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Business Model Innovation for Digitalization in the Swedish District Heating Sector †

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† This is an extension of the conference paper Beyond utility 2.0: A search for relevance in tomorrow's energy system. *Asia Pac. J. Adv. Bus. Soc. Stud.* **2016**, 2, 117–128.

Abstract: Despite decades of research and development, digitalization remains a key challenge for the Swedish district heating sector. Business model innovation is believed to be necessary to capitalize on digitalization, yet it is especially challenging for municipal companies. This study aims to identify the potential impact of digitalization on the business models of Swedish district heating companies and to analyze the barriers that exist for digital business model innovation. Through case studies of eight municipal district heating companies, this study demonstrates how the entire business model is potentially impacted by digitalization. This study also identifies the barriers to digital business model innovation that are linked to two conflicting views (restrictive versus comprehensive) on digitalization. The restrictive view diminishes the importance of business model innovation, outsourcing innovation to minimize both costs and risks for the company. In contrast, the comprehensive view embraces digital business model innovation through trial-and-error and opens the innovation process to stakeholder influence. These two perspectives are motivated by different beliefs about the need for digitalization to secure future business opportunities, as well as differences in owners' risk appetite. The implications for industry outlooks and the design of policy support for the digitalization of district heating are discussed.

Keywords: district heating; business model innovation; digitalization

Citation: Williamsson, J. Business Model Innovation for Digitalization in the Swedish District Heating Sector. *Energies* **2023**, *16*, 7457. https://doi.org/10.3390/en16217457

Academic Editor: Antonio Rosato

Received: 27 July 2023
Revised: 30 October 2023
Accepted: 2 November 2023
Published: 6 November 2023

1. Introduction

District heating (DH) constitutes a centralized production and distribution system for heating; in 2014, this system provided 55% of the total heat delivered in Sweden [1]. DH can be a source of renewable energy because it enables the utilization of energy and resources that would otherwise be wasted [2]. Cogeneration of heat and electricity also allows for a high degree of efficiency. In 2020, Swedish DH companies generated 5.1 TWh of electricity, or the equivalent to 3.8% of the national output that year [3]. The versatility and efficiency of DH may help reduce emissions of greenhouse gases and can thus play a key role in the transition to a future sustainable energy sector [4–6]. While cogeneration increases the flexibility of the energy system, heating constitutes the central part of the product portfolio of Swedish DH utilities. Since the deregulation of the energy sector in 1996, Swedish local heating markets have continuously been under pressure from substitutes such as individual heat pumps [1]. Despite an initial wave of privatization, more than 64% of existing networks are municipally owned, meaning that Swedish DH is a largely municipal concern [7]. During the 2010s, DH faced the challenge of falling demand caused by an increasing interest in energy efficiency and national policies that supported alternative heating sources to some extent [8,9]. Additionally, the introduction of disruptive innovations that use information and communication technology (ICT) combined with the Internet of Things (IoT) provided heating solutions tailored to customers' needs [10].

However, digitalization also offers business opportunities for DH companies [11]. The application of ICT and the IoT is thought to be key to the future of DH, and it is thus

