UNIVERSITÄT BAYREUTH

The Mitigation of Information Asymmetries: Digital Infrastructures and Organizational Capabilities in Sustainability Data Contexts

Dissertation
zur Erlangung des Grades eines Doktors der Wirtschaftswissenschaft
der Rechts- und Wirtschaftswissenschaftlichen Fakultät
der Universität Bayreuth

Vorgelegt
von
Paula Antonia Heeß
aus
Bad Dürkheim

Dekan:	Prof. Dr. Claas Christian Germelmann
Erstberichterstatter:	Prof. Dr. Jens Strüker
Zweitberichterstatter:	Prof. Dr. Maximilian Röglinger
Tag der mündlichen Prüfung:	22.07.2026

"Whatever you choose to do, leave tracks. That means don't do it just for yourself. You will want to leave the world a little better for your having lived."

Ruth Bader Ginsburg

Acknowledgments

Hinter dieser Arbeit stehen viele Menschen. Nicht nur als Ko-Autor*innen, sondern auch als Personen, die mich inspirierten, mir Energie gaben, die Höhen und Tiefen einer Promotion und des turbulenten Lebens drum herum miterlebten oder sogar selbst durchlebten. Personen, die mich forderten und förderten und Personen, die mir Halt gaben, zur Pause aufriefen, sie mit mir genossen und mir immer zur Seite standen. Euch allen möchte ich von Herzen danken. Ohne euch wäre ich diesen Weg so nicht gegangen, ohne euch wäre ich heute nicht hier. Und wie es in einem besonderen Musical so schön heißt: *Nur weil wir uns kannten, bin ich so wie ich bin.*

Danke an Lynne, Linda und Nina für eure Freundschaft und den bedingungslosen Rückhalt zu jeder Tages- und Nachtzeit, für all die vielen schönen aber auch herausfordernden Momente, die wir zusammen im Laufe der Promotion miteinander teilen durften.

Danke an Paul und Marc für eure Guidance und euer Coaching, das mich zur und durch die Promotion gebracht hat.

Danke an Jens für deine Betreuung, deinen wertvollen Input und die guten Diskussionen zu Wissenschaft, Politik und Gesellschaft. Danke für den Freiraum, den du mir gelassen hast, um meine Schwerpunkte zu finden und mich für meine Themen zu engagieren.

Danke an Max für deine Unterstützung und Förderung über die Promotion hinaus.

Danke an meine Kolleg*innen und Ko-Autor*innen für all unsere Zusammenarbeit und den Zusammenhalt im Team.

Danke an meine Familien und Freund*innen aus der Pfalz, Bayreuth und in der Ferne, die mir so viel Liebe und Geborgenheit schenken. Danke, dass ich der nerdy Schlumpf sein darf und bei euch immer wieder Zuflucht finde.

Danke an alle, die mit uns für eine bessere Welt kämpfen. Die Faszination für Wissenschaft liegt für mich darin, nach Lösungen zu forschen, die für alle Menschen, überall auf der Erde und in allen kommenden Generationen, ein würdiges und gutes Leben ermöglichen. Eines mit intakter Natur, echtem Frieden, Wohlstand für alle und Solidarität der Weltgemeinschaft. Heute gilt es mehr denn je, zusammenzuhalten, neue Wege zu erkunden und das Gute zu bewahren.
Also packen wir es an.

Zu guter Letzt danke ich meiner Mama. Du bist viel zu lange weg und doch immer da.
Dir widme ich diese Arbeit. Danke für alles, Mama.

Abstract

Information systems (IS) are foundational drivers of societal development and economic value creation. By reducing information asymmetries, enabling coordination across distributed actors, and supporting evidence-based decision-making, IS reshape markets, organizations, and infrastructures. At the same time, societies face the urgent challenge of sustainable transformation. Climate change, geopolitical instability, and resource constraints require fundamental changes in how energy is produced, products are designed, and value chains are organized. IS offer significant potential to support this transformation by increasing transparency, improving traceability, automating processes, and enabling new forms of collaboration across organizational and sectoral boundaries.

