and management guidelines, which has stopped data sharing to respect privacy and security (Marinakis et al., 2021).

As a part of the development and to decrease these obstacles, Data-ecosystems (DEs) are being created, which are infrastructures that are data-driven and allow participants to exchange data (Oliveira & Lóscio, 2018). DEs use a variety of mathematical methods to solve issues with interoperability while upholding the independence, security, and privacy of the data (Janev et al., 2021).

2.3.2. Regulations & initiatives

Data ecosystems (DE) can be connected to international strategies concerning data, such as the European Data Strategy (EDS) (EU, 2023), which is essential for the development of technology, data markets and to increase competition and digital jurisdiction. Even if there is a development of common DEs, businesses in the energy sector are still decided by the diversified infrastructure of EU members and the inconsistent regulations in different countries (Siuta-Tokarska et al., 2022). There are EU countries that have well-developed energy systems but far from all, and there is still a lack of development of cross-border trade (Janev et al., 2021) and self-sufficiency of energy (Siuta-Tokarska, et al., 2022). The Dependency Rate on Energy states that an increase in imported energy consumption has been made from 47% in 2019 to 53% in 2022, and to decrease the energy dependency there is a need to improve efficiency to maximize national energy sources and focus on renewable energy (Carfora et al., 2022).

Table 2. EU regulations & initiatives in the energy sector

Regulation/inititive	**Description**
General Data Protection Regulation (GDPR)	Gathering, use and storage of personal data of EU citizens and it applies to businesses and organizations wherever they are located. Businesses and organizations need permission from individuals to collect their personal data and secure, allow access, change and remotion of their personal data (EU, 2016).
The ePrivacy Regulation	Regulates how to use personal data in online forms of electronic communications and businesses need permission to collect data of individuals by offering the alternative of not participating (EU, 2002).
Directive 2019/944/EU	Energy companies need to offer customer access to their collected data on power use to increase transparency. The directive focuses on raising competition, increasing options and protection for customers (EU, 2019).
European Data Governance Act	Part of the EDS which expanding availability and trust in sharing data. It assists to advance common data spaces in the energy sector for both private and public participants (EU, 2022).

3. Methodology

3.1. Research approach

The purpose of the research is to examine how companies in the energy sector innovate their BMs by using data to create value, and what internal and external barriers exist in terms of data, and how these affect the possibility of innovating BMs. To achieve the purpose of the study, an inductive approach was selected by using primary data to analyze and develop patterns that connect to the content in the theoretical discussion (Saunders et al., 2007).

The research is built on an exploratory study based on qualitative data. With this, semi-interviews were a suitable choice (Cooper and Schindler, 2008), as the open approach would give the respondents opportunities to build and explain their answers, which would give a deeper understanding of the topic and support answering the research questions.

3.2. Research strategy

Firstly, a search began to find relevant literature in the areas of BM, BMI, data, the current energy market and European regulations regarding data. For this, EBSCO and Scopus were used to explore the supply of papers and sources within these areas. The search started by exploring and identifying highly citedpapers and authors published in Top Journals in different areas. After picking relevant papers/authors from these areas, the next step was to review the reference lists of the papers to extend the literature overview. With this, the theoretical discussion was created by relevant literature in the area with a balance of highly cited papers/ authors, with more present-to-day papers/authors.

Secondly, an identification was made of the most essential aspects of the theoretical discussion. By using semi-structured interviews, a prepared list of key questions was made with a theme-based structure. On the other hand, this preparation of key questions was not a set structure and depending on the respondent a different order of questions was used. An adaption was made as different questions, themes and contexts were more relevant for some respondents, than for others.

Thirdly, finding relevant companies in the energy sector in the Swedish and Portuguese markets by using Google and LinkedIn. Relevant companies to contact included well-established integrated energy operators, vertically integrated utility companies and multinational power companies. It also included start-ups, focusing on energy service providers and consulting firms. The choice of including different types of companies in the energy sector, from bigger cooperation to start-ups was to get different perspectives and an extended view of the topic. The companies' representatives to contact were based on their current role in the company and these could include CEOs, COOs, sales managers, technical advisors, and digital strategist consultants. Before setting up meetings, information was given out regarding the research questions to the contacted representative, to clarify the area of interest to assure that she or he had the fulfilled knowledge. The meeting was set up by using Microsoft Teams with a maximum time of 1 hour and 30 minutes and recordings and note-taking were made during the interviews.

Fourthly, an analysis was made of the input from the interviews from the recordings and the notes. The input from the company representatives was analyzed and structured based on the analysis approach chosen, described in 3.3, by structuring the notes by defined categories and analyzing the findings.

Lastly, the discussion and conclusion were formed by summarizing and interpret the main findings of the research, by connecting the findings to relevant areas in the theoretical discussion.