important to innovate and adopt business models to allow DH companies to capitalize on digitalization [6,12]. The challenge of digitalization is shared with DH companies in neighboring Nordic countries, such as Finland [13], and digitalization is expected to contribute to the transition to fourth-generation DH systems in Denmark [14]. Furthermore, business model innovation (BMI) has been linked to the ability of complex socio-technical systems, such as DH, to support the transition to sustainable energy systems in the U.K. [15] and Austria [16]. BMI is therefore a strategically important activity [17] in which municipal DH companies need to engage. Furthermore, technological development has led to the potential for DH companies to engage with digital business model innovation (DBMI). BMI is challenging for established companies [18] and, given a bureaucratic legacy as well as a monopolistic market position [8,19], the challenge of BMI is arguably even greater for municipal corporations. Barriers have been linked to resource-dependent or cognitive aspects of BMI [18]. Key to the latter type of barriers is the difficulty of identifying the proper business model for a specific context [18,20]. In addition, it has been suggested that strategic misalignment among collaborating parties may hurt BMI [21]. BMI can be both market-driven and market-driving [17], meaning that business decisions are shaped by managerial views on how the market is today and by views on how it should be in the future. In the Swedish DH sector, BMI linked to the use of ICT and IoT was found to be associated with two opposing perspectives: a 'wait-and-see' view and a more comprehensive transformative strategic approach [22]. Considering the slow rollout of digital technology [6,12], managers in the Swedish municipal DH sector appear to struggle with identifying and implementing business models that enable them to utilize new and possibly little-known digital innovations. Hence, this study aims to identify the potential impact of digitalization on business models of Swedish DH companies and to analyze the barriers that exist for the two perspectives on DBMI. This study identifies factors that influence BMI conducted in municipal energy utilities. Furthermore, this study informs readers about the ways in which managers address challenges associated with BMI that are specific to digital innovations in DH.

The paper is structured as follows: Section 2 presents research on BMI, digitalization, and Swedish DH. Section 3 explains the case study method and data collection. Section 4 presents the expected impact of digitalization on business models for DH in addition to the challenges associated with developing digitalized business models. Section 5 discusses the implications of the results in relation to DBMI and policy. Section 6 concludes the paper.

2. Previous Research

2.1. Business Model Innovation and Digitalization

The business model concept is used to explain the essential logic behind the production and delivery of customer value [17]. It has been shown that innovations that do not fit with the existing business model are more difficult to adopt [23]. As the business model allows the company to benefit from modern technology, there is pressure to develop or refine existing business models to exploit changes in customer demand [24] or to create and develop markets through market-driving [25]. Hence, BMI has become central to the commercialization of technological innovations [26]. In addition to the resource-based barriers identified, obstacles to BMI, such as cognition [18] and communication [21], can also be located in different areas in relation to the company. Obstacles are believed to exist at the micro, company, and macro levels [27]. At the micro level, obstacles may appear due to a shortage of resources or issues, such as negative outlooks on technological change among individual managers or staff. In the Swedish district heating sector, this has been shown to manifest in managerial sensemaking about the success and failure of BMI [28]. Obstacles may also be embedded at the company level through a conservative corporate culture or poor organizational design [27], for example. At the macro level, obstacles such as regulation and institutional pressure can be encountered throughout the business context [27].

Digitalization in the energy sector comes in many forms [29] and offers both opportunities and challenges for BMI. The domains of ICT and IoT are key to digitalization. The latter domain represents a group of technological solutions that enable efficient remote management of resources and processes [29] and therefore accommodate new business models for both the business-to-consumer [30,31] and business-to-business [32] segments. Digitalization has been identified as a driver of efficiency in addition to sustainability in the energy sector [33,34]. As such, digitalization is expected to have far-reaching impacts on the design of value offerings and value creation [6,12]. DBMI is thus complex and important enough to be considered a research field in itself [35,36]. Businesses capitalizing on the transformation from an analogue to a digital way of conducting business is central to the creation of digitalized business models. The transformation enables solutions that would have been difficult and costly to implement in an analogue context [36]. Consequently, DBMI will have a comparatively greater impact on companies that rely on analogue operations that are possible to digitalize.