A central pillar of sustainable transformation is the decarbonization of the energy system. The transition toward renewable electricity and low-carbon hydrogen, together with the electrification of heating, mobility, and industrial production, positions the energy system as the backbone of a climate-neutral economy. However, this transformation entails substantial complexity. The integration of distributed renewable generation, small-scale flexibility assets, storage systems, and responsive demand requires fine-grained coordination across heterogeneous market actors. Such coordination depends on reliable, interoperable, and verifiable data architectures capable of ensuring both system stability and market efficiency. Beyond the energy domain, decarbonized supply chains require robust mechanisms for documenting and verifying sustainability-related information in order to justify price premiums for low-carbon products or enable emission taxation. Digital Product Passports (DPPs) represent a promising instrument to enable transparency across product life cycles. Yet, the effectiveness of DPPs hinges on trustworthy data infrastructures that balance traceability and accountability with legitimate concerns for privacy, confidentiality, and data sovereignty.

This dissertation contributes to IS-enabled sustainability transformation by designing digital infrastructures to enable verifiable data sharing for both energy flexibility integration and digital product transparency. It further argues that sustainability transformation requires more than the passive collection and reporting of data. Instead, data must be proactively orchestrated as a resource for forward-looking strategic decisions that go beyond compliance obligations. The dissertation conceptualizes how data can be structured, bundled, and leveraged to create and capture sustainable value. It examines mechanisms that enable trustworthy data sharing, reduce information asymmetries, and support coordinated action across interorganizational ecosystems. Across multiple studies, the dissertation demonstrates how digital infrastructures facilitate the integration of distributed flexibility into energy systems, how DPPs operationalize verifiability in decarbonized supply chains, and how process mining and data management capabilities contribute to sustainable organizational transformation. Taken together, the findings reveal that IS play a pivotal role in transforming fragmented data into actionable knowledge, balancing privacy and verification, and enabling data-driven sustainability transformation at scale.

Table of Contents

List of Figures

List of Tables

Copyright Statement

The following chapters are partly comprised of content taken from the research articles in this thesis. To improve the readability of the text, I have omitted the standard labeling of these citations. This dissertation includes content generated with the assistance of generative AI tools (e.g. Claude, Perplexity, DeepL) for the purposes of formatting support and language editing. The use of these tools was guided by ethical considerations and standards of academic integrity, in accordance with the guidelines of the Executive Committee of the Deutsche Forschungsgemeinschaft (DFG / German Research Foundation) on the influences of generative models of text and image creation on science and the humanities as well as on the DFG's funding activities.

1 Introduction

1.1 Motivation

Over the past decade, global crises have reshaped the conditions under which economies and societies operate. The COVID-19 pandemic, geopolitical conflicts, and deepening tensions between countries have exposed critical vulnerabilities in energy supply chains, strained international cooperation, and shifted political priorities toward short-term security and economic stabilization (WEF, 2023). Against this backdrop, sustainability has lost its prominence in global policy debates, crowded out by more immediate imperatives of energy affordability, national resilience, and strategic autonomy. Yet this shift is a threat to our economy and society as a whole. Climate change continues to accelerate, resource constraints are tightening, and the long-term costs of inaction are increasing. Ignoring these forces transfers the burden onto future economies and generations in ways that will prove far more disruptive than the transition costs societies are hesitant to bear today (IPCC, 2023). Building resilience, therefore, cannot be separated from sustainability. The global community needs to develop and deploy intelligent solutions that sustain and extend welfare by actively shaping a sustainability transformation in ways that integrate both people and organizations. This means moving beyond top-down mandates and toward structures in which firms, public institutions, and individuals can participate meaningfully in a transformation that is as much about economic viability and social cohesion as it is about reducing emissions (Schreuder & Horlings, 2022; UNDESA, 2025).