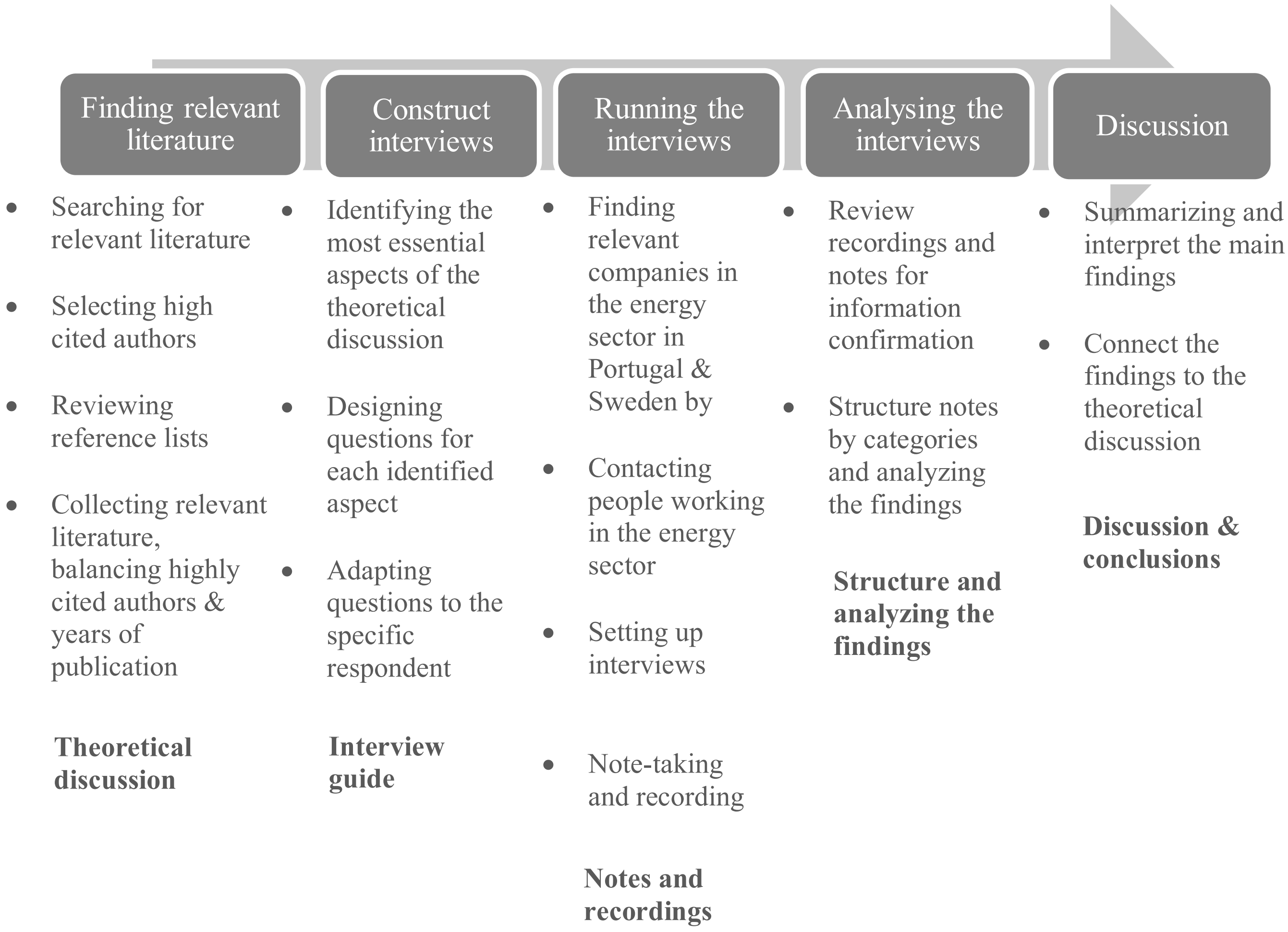

Figure 2. Summary of research strategy

3.3. Data collection

The semi-structured interviews were made from a sample of experts within the energy sector. The selection criteria were based on the respondent's role and knowledge of the innovation process of BMs and the role of data in these. A selection of experts from different countries to was preferable to expand the perspective, so the target sample was experts from Sweden and Portugal.

As mentioned in the previous section, it is also essential to point out that semi-structured interviews create the space for adding new questions depending on the respondent and to explore the research further to achieve the purpose and objectives of the paper. The possibility to adapt and change the structure of the interview gives the opportunity to not only acknowledge the *“what”* and the *“how”,* but also the *“why”*.

The analysis approach was a generic approach. This approach was formed to analyze the qualitative data with a four-step guide. The first step was to recognize categories to comprise the collected data. The first categorization was created based on the research questions, by creating one category for each research question. The second step was to connect the collected data to the suitable category by structuring the notes according to the categories. The third step was to develop the categories further which was done by the creation of sub-categories under respective research questions (Appendix E). Lastly, drawing potential conclusions with the structured findings from the interviews in combination with information from the theoretical discussion.

4. Findings

Table 3. Profiles of respondents

Code	Type	Name[1]	Title/dept.	Company[2]
R1	Services focused with solutions for energy companies	Bernardo Almeida	Techincal Adivsor	SMARTWATT
R2	Renewable Energy Semiconductor Manufacturing	Jonas Derwinger	Director of Sales	LUMA Energy
R3	Multinational power company	Vincent Gliniewicz	Senios Data Scientist & Strategist	Vattenfall
R4	Mulinational electric utility: Heat pumps[3]	Per Rosén	Senior Specialist Energy Systems	E:ON : Qvantum[4]
R5	Integrated energy operator	Carla Tavares	Head of Commercial Innovation Center	GALP
R6	Integrated energy operator	A	Data Strategy & Transformation	X
R7	Integrated energy operator	B	CoE Data Science & Monetization	X
R8	Global integrated utility company	C	Digital Strategy & Transformation Consultant	Y

[1] A, B and C are anonymous.
[2] X and Y are anonymous. X is used two times as it stands for the same company.
[3] E:ON is a multinational electric utility and Qvantum is providing heat pumps.
[4] Answered the questions from the perspective of both E:ON & Qvantum since he has worked at both companies.

4.1. Market conditions

R2 described how there are huge challenges in the energy market today with increased electricity prices and power crises. R4 also declared that there is a challenge in the energy market of a strong attachment to traditional practices. Connected to the traditional practices, R8 stated that, similar digital transformations have previously occurred in other industries, particularly those that are less capital-intensive and that are less infrastructure heavy. R8 continues that in the past, the energy sector operated in a linear manner with large-scale generation assets supplying entire cities and regions by transmission and distribution networks with fixed consumption points, such as households and industries. However, the current trend involves a decentralized proliferation of generation assets in diverse locations, but with the traditional core generation still existing. This transition from unidirectional flows into bidirectional ones can particularly be discovered in Europe.

R5 also highlighted the importance of the global sustainable objectives of decarbonization and carbon emission reduction by 2035, and the goal of net zero emissions by 20250, and how the objectives are pushing for increased innovation in the energy market. R1 highlighted a specific shift occurring in the renewable energy sector. Previously, there was a focus on cross-section development, however, the current shift revolves around comprehensive contracts that outsource various aspects. The goal is to increase revenue by changing the management of contracts by using data, allowing for flexibility by requesting different (SLAs), and renegotiating contracts as needed.

Still, R8 highlighted that operating within a heavily regulated sector presents significant challenges. Even if a current transformation occurs, regulations need to adapt to the ongoing transformation and the emergence of distributed systems with numerous operators. This shift is especially present in Europe, developing into a global trend due to the cost competitiveness of centralized generation. Managing individual agents efficiently becomes crucial to maximizing value for each country´s energy systems, promoting affordability and efficiency. R8 continued to express that those factors such as energy deployment, regional incentives for renewable energy and grid conditions, all influence decisions regarding where to invest a production that has regulatory stability to inject the energy at stable prices.

4.2. Innovation of BM

4.2.1 Customers

R8 stated how the energy sector holds huge potential for value creation through innovation. R2 and R5 highlighted the importance of having a comprehensive understanding of clients to create a competitive advantage. R5 provided an example of how innovation in business models is used to increase the understanding of clients. By going the extra mile and implementing systems that provide valuable insights for clients, the company can gather valuable information. R5 stated that with this knowledge, it is possible to enhance the convenience stores and considering changing the product offerings to fit the customer needs. Knowing the client opens possibilities to increase sales of non-oil products at the petrol stations. By providing other offerings, a market share can be gained from traditional supermarkets by entering a new business domain. R8 also discussed ways in which companies focused on retail can create value for their customers and offer competitive initiatives in renewables. This can for example be to create flexible energy communities with a low minimum number of participants which gives the opportunity to smaller entities to participate. As a part of this, companies can offer retail offerings for customers, including solar panel and heat pump installations, to capture individual energy needs.