2.2. Swedish District Heating and Digitalization

District heating constitutes local natural monopolies that rely on economies of scale to compete with substitutes [1,2]. Due to the considerable infrastructure investments necessary for converting and transporting energy efficiently, DH is a locally integrated socio-technical system that is supported by multiple stakeholder groups of various levels of political and financial importance [2,37]. DH has held a strong grip on the Swedish heating market [38,39]. A key contributing factor to the dominance of DH is the tradition among municipalities to own both the local DH company and manage a considerable amount of real estate [1]. Furthermore, since alternative heating solutions run on electricity and require considerable investments, they tend to be financially unattractive compared to DH unless electricity is cheap or a connection to the DH system is costly [1]. Digitalization of DH utilizes technology and software to create products and associated services that are expected to add customer value and raise willingness to pay a price premium [6]. Yet, end users, such as tenants, rarely have influence over their heating services. In such cases, DBMI would target property owners or property developers with services that improve energy efficiency and reduce heating costs [40,41]. DBMI oriented toward end-users would focus on segments where consumers are the decision makers, such as single-family dwellings, despite such customers consuming comparatively little heat and requiring resources for customer services. Substitutes, such as heat pumps, have become key competitors [1] and offer adaptable customer-oriented solutions. Digitalization needs to enable DH companies to offer a similar value proposition at a competitive price point. A complicating factor is that DH companies have been less adept at handling small customers due to technological reasons [8,9]. Concentrating on larger customers, such as property owners with considerable need for heating, DH companies have a system-oriented business model that focuses on scale in the management of production and distribution [1,2]. Substitutes, such as heat pumps, have instead developed a customer-focused business model with an individualized heating solution. Digitalized DH thus represents an opportunity for DH companies to develop a customer focus [6,40]. However, since DH is based on an interconnected technological system of different waste heat sources, boilers, pipes, storage units, and even buildings [1,42,43], the move toward a customer focus represents a significant challenge. Furthermore, it has been noted that opposing views exist among DH managers engaged with IoT and ICT about the implications of such technologies for BMI [22].

3. Materials and Methods

This study was conducted during the first half of 2015 as a series of eight case studies of business model innovation for digitalization in municipal DH companies. Part of the data gathered during that project was presented in a previous publication focusing on the BMI of the case study companies [22]. This paper highlights the expected impacts of

digitalization on the business models of the case study companies and extends previous work associated with BMI by providing new theoretically anchored analysis. This paper also contains project results not included in the previous publication.

A case study approach [44] was chosen since it enables the researcher to capture the complexities associated with social processes, such as business model innovation for digitalization. The case study companies were identified with the help of representatives from the Swedish DH industry organization. The specific case study companies were chosen because they had or were developing digital services and thus had experience with BMI for digitalized DH. The case study companies had annual turnovers ranging from EUR 50 million to several hundred million in the years preceding this study. Since both business model innovation and digitalization can constitute sensitive information, the respondents were offered anonymity.

Case studies enable the use of multiple methods for data collection [45]. For this study, interviews were conducted alongside the gathering and analysis of secondary data produced by the case study companies. By examining secondary sources, such as annual reports, corporate websites, and marketing materials covering digital services, it was possible to establish a comprehensive understanding of each company and their work with digitalization. Furthermore, the understanding of the company context was used to develop organization-specific interview questionnaires. In addition to the interviews and the gathering of secondary data, meetings were held to bring together two consultants working with digitalization and the companies. The purpose of the meetings was to verify information and discuss results from the case studies.

Interviews were conducted with eleven respondents from each of the case study companies. The respondents had experience of working with IT and IoT-related product development, targeting consumers and business customers. An interview guide [46] was designed for each interview based on the specific characteristics of the case study company in question. The interviews were between one and two hours in length. Every interview was recorded. The recorded interviews were transcribed and analyzed. The meetings with the consultants were not recorded, but the researcher kept detailed notes about the conversations instead. The analysis of the impacts of digitalization on the business models and BMI took the form of a thematic analysis [47], which was operationalized using the business model canvas (BMC) [48].

4. Results

4.1. Impact of Digitalization on District Heating Business Models

The impacts of digitalization on business models were identified and categorized using the BMC and are presented in Table 1.