While society requires this urgent sustainability transformation, we experience a profound digital transformation at the same time. Digital technologies, data infrastructures, and algorithmic systems are reshaping how organizations coordinate, produce, report, and exchange value across industries (Hinings et al., 2018; Legner et al., 2017; Vial, 2019). Foundational Information Systems (IS) research has emphasized that beyond automating existing routines, digital technologies can enable new forms of sensemaking, practice change, and organizational transformation (A. Bharadwaj et al., 2013; Yoo et al., 2010). Green IS scholarship, in particular, has argued that the discipline bears responsibility for addressing environmental sustainability and for developing digital solutions that support socially relevant transformation (Gholami et al., 2016; Melville, 2010; vom Brocke et al., 2013a; Watson et al., 2010). Research within this field has explained that IS can create functional affordances for green transformation, enabling organizations to rethink their processes, resource use, and coordination logic in ways that support sustainability outcomes (Seidel et al., 2013). More recently, calls for the use of digital technologies to improve organizational resilience against climate change have reinforced the argument that IS research must engage more with digital potential for sustainability (Boh et al., 2026). This dissertation builds on that tradition and asks how IS can be used to actively enable decarbonization and resilient value creation.

A central observation underlying this dissertation is that sustainability is also an information problem. Across energy systems, supply chains, and Environmental, Social, and Governance (ESG) reporting, key data are often fragmented, unverifiable, inaccessible, or withheld because they are commercially sensitive or distributed across organizational boundaries (Krasikov & Legner, 2023; Püchel et al., 2024). This creates information asymmetries that undermine coordination, trust, market formation, and credible decision-making. In the classic sense of Akerlof (1978), when quality cannot be verified, markets do not reward high-quality products. In the principal-agent relation, when one actor knows more than another, opportunism and moral hazard become harder to avoid (Eisenhardt, 1989). Sustainability markets face the same structural problem where buyers of low-carbon hydrogen, grid operators seeking energy flexibility, or investors evaluating sustainability claims need trustworthy data, yet the actors who hold that data often have legitimate reasons not to disclose it fully. For example, grid operators need to be certain of the type and capability of assets to deliver promised energy flexibility, but asset owners have reasons to remain private and do not disclose identities or personal energy consumption data. As a result, apart from financial investment the transformation toward sustainability depends also on digital infrastructures that can reduce information asymmetries without eliminating sovereignty or privacy (Babel et al., 2022; Kotlarsky et al., 2023). The need for trustworthy data and secure infrastructures is unlikely to diminish over time. As Artificial Intelligence (AI) and, more recently, agentic AI systems become active participants in energy markets and sustainability processes, the provenance of data, the integrity of automated decisions, and the verifiability of system behavior take on even greater consequence. The structural information asymmetries that motivate this dissertation are therefore not a transitional problem to be solved once but a persistent and intensifying governance challenge.

Within the broader challenge of an IS-enabled sustainability transformation, two domains are particularly important. The first is energy, because the energy system is the backbone of decarbonization and an essential field in which fossil dependence must be reduced (IEA, 2023b). The decentralization of energy generation due to the increase of Renewable Energy Sources (RES), the electrification of demand, and the rise of flexible assets such as electric vehicles, heat pumps, batteries, and power-to-X technologies require data sharing between different actors and assets, thus increasing the complexity of market coordination (Bindeeba et al., 2025; Watson et al., 2022). The second is ESG data, because sustainability management increasingly depends on the ability to measure, report, verify, and operationalize environmental and social claims across organizational and supply-chain boundaries. Recent research has demonstrated that sustainability data sourcing is itself a nontrivial organizational practice shaped by regulatory pressure, data quality issues, and interoperability challenges (Krasikov & Legner, 2023). More broadly, sustainability transformations depend on data becoming actionable resources rather than remaining isolated records of facts (Püchel et al., 2024). This dissertation therefore focuses on the informational foundations of sustainability and establishes how data are generated, verified, shared, and used to enable decarbonization.

The relevance of transformation processes towards sustainability is evident in both the policy environment and market developments. Global investment in Renewable Energy (RE) has grown rapidly, reaching roughly USD 1.74 trillion in 2023 after nearly 40 percent growth between 2020 and 2023 (IEA, 2023a). In the European Union, the Corporate Sustainability Reporting Directive (CSRD) and related disclosure frameworks have expanded the demand for verifiable sustainability data and have increased the pressure on organizations to improve their data practices (European Commission, 2021, 2022).

Developments, specifically in the energy sector but also across the entire industry, make it clear that sustainability and digital transformation are not separate agendas, but should be examined together to leverage synergies and exploit the potential of IS for a decarbonized world (Christmann et al., 2024; Kotlarsky et al., 2023).