4.3. Value of data

R5 stated that data is needed for analyzing and optimizing various aspects, such as cost savings, performance improvement, and implementing new BMs. R8 continued to highlight that data plays an important role in creating efficient operations and maximizing the value from investments. R3 also highlighted the importance of using data in a valuable way to be able to gain a competitive advantage. There is an important aspect of challenging current business models and verifying their applicability in the current market. Data is being used to develop offerings to possess measurement data for increased responsiveness and to create data analysis to estimate past prioritizations to make better decisions in the future.

R6 communicated that an introduction has been made to companies with the objective to create a fresh perspective on data and highlighting its potential. Regardless of whether the data is currently possessed or not, the focus is on leveraging it to create greater value for the company.

R6 continued to describe how the company is in the process of developing into a data-driven company, but R7 highlighted that there is a current struggle. R6 described how implementing data into innovative products still is an area where foundations need to be built. However, R6 confirmed that the focus right now is on laying a groundwork to leverage data effectively and having the capability to truly transform the BMs and introduce new products and initiatives based on the insights gained from the data that is currently being analyzed.

4.3.1. Customers

R1 declared that the innovation process involves learning from client data and leveraging information to develop improved products or functionalities that serve diverse client requirements. R2 also pointed out the significant emphasis on the value of accurate data. Software was developed as part of the offering and active work is currently in motion to integrate all components of the business into a cohesive whole that can deliver enhanced value to customers. The development of the software has been gradual, and initially, there was not a strategic plan in place to capture and utilize the data, which shows a strategy that emerged organically as more knowledge and insights were obtained about the possibilities offered by data.

R8 expressed how data is an important part of the retail market in creating new value-added offers to customers. To stay competitive in the market, retailers try to differentiate their offerings, which require customer data. This can for example be insurance, fixed pricing, mobility solutions and energy efficiency packages. Data helps retailers to understand preferences, the propensity to switch providers, upsell opportunities and create specific profiles for targeted offers.

Even if there are a lot of opportunities for using data to increase the value for customers, R2 expressed that there is still a lack of understanding of the data to fully leverage it to increase the understanding of customers. R4 also stated that as a consequence of traditional practices in the sector, customers expect businesses to follow traditional practices, preferring a cautious approach to progress and innovation, which contributes to slow-moving advancements.

4.3.2. Internal processes

R8 highlighted that nowadays, gathering sensor data to gain insights into the system´s status has become more commonplace and mainstream and as a result, the requirements for data analysis and interpretation are becoming increasingly demanding. R6 described how there are numerous initiatives aimed at optimizing internal processes, which play a crucial role in saving time, resources and reducing errors. R6 and R8 agreed that ongoing work is being done to implement predictive maintenance models and algorithms to identify maintenance needs and bring more value to businesses. R6 continued that while being involved in various aspects of data utilization, the industrial area in the energy sector has exhibited greater maturity in leveraging data, enabling us to further enhance business value.

R8 continued the discussion of the challenge of internal preparedness and investment in building capabilities within the data domain. It is crucial to have a solid integration and consolidation of data across various systems. Managing large volumes of data stored in different systems is inherent to the nature of the business, requiring adaption to effectively harness the value of data. Operational data has always been present, but the cost and complexity associated with its transformation, transportation and processing have traditionally hindered its utilization. However, this landscape has now changed significantly, making it more accessible and usable. Consequently, organizations must establish internal capabilities to effectively capture the value derived from different data areas. Utilities are actively investing in these capabilities to capitalize on the opportunities presented by data.

R8 also referred to another aspect, which is to consider the importance of clear priorities: enabling growth and becoming a top-notch operator of generation assets, as well as developing intelligent grids. The challenges in the grid network, such as congestion and the need for investments, create a focus on intelligent grid solutions. Another important aspect is being a responsible operator, striving to be top-notch in managing the existing installed capacity. This means minimizing operational costs/megawatt and maximizing production efficiency. Strategic decisions are being made about turbine maintenance, placement, interventions, and asset monitoring. Being an asset-heavy industry contributes to being labor-intensive, but technology and data create notable potential to outperform competitors. Therefore, there is a competitive drive among the players in the industry to leverage data ideally and gain a competitive advantage in the market.

4.3.3. Data sharing

R1 stated that they cannot typically share data between customers, but this is a normal practice as businesses work to protect their own interests and maintain a competitive advantage. R1 continued to describe the importance of prioritizing data privacy and how they are not involved in cross-selling data. R5 also highlighted the common use of non-disclosure agreements to protect confidential data shared between projects in the company. However, client data and industry-specific data are never shared with a third party. There are exceptions to this, and that is when a collaboration is created, e.g. with competitors or other partnerships. Also, in consortium projects, data is shared among the members of the consortium for funding motives. It was also highlighted that data sharing is not a current practice, and achieving data confidentiality is a high priority in all projects. R3 also discussed customer data and how it usually stays within in the respective business unit. With different business units in different countries, the potential for sharing data for specific purposes is manageable. However, this process of sharing is not smooth but it remains possible.

R1 gave one example of how to share data and that is if a client is, e.g. operating a single wind turbine in the renewable energy sector, and wants to create performance algorithms. In these cases, it is possible to use data from other clients to develop a more strong model for the specific turbine. There is an important benefit that can be created from sharing data between companies and it is actively motivated to do so. R1 focused the discussion on renewable companies and how they have a clear perspective on how they operate, which is that they are more willing to engage in cross-sharing data and knowledge exchange. Despite being competitors, they understand that each company has different assets and strategies, and therefore there is no direct competition.

4.4. Use of data

4.4.1. Initiatives

4.4.1.1. Technologies

R5 described a project of vehicle-to-grid (V2G), which involves using batteries of electric vehicles to provide grid services. This project entails working with a substantial amount of data, including car, and building consumption, as well as being able to establish effective communication between them. Data can also be used to track how many miles the car has been driven, the optimal charging times and the most effective moments to consume energy from the car. This one-year V2G pilot study was made in collaboration with a potential client who had several electrical vehicles and a high-energy consumption building. What could be seen after the project through a detailed analysis of kWh consumption and miles driven was that the implementation of this V2G technology could result in potential savings of around €50 per car per month for the client. R5 and R6 agreed that innovative concepts such as V2G solutions are increasing in the market. However, the development of these concepts is dependent on system preparedness. F6 explained that V2G is still in its early stage, and many charging stations are not equipped for bidirectional energy flows. Owning charging infrastructure and commercializing the energy, aims to create mutually beneficial collaborations and offers attractive tariffs to customers connected to the grid and charging stations. A strategic position in both infrastructure and energy retail, creates an opportunity to capitalize on various opportunities in the market.

R5 continued with another example of the use of second-life batteries, which refers to batteries that are no longer suitable for electric vehicle (EV), due to the demanding nature of EVs. There is currently a conduction of tests on specific use cases of second-life batteries, however, their value diminishes if they are not able to communicate with associated assets, such as buildings or solar panels. It is therefore crucial for companies to develop battery and energy management systems to enable communication between assets and data plays an important role in managing the system efficiently. There is a need to optimize the system by determining when it should consume energy from the grid and when it should recharge from clients charging their vehicles, or when it should balance the energy flow with the grid. By the use of data, it is possible to realize if these initiatives result in energy savings for customers and if the battery performance meets expectations. Without data, it would be impossible to observe outcomes and make informed decisions about optimizing processes.