As is evident in the table, digitalization affects all parts of the BMC. Digitalization requires that DH companies work with new types of partners to develop and implement hardware and software. Digitalization also increases the amount and quality of data generated in production and use of heating services. This enables the establishment of tighter links between the different parts of the DH network. Pricing models that communicate incentives between those that generate and consume heating are key to such interconnectedness. Similarly, digitalization can be used to improve the speed, quality, and quantity of customer communication. DH companies may thus segment their customers in new ways and generate new types of value, specifically targeting customers interested in aspects such as control, efficiency, and sustainability. Additionally, early adopters, a group not associated with DH, were thought to be a viable customer segment. New value propositions would rely on a computerized substation that is adaptable to various DH systems and buildings, owned by either customers or utilities, and capable of sending high-frequency, high-quality data to the DH operator. It would also be necessary to give multi-user access to the substation, ensuring individual autonomy within system limits while having a master algorithm overseeing everything. The substation would also be used to establish partnerships with other service providers, necessitating direct collaborations

with software developers and Internet-based service companies. Digitalization thus requires many new assets and resources, which gives rise to additional costs and becomes a driver of organizational modernization. Yet, digitalization also opens up new strategic opportunities and associated revenue streams.

Table 1. Impacts of digitalization on DH business models.

Areas	Building Block	Effects
Infrastructure	Key partners	Distribution of procurement, operation, and maintenance of facilities and peripheral equipment among partners.
	Key activities	Portfolio approach where services are visualized, evaluated, and linked to effects on production and use. Market segmentation of customers. Continuous updating of contracts. Designing and maintaining a digital platform and facilitating third-party services.
	Key resources	Control systems linked to a computerized customer substation, IT systems that analyze and act on data, updated pricing models.
Offering	Value proposition	Integrated individualized climate solution. Customer-differentiated value proposition. Customizability, the option to make choices both before and after selecting a product or service. Increased transparency in all steps in the value chain. Energy efficiency, platform services, openness to third-party agreements.
Customers	Customer relationships	Moving from communicating through billing processes, email, and printed materials to continuous two-way information exchange and digital control of the customer's computerized subunit.
	Channels	Webpages, applications, customer services, service technicians, computerized subunit.
	Customer segments	Customer is attracted by comfort, transparency, control, sustainability, and technology.
Finances	Cost structure	Procuring, operating, and maintaining facilities and peripheral equipment. Research and development targeting new services. Marketing for demand development. Staff training. Updating contracts and contractual forms, existing control systems, existing IT systems, and pricing models. Impacts on production and administration (savings): • Improved capacity for load management (indirect and direct); • Remote fault reading for troubleshooting; • Efficient billing and administration.
	Revenue streams	Selling and leasing facilities and peripheral equipment. Operation and maintenance contracts.Ability to increase revenues through detailed market segmentation. Selling additional services: • Energy efficiency improvement; • Customized comfort agreements; • Third-party services to customers; • Platform services to entities other than customers.

4.2. Strategic Implications of Digitalization

Digitalization aims to measure, control, and visualize DH systems while transforming the DH company into a hub for energy-related information flows. On a micro level, the individual consumer living in a single family or small multi-dwelling unit would have a user experience similar to that provided by more digitally mature substitutes. The consumer would have better control over their usage of heating and have an improved understanding of the environmental footprint that their heating generates. On a meso level, a property owner controlling one or multiple buildings would be able to better understand how the heating is distributed, which would help identify where to make cost-efficient energy savings and could utilize the data generated for the environmental footprint in sustainability reporting. At the macro level, the utility company and the municipality would more easily understand aggregated energy use and could increase efficiency in the production and distribution system. This knowledge could be utilized to improve the environmental performance of the energy system in its totality, especially by examining how heating interacts with the electricity system. The idea of an integrated energy system balanced by a central actor with respect to efficiency and utility was, however, challenged by an ideal of prosumerism and energy independence.