1.2 Research Aim

The overarching aim of this dissertation is to investigate how IS-based solutions can address information asymmetries in the sustainability domain and thereby support digital decarbonization. More specifically, the dissertation examines how IS can enable the collection, verification, sharing, and use of sustainability-relevant data in ways that create ecological, social, and economic value. The guiding idea is that sustainability cannot be effectively managed if relevant data remain fragmented across organizations, systems, and regulatory regimes, nor if the data that do flow across these boundaries cannot be trusted by those who rely on them. Markets for energy flexibility, low-carbon products, or ESG-based decision support depend on mechanisms that make data accessible as well as verifiable and actionable (Krasikov & Legner, 2023; Püchel et al., 2024; White et al., 2021).

To address the lack of reliable sustainability data, the dissertation develops the concept of IS-enabled sustainability as a response to information asymmetries. This perspective connects different IS research streams. First, it builds on Green IS and sustainability transformation research, which demonstrates that IS can enable environmentally sustainable practices, organizational learning, and new forms of coordination (Melville, 2010; Seidel et al., 2013; Watson et al., 2010, 2022). Second, it draws on data ecosystem and data sovereignty research, which emphasizes that value from data depends on the ability to share data in sovereign, interoperable, and verifiable ways (Beverungen et al., 2022; Jarke et al., 2019). Third, it integrates organizational capability perspectives that explain how firms turn digital and informational assets into strategic outcomes through resource orchestration and related capabilities (Sirmon et al., 2011). Finally, it engages with process-level analysis revealing how IS capabilities such as process mining can be deployed to measure, monitor, and improve ESG performance within and across organizations (Costache et al., 2025; vom Brocke et al., 2012). Taken together, these streams suggest that sustainability outcomes depend on both the existence of data and on the infrastructure and organizational capacity to transform data into action. The contribution of this dissertation therefore lies in designing and evaluating the technical and organizational contexts that determine whether existing data can be trusted, shared, and translated into decision-making.

This dissertation pursues four complementary research aims. The first is to characterize the domain in which sustainability-related information asymmetries arise, with a particular focus on energy markets, flexibility integration, and decentralized coordination, so as to establish why IS-based interventions in this domain are both necessary and consequential. The second is to design and evaluate digital infrastructures that make sustainability data verifiable and sovereign, thereby enabling new forms of market coordination and reducing the informational barriers that currently constrain trust across organizational boundaries. The third is to identify and specify the organizational capabilities that allow firms to move beyond data possession toward effective data use, examining how organizations can source, structure, and leverage sustainability data for strategic and operational value creation. The fourth is to demonstrate, at the process level, how IS capabilities connect the availability of sustainability data to measurable improvements in ESG performance, thereby bridging the gap between digital infrastructure and organizational transformation. Together, these four aims reflect the dissertation's core argument that effective decarbonization requires better data alongside the infrastructure, capabilities, and process-level mechanisms needed to make that data trustworthy and actionable.

Methodologically, the dissertation adopts a cumulative, multi-method design. Across the eight papers, it combines design science, multi-methods approaches, qualitative case studies, expert interviews, systematic literature reviews, and quantitative modeling. Methodological diversity arises from the diverse topics addressed in this dissertation that require different approaches. The dissertation contributes to Green IS, data ecosystem research, resource-based and capability perspectives, and the emerging literature on sustainability transformation (Kotlarsky et al., 2023; Melville, 2010; Püchel et al., 2024; Seidel et al., 2013). Practically, it informs the design of energy flexibility markets, Digital Product Passport (DPP) infrastructures, ESG data platforms, and organizational data strategies for sustainability.

In sum, the dissertation asks the following research question: *how can IS reduce sustainability-related information asymmetries and thereby enable decarbonization and resilient value creation?* The answer developed across the sections is that IS can serve as infrastructural, organizational, and strategic enablers of sustainability when they make data verifiable, sovereign, and actionable.