R8 also described the opportunities with data within the energy management business and how there is an opportunity for arbitrage, where the objective is to capitalize on the balance of the system and leverage surplus or idle capacity. E.g., in the case of the charging of EVs, the battery can be charged without immediate usage which creates a flexible capacity that can be used when the system demands it, and this opportunity can capture important value for companies.

R5 lays out another initiative of how data is being used in the retail domain to create a platform with basic features for customers, but there is still a lack of loyalty programs and developed customer data tracking. To develop this part, a preparation is being made to launch a pilot project using computer vision in one of the stores. This involves the installation of cameras to track customer movements as well as ensure anonymity. This contributes to real-time data on queue lengths, average number of people queuing and seating occupancy. This development of a data-driven approach opens up new avenues for possibilities and optimization.

4.4.1.2. Empowering the grid

According to R8, there is a significant importance of sensor data of local or hyperlocal data that is crucial for aspects such as investment planning for generation and grids, as well as for adapting to the competitive retail market. Hyper-localized sensor data has transitioned from being a highly operational consideration to now being a critical business consideration. It is a central part of financial operations to optimize returns and profitability when engaging in transactions such as investing, gaining concessions, building, operating, selling, or disposing of wind farms. Being able to leverage sensor data creates the ability to decrease operating costs and maintain wind farms as high-performance assets.

R3 also discussed how data plays a crucial part in decision-making. It can be discovered that the maintenance work has become more data-driven, especially for companies working with electricity networks with extended assets. However, R3 and R4 agreed that as a consequence of the practical constraints in the energy sector, all equipment cannot be continuously monitored. In these cases, physical check-ups are still required with a focus on failure-prone equipment and prioritizing what should be measured. Increased digitalization and sensor data enable quicker updates but will not replace annual check-ups.

R2 gave an example of how collaboration between the company and the Swedish Transmission System Operator (TSO), which oversees the power grids beyond the customers´ electricity meters, can create value by using data. The company can assist the Swedish TSO by ensuring grid quality by helping customers to manage their installations. The customers will benefit as they receive compensation from the Swedish TSO for this service. With this opportunity, extensive and continuous data collection is a crucial component to creating new revenue streams for the company. These potential streams can be integrated into existing businesses or developed as a part of new ventures.

4.4.1.3. Renewables

R8 highlighted that investing in renewables, mainly in the generation and network industry, can create the most value in the current market. Maximizing the use of data and take advantage of intelligent solutions can help to achieve the growth objectives in terms of generation. This includes the usage of data on wind patterns, solar panels, demand projections, raw materials, and project expenses. R3 also focused on the use of data in the development of renewables, focused on the presence of sensitive species, leveraging precise wind forecasts, and increasing the understanding of maintenance. R8 stated that with the use of this data, it is possible to increase growth and follow the objectives focused on expansion, which is a common goal shared by many businesses in the industry.

R5 focused on explaining how the expansion into new renewable ventures takes place. The expansion follows a specific approach which is an independent one that allows these ventures to operate independently, separately from the corporate legacy, which makes it easier for them to establish their own structures, internal systems, and accounting processes. Connected to this is the challenge presented by R3 which explained how larger energy companies are used to handling extensive projects and may struggle with executing smaller-scale projects effectively. R5 continued to explain how this approach is speeding up the growth of innovation as it is made independently. Once the new venture matures, a seamless integration is made by integrating it into the company, by e.g., aligning systems and software. Although this integration process requires time and effort, it is achievable. Taking this independent approach and launching new ventures outside the large corporation, allows for greater freedom and increased independent success.

4.4.2. Implementation

R7 described how there are various teams dedicated to implementing a data strategy to drive a data-driven mindset throughout the organization. Right now, there is a strong focus on implementing the right mindset regarding data in all departments so the use of data can successfully be implemented in the business model. R1 agreed on the importance of a strong focus on the knowledge and expertise of the people and implementing data as a living entity within the organization.

R6 highlighted the aspect of the different knowledge levels regarding data between individuals and departments within the company. Therefore, it is important to bring the transformation into the company to increase the knowledge about data in all departments. A current initiative is to provide employees´ with a program with different steps where it is possible to choose the level that is most suitable for the employee´s role and current knowledge regarding data. R7 pointed out that this addresses the challenge of using data in a big corporation and to increase the common understanding of data. R8 also highlighted how the creation of organic and inorganic growth is a challenge for a globally integrated utility company and how a unified approach is needed across the entire organization to be able to leverage data.

R3 discussed the collaboration between departments and regarding data projects, there is usually a close collaboration between the IT and business departments, but their different objectives and ways of working can create challenges. The business unit is often used for placing orders with the IT department, but a data project requires closer collaboration and interpretation to make data usable and the complexity increases when a data project involves different departments. As a consequence of the lack of a successful collaboration and common objectives, the development becomes slow and circular as the projects demand engagement in the whole organization to be successful. Within the process, R7 confirmed that one of the main priorities is to understand the final user and the desired outcome, whether it is a dashboard, a model, or sales predictions. Challenging the business unit is important to ensure that the vision is aligned, and a common understanding of the final goal and output is fulfilled. Unfortunately, R3 described how traditional companies in the energy sector still have outdated working methods in place. This can be challenging when stakeholders express an interest in a project, which creates an expanding involvement of numerous decision-makers. The challenge with this is to reach a consensus, but the project will fast become time-confusing and with many preferences but without a common objective. These expectations lead to project stagnation, hindered by different needs and without a clear common direction.

R2 also pointed out the importance of exploring continuous data collection and making use of the information across the entire sales, delivery, and after-sales processes. There is a recognition that the internal flow of valuable information between different channels is crucial, and that requires ensured coordination and thoughtful data entry. R3 agreed and explained how the company is actively working to bring everyone together with implemented initiatives as a cloud analytics platform to address technical challenges and streamline data processes and build data products that enable delivery and use of ready-made data.

4.4.4. Challenges

R3 declared the significant importance between data and useful data, and there is a lot of data that is not useful. Firstly, there is a need to find useful data but then also have access to it. The data can be possible to find but the next challenge is the access, as it can be a lack of the key or it may be in a system with closed access, which further reduces its usefulness. R3 also underlined the importance to understand the data. Even if there is access to the data, it can demand knowledge of a very specific conceptual model that may be unintelligible as it was created in an IT system from the past, which may be time-consuming to translate and effectively leverage. R3 and R7 described how companies that rely on sensors and external data need to question the calibration and accuracy of the data. R7 claimed that if there are any uncertainties, basing decisions on such data can be risky. It is a challenge to verify the data without physically visiting the location and observing it first-hand. This challenge becomes stronger for large energy corporations that operate across multiple borders and use extensive systems.