Due to the need to incorporate the view of the customer, digitalization challenges the way that DH historically operated. For example, DH utilities previously had a modest

customer service unit and the industry unironically referred to customers as 'heat sinks': a nickname derived from the need to achieve a low return temperature from the customer's central heating. Technical staff working with customers also had little training with regards to customer interaction. To capitalize on digitalization, participants recognized that utilities would have to change how the staff worked when interacting with customers. Additionally, to capitalize on the new types of data gathered, it would also be necessary to make internal changes to enable value creation through new uses of information.

4.3. Barriers to DBMI

An analytical framework for barriers to DBMI was developed using categories based on the division between resources, cognition, and communication [18,21] and the location (micro, company, and macro) of barriers [27]. The development of DBMI in Swedish DH is characterized by two general yet opposing views on digitalization [22]. Based on their characteristics, the views can be labeled as restrictive and comprehensive. According to the restrictive view, digitalized services are developed and offered separately from the existing portfolio of services that the DH companies provides. Introducing a standalone digital service was expected to be costly and likely to necessitate a price hike, making it less appealing to customers. The lack of mandate from owners to innovate was the key reason these managers did not relate digitalization to other business opportunities. The focus was instead on short-term results and avoiding unnecessary risks. These managers were reluctant to alter their existing business models to make room for digitalization. Instead, they anticipated that if digitalization proved valuable, others would adopt and refine the technology. This way, risk-averse companies could later implement digitalization with minimal changes when the technology matured and costs dropped. In Table 2, the barriers to DBMI associated with the restrictive view are compiled.

Table 2. Barriers associated with the restrictive view.

Barriers	Resource	Cognitive	Communicative
Micro	Lack of IT-related expertise.	Short-termism	Lack of convincing vision of digitalization and DBMI.
Company	Prohibitive costs	High risk-aversion. Poor connection to existing product portfolio.	Poor communication with owners. Difficulty of communicating customer value to production unit.
Macro	Lack of supportive policies.	Uncertainty about future industry and technology trends.	Poor communication with suppliers.

The barriers to DBMI linked to the restrictive view portray individuals, organizations, and a context that are starved of resources, focus on short-term performance, and lack a clear vision of digitalization around which stakeholders can gather. These barriers prevent the organizations from initiating the development of a digitalized business model for DH.

The comprehensive view implies that digitalization is expected to impact all aspects of the company's business model while creating considerable customer and owner value. Designing and implementing a digital business model are seen as complex tasks that require a trial-and-error approach. Owners need to tolerate the risks tied to digital investments, accept potential losses, and co-create the business model with other actors. If owners resist DBMI, profitability is expected to decrease over time. Table 3 contains the barriers associated with the comprehensive view.

The barriers linked to the comprehensive view are associated with later-stage development and implementation of a digitalized business model for DH. The barriers indicate areas where the organizations need to put in more effort to bring internal and external stakeholder onboard and fully realize the benefits of digitalization.

Table 3. Barriers associated with the comprehensive view.

Barriers	Resource	Cognitive	Communicative
Micro	Lack of DBMI-related expertise.	Difficulty of estimating the extent of impact from digitalization.	Digitalization clashes with historical production-focused business logic.
Company	Organizational structure not supporting digitalization.	Time-consuming to build knowledge and organizational capital linked to digitalization.	Difficulty of identifying and communicating with potential customers.
Macro	Lack of industry-wide standards.	Difficulty finding likeminded decision-makers in other DH firms.	Difficulty of finding innovative suppliers that push the company forward.

5. Discussion

The BMC-based analysis shows that digitalization has the potential to impact all parts of the business model. While considerable value is expected to be generated through digitalization, it will also require considerable investment in hardware, software, and staff training. Digitalization will impact customer relationships and require the DH firm to establish collaborative agreements with new partners and open the business model to third parties. The strategic implications of these changes are evaluated differently based on which view on digitalization that the decision-maker is leaning toward. The views on digitalization are associated with different types of barriers to DBMI. The restrictive view is linked to barriers that prevent the initiation of work with a digitalized business model for DH, while the comprehensive view is instead associated with barriers to later-stage development of DBMI. The comprehensive view stresses the interconnectedness between BMI and business strategy [17] and is aligned with the idea that digitalization will have considerable impact on business models, emphasizing the importance of DBMI [6,36].