1.3 Structure of the Dissertation

The dissertation is structured into six sections, with eight embedded research papers distributed across the core thematic blocks (cf. Figure 1.1). Section 2 explains the pressures for sustainability transformation and builds the system context to motivate the remainder of the dissertation. Section 3 addresses digital infrastructure for verifiable and sovereign sustainability data, which in turn requires corresponding organizational capabilities for sustainability data use examined in Section 4. Section 5 then integrates these insights and explains how appropriate digital infrastructure and organizational capabilities promote IS-enabled sustainability transformation and digital decarbonization. Section 6 concludes the dissertation by summarizing contributions and outlining implications for research and practice.

Section 2, *Sustainability Transformation Pressure and System Context*, contains Research Papers 1 and 2. Research Paper 1 analyzes the drivers of RE investment and finds that economic, political, technological, and social conditions jointly shape the investment landscape; crucially, it identifies digital technologies as a necessary enabler of the energy transition. Research Paper 2 examines negative electricity prices and demand-side flexibility, demonstrating that market outcomes in energy systems depend strongly on pricing logic, network constraints, and information signals. Both papers establish the basis for the dissertation's energy context: a system in which decarbonization requires infrastructure expansion but also better information, coordination, and a suitable market design.

Section 3, *Digital Infrastructure for Verifiable and Sovereign Sustainability Data*, contains Research Papers 3, 4, and 5. These papers move from the system context to the design of digital infrastructures that can support trustworthy data sharing across organizational boundaries. Research Paper 3 presents a multi-agent system design for decentralizing redispatch that combines self-sovereign identity and zero-knowledge proofs to make small-scale flexibility assets verifiably and data-sovereignly available to grid operators. Research Paper 4 introduces the Trust Diamond as a conceptual framework that maps the inherent tension between data verifiability and privacy in energy flexibility provision and derives design principles for wallet-based identity management. Research Paper 5 extends the argument to low-carbon hydrogen and supply-chain traceability, showing how DPPs can reduce information asymmetries while preserving data sovereignty. Collectively, these papers explain how digital infrastructures can enable new markets and new forms of coordination by making sustainability data verifiable without forcing full disclosure.

Section 4, *Organizational Capabilities for Sustainability Data Use*, contains Research Papers 6 and 7. This section shifts the analytical focus from infrastructure to organizational practice. Research Paper 6 develops a Sustainability Data Management Maturity Model (SDM-MM) that conceptualizes sustainability data as a latent strategic resource and specifies the organizational capabilities needed to structure, bundle, and leverage it for value creation, drawing on resource orchestration theory. Research Paper 7 examines how ESG data can be mobilized within and across organizations through a resourcing perspective, showing how coordinated, network-level data practices transform ESG data from dispersed compliance assets into resources for strategic decision-making. Together, these papers contribute to the dissertation's argument that digital infrastructures for verifiable data sharing alone are insufficient: organizations must also develop capabilities to interpret, govern, and use sustainability data effectively.

Section 5, *IS-enabled Sustainability Transformation and Digital Decarbonization*, contains Research Paper 8. This paper examines how process mining capabilities can support ESG performance, identifying 30 use cases through a Delphi study and revealing substantial potential in resource optimization, compliance monitoring, and employee well-being. It demonstrates that process-level analytical capabilities represent a concrete mechanism through which IS contributes to sustainability transformation by converting event log data into actionable ESG insights. The section also synthesizes the broader implications of the dissertation's findings, connecting the context, infrastructure, and capability perspectives into a broader view of IS-enabled decarbonization.

Section 6 concludes the dissertation by summarizing the scientific contributions and discussing implications for future research and practice.

Figure 1.1 captures the dissertation's argumentative logic: the pressure for a sustainability transformation and in particular the current context of our energy system motivates the search for verifiable digital infrastructure, digital infrastructure depends on organizational capabilities to unfold its full potential, and together these elements promote IS-enabled sustainability transformation.