R3 pointed out how important it is to weigh if it is worth making data-driven decisions and to what extent, as it incurs substantial expenses. Data-driven decisions generally improve decisions and operations but it is impossible to measure exactly how much better. Business cases usually lack clarity and one of the challenges is that it is difficult to quantify the degree of improvement achieved. It is often deprioritized as there are so many other things that have measurable benefits.

Another perspective is the restricted use of data, and R3 explained how one type of data may work in one area but not in another as it may be an old system or company. For example, if the company has acquired many companies, it is possible that they have data from many sources that represent the same thing, but are not modeled in the same way, which presents numerous challenges. On the other hand, it all comes down to how much it's worth to go through it all to make a slightly better decision. To make these decisions, it is crucial to understand the complexity, challenges, and value, which ultimately contribute to a cost issue.

R2 expressed a challenge from a more economical perspective, and how there is a hinder of implementing innovative solutions as there is a significant struggle to generate a positive cash flow and deliver tangible results, in a market with high capital cost that creates obstacles. Using data for development requires investments in terms of finances, time, knowledge, and resources and today, investors have decreased their tolerance for startups or initiatives that operate at a loss and raising capital has become a bigger challenge and more costly.

4.5. Regulations

4.5.1. GDPR

R5 and R8 discussed how GDPR creates crucial barriers in terms of anonymizing data and transforming images into metadata. Challenges arise when tracking people inside the stores, where self-checkout solutions and sensor-based systems call for risk mitigation measures to comply with GDPR. These measures may contribute to delays, but the strongest prioritization is to focus on risk avoidance to protect the corporation from potential fines. Another barrier, according to R5, is the location of different servers. A strict collaboration is made with companies that have servers located in the EU to ensure GDPR compliance. Working with non-EU companies or with companies that have servers solely in the US, requires additional risk analysis and risk mitigation measures to live up to the GDPR requirements. Therefore, prioritization is made to mostly work with companies in the EU, or those with servers in the

EU to avoid potential risks. R2 highlighted, in terms of GDPR, that there is an acknowledged awareness that the understanding is limited in the company. However, there is a reliance on the CRM system providers that ensure that the collected data is in terms of regulations.

R7 also discussed how there is a lot of access to data in the industrial part of the company as a consequence of the extended use of IOT systems which gives access to a lot of used cases to take advantage of. For example, from a regulatory perspective, it is common to use safety cameras on renewables to understand potential incidents or to see if the right safety is being used in the field but being able to implement this system is a challenge because of GDPR.

R1 also highlighted the challenge in larger corporations to implement innovation in the BMs considering the barriers of regulations and GDPR on sharing metering data. Big companies try to address this challenge by creating well-defined contracts with partners to share data. Unfortunately, establishing these kinds of contracts to use personal data in potential projects is highly complicated and time-consuming which contributes to difficulties to undertake small experimental projects and to increase innovation.

4.5.2. Grid data

R8 discussed that the impact of regulations on data is important as it determines the data that can be accessible, especially in grid operations. This will have an effect on the decision-making processes of various stakeholders such as investors and real estate developers. For example, if a developer is planning a housing project, it needs to be able to have access to the grid´s congestion levels and be able to develop infrastructure necessities to incorporate charging stations. These decisions include large-scale investments which are influenced by the electricity system which is a critical backbone of developed economies. Important data on electrification, heating, mobility, flexibility, and distributed energy generation (e.g., solar panels) play a significant role in deciding the feasibility and market conditions for competition and market entry. Making sure that comparability and harmonization of data standards are in place, especially at an EU level, is critical for facilitating integration and for businesses to be able to operate effectively.

R3 explained the situation of power grid data in Sweden, and it is stated that it is a critical component of national security infrastructure and therefore there is strictly limited access to it.

The regulations regarding this type of data are usually open for interpretation, leading to a risk-averse approach where a strict interpretation is being made and this contributes to unused valuable data. It can also contribute to different interpretations being made by different companies, contributing to disagreements, and wasted recourses. This creates a clear paradox as informed decisions require relevant data. It can seem to be reasonable to take calculated risks to benefit from the data, but safety measures need to be in place to minimize the risks.

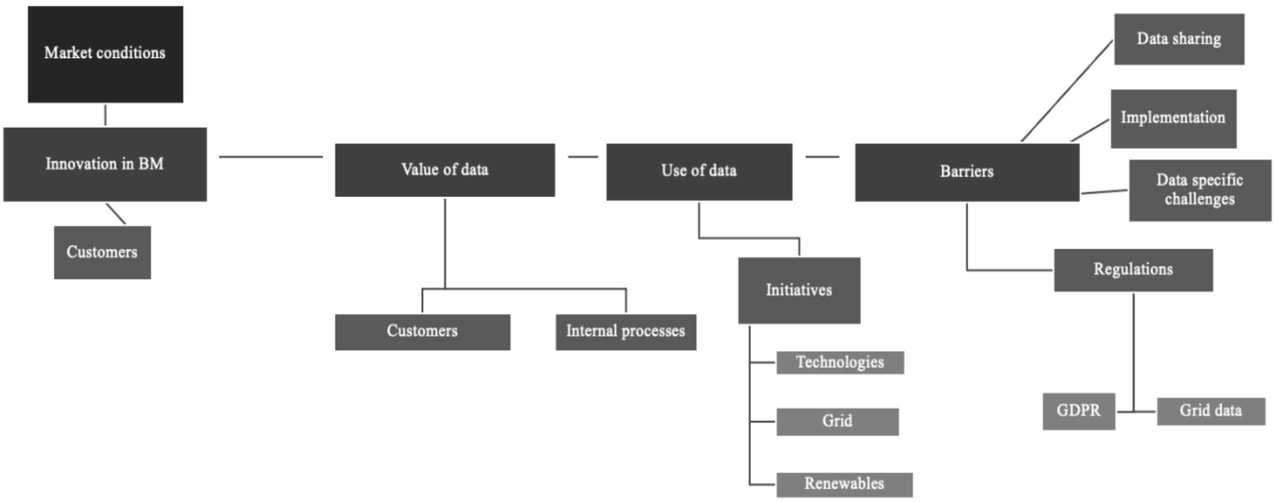

Figure 3. Summary of findings

5. Discussion

The purpose of the research was to examine how companies in the energy sector innovate their BMs by using data to create value, and what internal and external barriers exist in terms of data, and how these affect the possibility of innovating BMs.

Starting by observing the general energy market, it is being confirmed by multiple experts that the current market conditions include increasing energy prices, power crises, and the adaption to renewables presented by Aranda et al. (2023) and Siuta-Tokarska et al. (2022). However, an extended understanding of the market conditions outside the current literature is being presented by experts. This includes a reflection of how a gradual shift is accruing with a transition of flows, the structure of contracts, the practices of risk assumptions and the emergence of distributed systems with numerous operators. This extended view of the market conditions demonstrates an evident transition that showcases the development of a more competitive marketplace (Amit & Zott, 2012). However, from a perspective of innovation development in the market, Aranda et al.´s (2023) state that new circumstances encourage innovation in an otherwise traditional sector, such as the energy sector.