Differences between the perspectives are partially explained by how the respondents interpreted the intent of the owners, with the restrictive view being linked to less visionary and less permissive owners. However, since the respondents were senior managers, they are expected to have frequent interactions with the owners and their representatives. Therefore, the difference in outcome might not solely be a consequence of interpretation. Instead, it could be argued that the results mirror differences in communication between managers and owners about DBMI and strategy. More precisely, the results indicate that the restrictive perspective is associated with a more negative outlook on the future of the DH sector, and that view is used when communicating to the board about the potential benefits of digitalizing. Since the comprehensive view is predicated on greater freedom and a conviction that failure to innovate would lead to a future decline in competitiveness, it is possible to argue that if top managers want to pursue DBMI, they need to engage with key stakeholders to collectively shape a convincing narrative [28] about how the company should produce and capture value from DBMI. The result aligns with research that points to the importance of good communication, shared visions, and clear responsibilities for successful BMI [21].

Considering that digitalization may benefit both efficiency and environmental performance [33,34], policies could be used to support the development and adoption of digitalized DH. Yet, the two views have different implications for the design of policy support for digitalization. Regarding the restrictive view, it is likely that companies following such a vision would be best helped by investment subsidies directed toward customers. While such a support would incentivize adoption and lower the overall cost to the consumer, it would not be technology-neutral [49], and it would also be unlikely to incentivize BMI or R&D. Since the comprehensive view embraces trial-and-error as well as stakeholder-driven open BMI, policy support would have to support networks of actors who engage in the development of digitalized DH. Such policy support would align better with triple-helix-oriented innovation support [50] and the norm of technology-neutrality.

With regard to the framework for barriers to BMI compiled for this study, the combination of loci [27] and cause [18,21] proved useful to categorize barriers. However, when

comparing the two views on DBMI, the results indicate that it also would be useful to consider a temporal dimension with regard to maturity in the DBMI process.

This study examines the challenges that managers perceived during a period when digitalization was new to the DH industry. While the data that this paper is based on are somewhat dated, the fact that contemporary research on potential future DH stresses the importance of digitalization [6,12] indicates that the results from this study remain relevant. Future research may thus explore how the digitalization of Swedish DH has progressed and what implications the restrictive and comprehensive views have on contemporary DBMI.

6. Conclusions

Based on the slow adoption of digital technologies in the Swedish DH sector, this study identified the potential impacts of digitalization on business models of Swedish DH companies and analyzed barriers to DBMI in the DH sector. Through case studies of DBMI in eight municipal DH companies, it was identified that digitalization has the potential to impact all aspects of the business model and thus should be viewed as a strategic challenge to DH companies. This study also identifies barriers to DBMI linked to two opposing views on the impact of digitalization on DH. A restrictive view conservatively separates digital innovations from existing operations and expects to adopt technological innovations as they become more affordable and easier to adapt. The comprehensive view is more ambitious, emphasizing visionary leadership and stakeholder dialogue while integrating digital components into the business models of DH companies. Owner influence and communication patterns play significant roles in shaping these perspectives. The results also have implications for policy. The restrictive view suggests that the DH industry is best helped by customer-focused investment subsidies, while actors with a comprehensive view would be best served by support for triple-helix-oriented research collaborations. Ultimately, the results suggest that to pursue DBMI successfully, top managers should dedicate resources to addressing cognitive and communicative barriers, engaging with key stakeholders to create a compelling narrative about how DH companies can create and capture value through digitalization.

Funding: This research was funded by Energiforsk.

Data Availability Statement: Data are available on request.

Acknowledgments: The author would like to thank the respondents for graciously dedicating their time and sharing valuable insights during the interviews.

Conflicts of Interest: The author declares no conflict of interest.

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