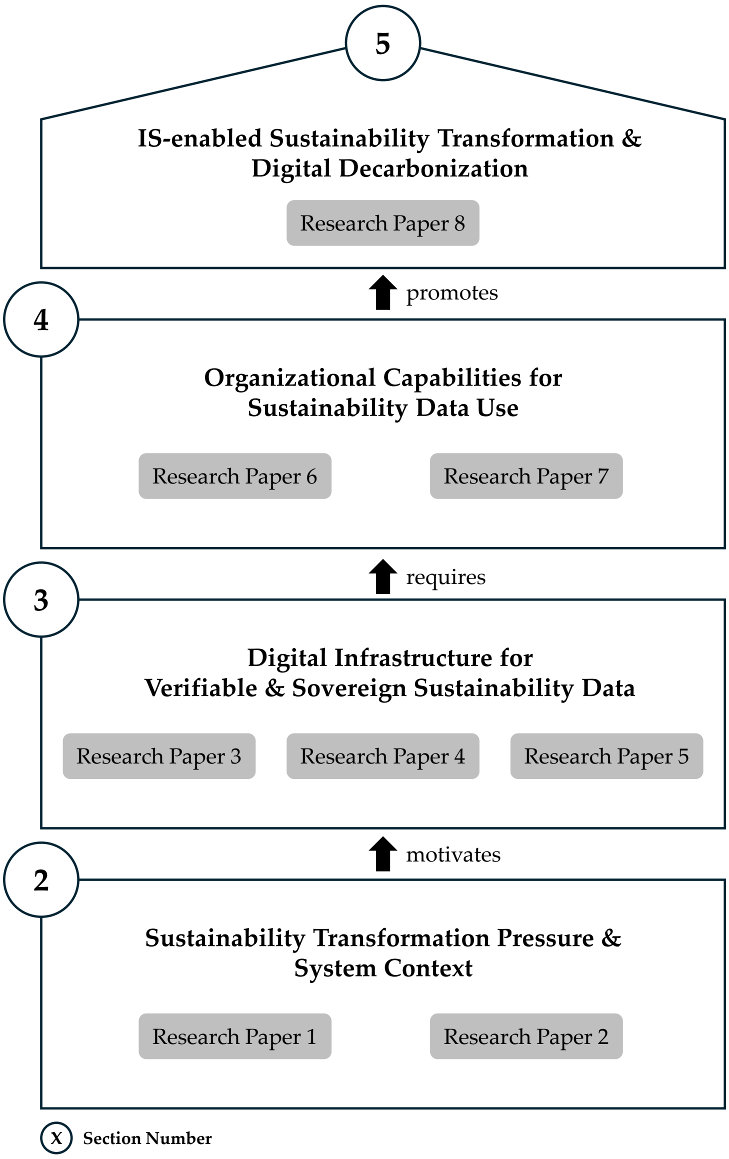


Figure 1.1: Structure of Dissertation and Embedding of Research Papers

2 Sustainability Transformation Pressure & System Context

The global energy system is undergoing a fundamental transformation. Driven by the urgent need to address climate change and reduce greenhouse gas emissions, policymakers worldwide have set ambitious targets for a sustainable energy transition. In the European Union, renewable energy sources accounted for 24.5% of gross final energy consumption in 2023 and 25.4% in 2024, while the revised Renewable Energy Directive raises the binding 2030 target to at least 42.5%, with an aspiration to reach 45% (European Commission, 2024; European Environment Agency, 2025; Eurostat, 2024). Germany reported a share of 21.6% RES in gross final energy consumption in 2023, and its electricity sector target remains at least 80% RES-based electricity by 2030 (Umweltbundesamt, 2025a, 2025b). Achieving these targets demands substantial and sustained growth in RE investments.

The electricity sector occupies a central position in this transformation. Decarbonizing the economy at large across the sectors of heating, transportation, and industry relies critically on access to a clean, reliable electricity supply. The broad electrification of heat pumps, electric vehicles, and industrial processes simultaneously increases electricity demand and raises the stakes for a decarbonized grid (Fridgen et al., 2020; Ramsebner et al., 2021). At the same time, the energy system itself is shifting from large, centralized, and dispatchable fossil-fuel power plants to a growing number of distributed, volatile RES such as photovoltaic systems and wind turbines. This structural change creates new challenges for system operation, market design, and investment. Generation becomes intermittent and weather-dependent, ownership of generation assets is distributed across utilities, businesses, cooperatives, and private households, and the traditional boundary between producer and consumer shifts toward the emergence of the prosumer (Michaelis et al., 2024). As a consequence, the energy system faces a trilemma of simultaneously ensuring reliability of supply, environmental sustainability, and affordability (Heffron et al., 2021). Apart from engineering and financial solutions, this challenge requires appropriate information flows and digital infrastructure (Körner et al., 2022).