In terms of innovation in BM, experts agree on the potential for value creation through innovation, especially regarding understanding clients to create a competitive advantage. Experts confirm what is being presented in the literature regarding value creation (McGrath & MacMillan, 2000), by presenting the need for implementing new systems to better identify and involve customers. Experts confirm the definitions of value creation, value capturing and value proposition (Teece, 2010; MacGrath & MacMillan, 2000; Hedman & Kalling, 2023) by highlighting the contribution of new customized offerings, gained market shares and the possibility to enter new markets. Additionally, Amit & Zott´s (2001) view on BM is being confirmed by experts as new competitive initiatives are being implemented as a consequence of business possibilities in the market. With this, experts stretch this view by giving a concrete example of the initiative of flexible energy communities, which as well, can be reflected as a way to create value by meeting client demands by focusing on renewables (Zhang et al., 2021; Foss & Saebi, 2017).

By stepping away from the BM perspective and into a value chain perspective, Shomali & Pinkse (2016) and Weiller & Pollitt (2013) draw attention to the retail part by highlighting the flexibility and the innovative-positive approach in the retail market. In contrast to this, experts declare a hesitation of this by highlighting that customers to some degree still want companies to follow more traditional practices, especially in more traditional energy companies.

The discussion continues by evaluating the value of data in the innovation of BMs. Experts confirm Chen et al.´s (2011), Siuta-Tokarska et al.´s (2022), and Frost and Sullivan´s (2013) ideas of the importance of investing in analytical tools and services to drive changes and innovation in BMs, and give examples of the current development of intelligent grids. Experts also highlight how analytical tools and technology create value through the potential to minimize operational costs and maximize production efficiency, confirming the ideas of Trzaska et al. (2021) and Hartmann et al. (2016). However, experts contribute with additional input to the literature by explaining *why* there is an increased need for analytical investments. Experts state that a shift is currently taking place, from previously isolated data systems to a more commonplace approach, and how this contributes to a need for increased capability for companies to use data over various systems.

McAfee & Brynjolfsson (2012) also highlight the fact that technology and data contribute to better decision-making, which experts confirmed. Continuously, experts also provide examples of how businesses can gain a competitive advantage by using data and analytics, confirming the idea by Davenport (2006).

Having access to analytical tools and data, create opportunities for using data to innovate BMs in practice. Siuta-Tokarska et al. (2022) communicated how this can be done by implementing V2G concepts, which experts confirmed as the current initiative. However, experts expanded the perspective of utilization, including V2G concepts, usage of second-life batteries, usage of sensor data, and implementation of computer vision. Continuously, Porter & Heppelmann (2014) discussed the implementation of sensor and network modules to make device interactions possible, which experts confirmed by stating its cruciality for the valuable use of second-life batteries. Nonetheless, even if the increase in technological solutions opens up for innovation, experts point out that the increase of data-governed products in the current market, does not entirely negate the importance of physical needs, especially products connected to grid maintenance.

In terms of the implementation of data-driven-business models, experts declare that a current process is in motion of collecting client data and leveraging the information to develop differentiated offerings with more customized products/services, e.g. energy efficiency packages and customer platforms, which confirm the implementation of components from the data-driven business models framework (Figure 2) inspired by Hartmann et al. (2016). Continuously, experts also confirm the use of sensor data for maintenance efficiency and internal data for optimizing internal processes, as well as the use of external data from power grid collaborations for extending business offerings, which confirms Hartmann et al. (2016).

Even with the increase of data-driven business models, analytical tools, and the opportunities of using data to innovate BMs, a lack of understanding is still acknowledged of data that can be used between different systems and stakeholders. In terms of data sharing, the two perspectives of Chen et al. (2011) were raised and confirmed by experts. However, an additional point was added by experts to the second perspective regarding the cross-sharing of data, which is that data sharing typically takes place within specific collaborations, partnerships, or contracts to prioritize privacy. This extended view of the data-sharing perspective, confirms the lack of knowledge of data ownership (Marinakis et al., 2021). This statement by experts also strengthens the literature in terms of the hindering of value creation created by data sharing, due to the respect for data privacy and security (Marinakis et al., 2021). Developing these findings from experts even further, it can be reflected that there is a lack of development of DEs (Oliveira & Lóscio, 2018; Janev et al., 2021) in the current energy market. However, experts highlighted an extending perspective to the literature regarding data sharing in terms of renewables. Experts stated that companies that primarily work with renewables are more willing to engage in cross-sharing data and knowledge exchange than others.

Even if there is significant potential in using data to innovate BMs, there are additional barriers and potential obstacles that need to be taken into account. In the discussion regarding the implementation of innovative data-driven solutions, experts point out the importance of successfully incorporating data into the *overall* business, and not only in the originally data-focused units, confirming the discussions by Zolnowski et al. (2016) and Hartmann et al. (2016). Additionally, experts add a perspective to the literature on how a strong foundation needs to be built for achieving a successful implementation of data into BMs, especially for companies that seek to implement a completely data-driven BM. Contrary to this, Voelpel et al.´s (2004) highlighted the existing link between the innovation of BMs and disruptive transformation, and not as a gradual transformation as experts concluded. Experts continued on this idea and concluded that a change in BM is a gradual and organic process, dependent on the development of knowledge and insights about the possibilities of data. However, examples from experts regarding the implementation of new data-based initiatives show an additional perspective, which is the importance of an independent approach for launching new ventures in large corporations, to allow faster growth. This idea is, contrary to the previous statement, well connected to Voelpel et al.´s (2004) idea of the need for faster innovation, instead of a gradual transformation.

Continuing with the implementation of data in BMs, Chesbrough (2010) and Chesbrough & Rosenbloom (2002) raise the organizational barriers that can occur during the implementation. These barriers include company culture, behavioral habits, and resistance to change, which is extensively confirmed by experts. Experts extend the perspective of resistance to change and point out how traditional energy companies, to some degree, still work with outdated methods and that a lack of common knowledge of data occurs in various departments. This absence of equal data knowledge among departments, confirms that there is a clear shortage of knowledge on how data in fact impacts organizations (Sorescu, 2017; Schüritz et al., 2017). An additional perspective of implementation, discussed by experts, is from an economical one. It highlights how the pressure of generating positive cashflows hinders the implementation of innovation. Experts mean that even if innovation in BMs is positively associated with increased value and financial performance (Zhang et al.,2021), many companies do not even have the opportunity to implement innovation, especially in start-ups.

Another challenge raised by experts, which lacks literature back-up in the theoretical discussion, is the challenges directly connected to using data. Experts pointed out the challenge of the usefulness of data. The experts continued by developing this challenge by adding the obstacle of accessing the data, understanding the data, trusting the data and lastly, measuring the worth of using data. A part of this perspective is confirmed by Paukstadt & Becker (2019) with the lack of knowledge of value and data, but not to the extent of the discussion by experts.

Lastly, experts highlight another crucial barrier for energy companies that use data in their BMs, which is the regulatory one, especially GDPR. High prioritization of privacy and the fear of fees contribute to a very cautious approach to data sharing with well-established contracts and collaborations. Continuously, experts did not highlight the importance of other regulations, in terms of data and privacy. However, experts highlighted the importance of accessibility of grid data and how regulations can create obstacles and interpretation differences, which is a perspective that is lacking in the theoretical discussion.

6. Conclusion

In conclusion, the aim of this research was to examine how companies in the energy sector innovate their BMs by using data to create value and what internal and external barriers exist in terms of data, and how these affect the possibility of innovating BMs. Market conditions in the energy sector drive for innovation of the companies´ BMs and the research conclude 3 main points: (1) to create value by innovating their BMs, the primary focus is on the customers and to discover solutions that contribute to new products/services offerings, increased market shares and market expansions to create a competitive advantage. Working to achieve these objectives, (2) implementing data in their BMs create potential value in terms of cost savings, performance improvement, operations efficiency and better decision-making, which as well contributes to a potential competitive advantage. The potential value from data can be recognized from both a customer-focused agenda and a company-focused agenda, and the use of data can be observed in current initiatives by companies in the market. However, (3) there are acknowledged to be internal and external barriers to data, such as understandability, accessibility, trustfulness and measurability, as well as limitations in data sharing, implementation and regulations.

From a BM perspective, value creation can be created by understanding the customers, which requires the implementation of new systems and strategies to involve and identify customers to a higher degree. From a data perspective, implementation of data can contribute to achieving various business goals in all the departments, and be a foundation for creating a data-driven business model. From the perspective of using data, it can be recognized in various ways, such as initiatives focused on technologies, grid efficiency and renewables. Considering all these steps, multiple internal and external barriers can be identified that hinders the progress of developing data-driven practices, which calls for highly important actions from diverse stakeholders.

Recommendations for companies operating in the energy sector is to develop a well-defined structure, pointing out *where* and *how* the innovation in the BMs should take place, and what objectives the company wants to achieve in every part of the BMs. With this, creating systems, either internal or external, to collect, analyze and create models by using data, which gives an opportunity to achieve the set objectives. For this to be possible, it is necessary for companies to implement tools that can understand and use data in the most valuable way. It can also be beneficial for companies to develop initiatives for sharing data with each other, to create significant outcomes that would not be possible without collaboration. Another important perspective is to understand the crucial challenge of implementing a data-driven mindset within the company, which requires initiatives such as internal programs, or completely new divisions that mainly work with creating a data-driven approach within the company. Developing internal initiatives and developing new units focused merely on the regulatory part, is also crucial for increasing the potential use of data.

The research contributes to an extended understanding of how companies in the energy sector can create value by implementing and increasing the use of data within the entire company. It also highlights the various barriers to implementing and using data in companies´ BMs and gives an extended view of the obstacles faced by companies in the energy sector in terms of data usage. These findings are a potential foundation for future research to further explore different data-driven business models more deeply by applying and comparing different models and components to the current operations of energy companies, as well as study specific obstacles for each company type and create a comparison between those.

7. Limitations

Due to time limitations and a lack of responses, the interviews were limited to 8 respondents, which affect the accuracy of the findings. A larger amount of respondents would have contributed to a more reliable picture of the research. Still, the amount of knowledge, experience and input from each respondent contributed to a remarkable amount of valuable findings.

In addition, the interviews were constrained by experts from two different countries, Sweden and Portugal, with a larger sample of companies established in Portugal. This contributes to a limited application of the findings to the rest of Europe, and even countries outside. However, the regulations and market conditions in Europe are similar as a part of globalization and the EU.

Additionally, as the interviews were limited to only company representatives, although a various amount of company types, an interesting perspective would be to include customers to expand the understanding of the research, as their view on, e.g., current demand, value and data privacy may differ.

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Appendices

Appendix A: Extended profiles of respondents

Code	Type	Name[5]	Title/dept.	Company[6]	Interviw duration[7]	Location
R1	Services focused with solutions for energy companies	Bernardo Almeida	Techincal Adivsor	SMARTWATT	Forty-nine minutes	Portugal
R2	Renewable Energy Semiconductor Manufacturing	Jonas Derwinger	Director of Sales	LUMA Energy	Thirty-eight minutes	Sweden
R3	Multinational power company	Vincent Gliniewicz	Senios Data Scientist & Strategist	Vattenfall	Fifty-three minutes	Sweden
R4	Mulinational electric utility: Heat pumps[8]	Per Rosén	Senior Specialist Energy Systems	E:ON : Qvantum[9]	Eighty-three minutes	Sweden
R5	Integrated energy operator	Carla Tavares	Head of Commercial Innovation Center	GALP	Forty-seven minutes	Portugal
R6	Integrated energy operator	A	Data Strategy & Transformation	X	Forty-five minutes	Portugal
R7	Integrated energy operator	B	CoE Data Science & Monetization	X	Forty-eight minutes	Portugal
R8	Global integrated utility company	C	Digital Strategy & Transformation Consultant	Y	Forty-one minutes	Portugal

[5] A, B and C are anonymous.
[6] X and Y are anonymous. X is used two times as it stands for the same company.
[7] Rounded up to the closest number.
[8] E:ON is a multinational electric utility and Qvantum is providing heat pumps.
[9] Answered the questions from the perspective of both E:ON & Qvantum since he has worked at both companies.

Appendix B: Interview request on LinkedIn[10]

Dear X, I'm a student at Católica Lisbon School of Business & Economics, currently writing my Master's Thesis. I'm contacting people to interview regarding my topic of how companies can innovate their business models in the energy sector with the use of data. I´m happy to give you more info!

Appendix C: Follow-up interview request[11]

Thank you for your fast reply.

My name is Fanny and I´m a second-year student in the Master´s program in International Management at Católica Lisbon School of Business & Economics. I am currently writing my Master's thesis and I am very excited to interview you as a part of my thesis, as I am convinced that X is able to give valuable input on the subject matter.

Here is a short introduction to my topic:

The phenomenon of digital transformation brought new opportunities to all firms in the energy sector. The appearance of new digital products and services, new digital procedures, decisions across organizations, and the amount of data gathered are just some of the changes that firms need to be aware of. Therefore, organizations and managers need to be responsive to those changes and adapt the current business models to remain competitive in the markets. However, firms also need to deal with different regulations across countries due to the amount of generated data. Therefore, my thesis aims to answer the following:

- How is the energy sector creating value by innovating its business model?
- What potential value does data have in the energy sector?
- How does the energy sector use data in innovating its business model?
- What are the potential internal and external barriers to innovating business models in the energy sector?