This section establishes the system context for the dissertation's research agenda. Section 2.1 examines the factors driving RE investments, drawing on Research Paper 1, and identifies digital technologies as relevant enablers of the energy transition. Section 2.2 turns to the electricity market perspective, using Research Paper 2 to analyze how the growing share of RES reshapes market dynamics and highlights the relevance of integrating demand flexibility into our energy markets.

2.1 Factors Driving Renewable Energy Investments

Accelerating RE deployment requires a clear understanding of the factors that enable or constrain investment decisions. Research Paper 1 addresses this question through a systematic literature review of 132 articles combined with 17 semi-structured expert interviews with practitioners from across the energy sector. Applying a Political, Economic, Environmental, Social, and Technological (PEEST) framework (Gerry et al., 2017; F. Li et al., 2021), the study identifies 37 factors that shape RE investment decisions and synthesizes 13 key takeaways for policymakers, investors, and researchers.

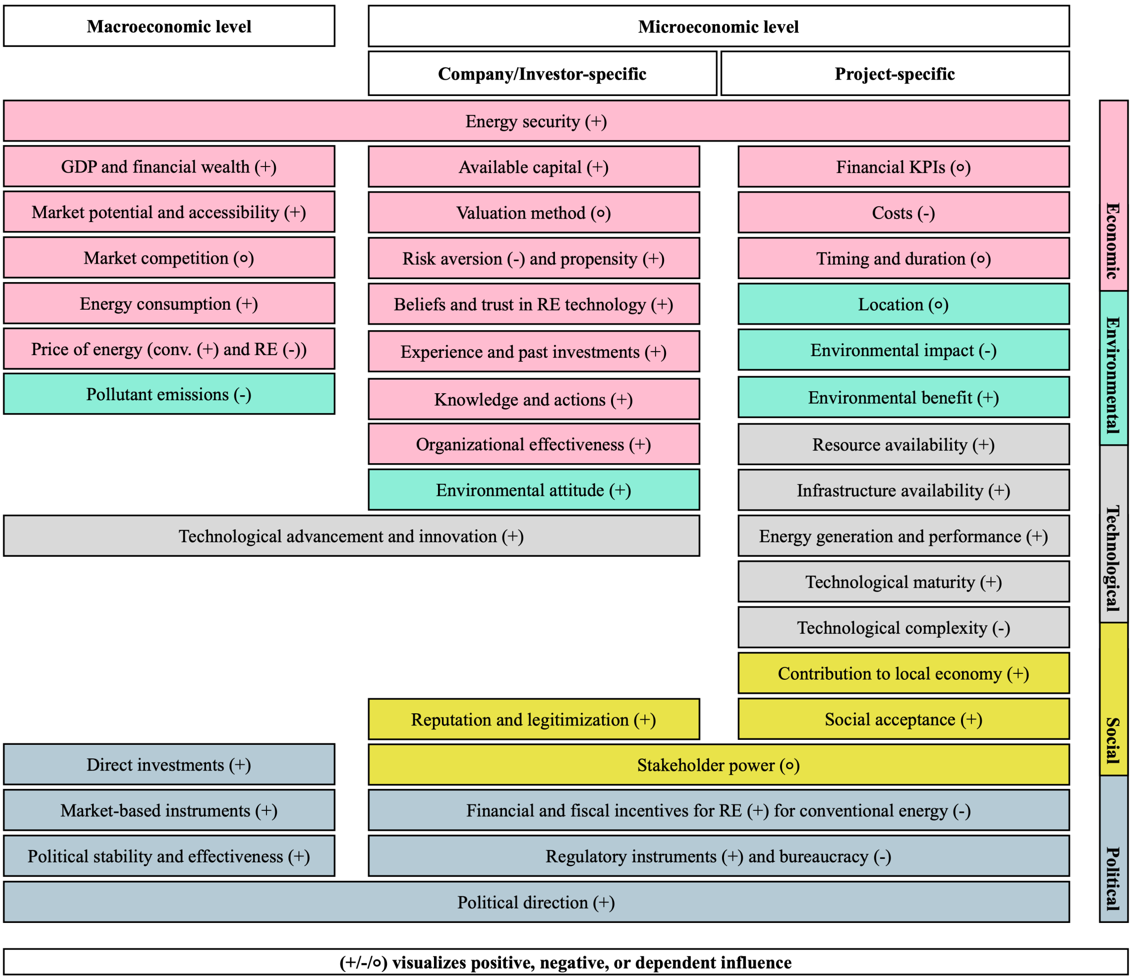


Figure 2.1: Overview of the factors influencing RE investments. *Source: Research Paper 1*

As the identified investment factors in Figure 2.1 and the corresponding key takeaways in Figure 2.2 illustrate, Research Paper 1 maps the investment landscape across five dimensions.

Economic factors. The study's central finding is that *economic factors are the necessary drivers* of RE investments (KT1). Regardless of environmental imperatives or policy ambitions, capital will only be deployed if the business case is sound. Economic profitability, captured through financial

KPIs such as the internal rate of return and the net present value, constitutes the prerequisite for any investment decision (KT1, KT2; Masini and Menichetti, 2012; Wüstenhagen and Menichetti, 2012). Financial risk, driven by price volatility and regulatory uncertainty, is the corresponding constraint (KT3; Fuss and Szolgayová, 2010; Kul et al., 2020).

Political factors. Political factors shape the framework within which economic viability is determined (KT10). Clear and stable political direction manifested through market-based instruments such as feed-in tariffs and contracts for difference, direct public investments, and financial incentives reduces regulatory uncertainty and thereby lowers the risk premium investors require (Lipp, 2007; Polzin et al., 2015). Bureaucratic complexity in permitting and grid-connection processes, as well as political instability, can significantly delay or deter projects (KT11, KT12). Research Paper 1 finds that all 17 interviewed experts identified political stability and regulatory clarity as critical investment conditions.