[10] Maximum number of characters was 300.
[11] Used for both LinkedIn and email.

It is also valuable for my research to know the general challenges regarding innovation and data for companies in the energy sector.

The interview is slated to run for around 40-60 minutes on a suitable day and time.
Thank you so much for your kind consideration. I´m here to answer any further questions!

Kind regards, Fanny Nyström

Appendix D: Interview guide[12]

General innovation in business models:

- How do you see that the energy sector has changed in recent years regarding innovating its business models?
- What kind of innovation does X have in its business models in the energy sector? E.g., peer-to-peer (P2P), electricity trading, virtual power plants (VVPs), flexibility management, local energy market, and the vehicle-to-grid concept.
- In what ways does the innovation of business models create value for you and your stakeholders?

Using data in business models:

- Has X used data as a part of innovating its business model in recent years, if yes, can you explain how it contributes to innovation in the business model?
- What value would you say that data have for you and X business models?
- Would you say that you have in a way totally reinvented the business model or if you gradually have implemented small changes, in the perspective of using data?
- Are you using data for a company-centric agenda or customer-centric agenda, or both, and how does this create value for customers/your company?
- What is you are perspective on using data as a part of competitive advantage in the future market and what do you think X or energy companies, in general, will use data to be competitive in the market?

[12] Not all questions were used in all interviews. The selection of questions was adapted to the respondent´s role and background, as well as the flow of the interview.

Data and analytics:

- Is data a primary resource in your business model?
- Which kind of data are you using in your business model?
- Do you experience it being a challenge to collect and produce high-quality data? Is it a challenge to collect and analyze data in a complete and consistent way?
- Is there a challenge in combining different data sets to receive new information?
- How does the analysis of data create new information that is helpful for your business model?
- It seems having access to data is one thing, but actually making use of it and creating value of data is something else. What is your experience and view on that?
- Are the collection and analysis of data done internally or externally, or both?

Barriers:

- Do you see any barriers to using data in the business model? These can be internal barriers (company culture, internal regulations), general technological barriers, and external regulatory barriers.
- How is the development going in using data in bigger ecosystems? Data and analytics may now gather insights, not just about the organization itself, but also about other firms or industries.

Appendix E: Categorization of analysis approach

How is the energy sector creating value by innovating its business model?

Sub-categories	Summary of findings
4.1 Market conditions	• Electricity prices • Power crises • Traditional practices • Unidirectional to bidirectional flows • Sustainability objectives • Outsourcing • Flexible contracts • Individual agents • Regional initiatives • Energy deployment • Grid conditions
4.2 Innovation in BM	
4.2.1 Customers	• Competitive advantage • Adaption of product offerings • Increase sales • Increase market share • Expanding markets • Initiatives in renewables

What potential value does data have in the energy sector?

Sub-categories	Summary of findings	Additional findings
4.3. Value of data	• Cost savings • Performance improvement • Innovation in BM • Operations efficiency • Competitive advantage • Better decision-making	**Risk Awareness** R1 → • Increased value of data allows companies to assume some risks and reduce commissions. • Strong risk awareness, especially in operational aspects, is important. • Deeper understanding of data gives organizations confidence in taking calculated risks. • Willingness to take risks often leads to increased revenue. • Although potential losses are acknowledged, understanding the underlying reasons behind them provides an advantage.
4.3.1. Customers	• Improved products • Crucial in retail-markets • Limited customer market utilization • Traditional practices hinder progress	
4.3.2. Internal processes	• Higher requirements for data analysis • Demanding interpretation • Optimization • Data management • Increased accessibility and usability • Enabling growth • Top-notch operator	**Enhancing well-being** R6 → • The focus is on prioritizing the well-being of people as a pillar of value. • Increasing engagement in initiatives beyond monetary value is seen as valuable. • Identifying necessary changes to contractors and investing in safety performance. • Improved safety performance leads to improved Key Performance Indicators (KPIs).

How does the energy sector use data in innovating its business model?

Sub-categories	Summary of findings	Additional findings
4.4. Use of data		**Selection of data** R1 → • Accessing a large amount of data is not necessary for crucial outcomes. • Understanding the background and potential applications of variables is more important than collecting excessive data. • Typically, around 5 variables account for 80% of the client's objective. • Exploring the additional 20% of the dataset requires additional effort. • There are options to achieve similar outcomes with fewer variables. • Some clients still invest in extensive data due to the belief that even a 1% improvement can be crucial. • Focusing on a few variables makes clients to make progress in their data-driven business innovation. • Dedicating resources for marginal improvements may not be justified considering the costs. • Many clients prioritize using and analysing all available data, but the financial burden becomes apparent later.
4.4.1 Initiatives		
4.4.1.1. Technologies	• V2G • Second life batteries • Energy management systems • Computer vision	
4.4.1.2. Empowering the grid	• Sensor data • Local & hyperlocal data • Optimize returns & profitability • Check-ups • TSO	
4.4.1.3. Renewables	• Intelligent solutions • Wind patterns, solar panels, demand projections, raw materials & project expenses • Increase growth • Operate independently	

What are the potential internal and external barriers for innovating business models in the energy sector?

Sub-categories	Summary of finding	Additional findings
4.3.3. Data sharing	• Typically no sharing and cross-selling • Non-disclosure agreements • Collaboration and partnerships • Consortium projects • Prioritizationdata of privacy • Develop strong models • Ecosystem	
4.4.2. Implementation	• Drive a data-driven mindset • Living entity • Program initiatives • Data projects • Cloud analytics platform • Common objectives • Final users and desired outcomes • Reach consensus • Project stagnation	
4.4.3. Challenges	• Usefulness • Accessibility • Understandability • Truthfulness • Measurability • Restrictiveness • Economical market conditions	
4.5. Regulations		
4.5.1. GDPR	• Anonymization • Risk mitigation measures • Potenital fines • Localization of servers • Well-defined contracts • Hinder creation of small experimental projects	
4.5.2. Grid data	• Accessibility • Decision-making • Feasibility and market conditions • Comparability and harmonization • Risk-averse approach • Different interpretations • Safety measures	
		Developong projects R1→ • Emphasizes the existence of regulatory barriers beyond data handling and GDPR. • Regulatory barriers affect the development of projects in the energy sector, such as offshore wind farms. • These barriers pose challenges and hinder project progress. • Companies in the sector face complexities due to diverse revenue streams and government contracts. • Decision-making and partnerships can be limited as a result. • Projects may need to be altered or abandoned to comply with regulations. • Companies must navigate these complexities to find solutions aligned with regulations and business goals. **EU taxonomy** R2 → • There is the impact of the EU Taxonomy on companies in the sector. • Customers expect companies to improve reporting and accounting practices. • The increased demand for extensive data creates both barriers and opportunities. • It can be seen as a barrier due to the challenges of collecting and structuring data. • However, it also presents an opportunity for companies to expand their offerings in the market.