Environmental, social, and technological factors. Environmental, social, and technological factors play a supporting role, shaping the conditions under which economic factors translate into actual investment (KT4). Environmental targets and a strong environmental attitude influences the willingness to invest in RES (Hartmann et al., 2021). Social acceptance or its absence can be decisive at the project level. Local opposition following Not In My Backyard (NIMBY) dynamics can terminate investments regardless of their financial attractiveness, while participatory ownership models foster Please In My Backyard (PIMBY) effects and community support (KT9; Gamel et al., 2017; Wüstenhagen et al., 2007). On the technological side, grid expansion and storage capacities are identified as essential infrastructure prerequisites (KT5). Technological advancement and particularly the dramatic cost reductions achieved in solar photovoltaics and wind energy has expanded the economic frontier for RE investment globally (Bamati & Raoofi, 2020; IEA, 2023b).

Of particular importance for this dissertation is *Key Takeaway 6* (KT6) of Research Paper 1, which identifies the range of energy sources and digital technologies as enablers of an efficient energy transition. Experts consistently emphasized that multiple RES and technology types are essential for RE development, and that IS and digital infrastructure represent a necessary condition for the energy transition (Çelik et al., 2022; Lin & Huang, 2023; Olabi et al., 2023). Digital technologies enable real-time grid monitoring, data-driven dispatch and redispatch, automated demand response, and the integration of distributed small-scale assets into energy markets, capabilities that are foundational to operating a reliable, sustainable, and affordable energy system at scale (Kossahl et al., 2012; Melville, 2010; Watson et al., 2010).

The connection between digital enablement and economic profitability, the primary driver of RE investment, runs through multiple channels. Digital platforms and smart grid infrastructure reduce transaction costs and information asymmetries that currently prevent smaller actors from participating in energy markets. Crucially, they enable new market mechanisms through which the flexibility of distributed assets can be monetized, directly improving the business case for investments in photovoltaic systems, battery storage, electric vehicles, and heat pumps. Research Papers 3 and 4 of this dissertation develop IS-based approaches that allow small-scale asset owners to participate verifiably and data-sovereignly in redispatch and flexibility markets,

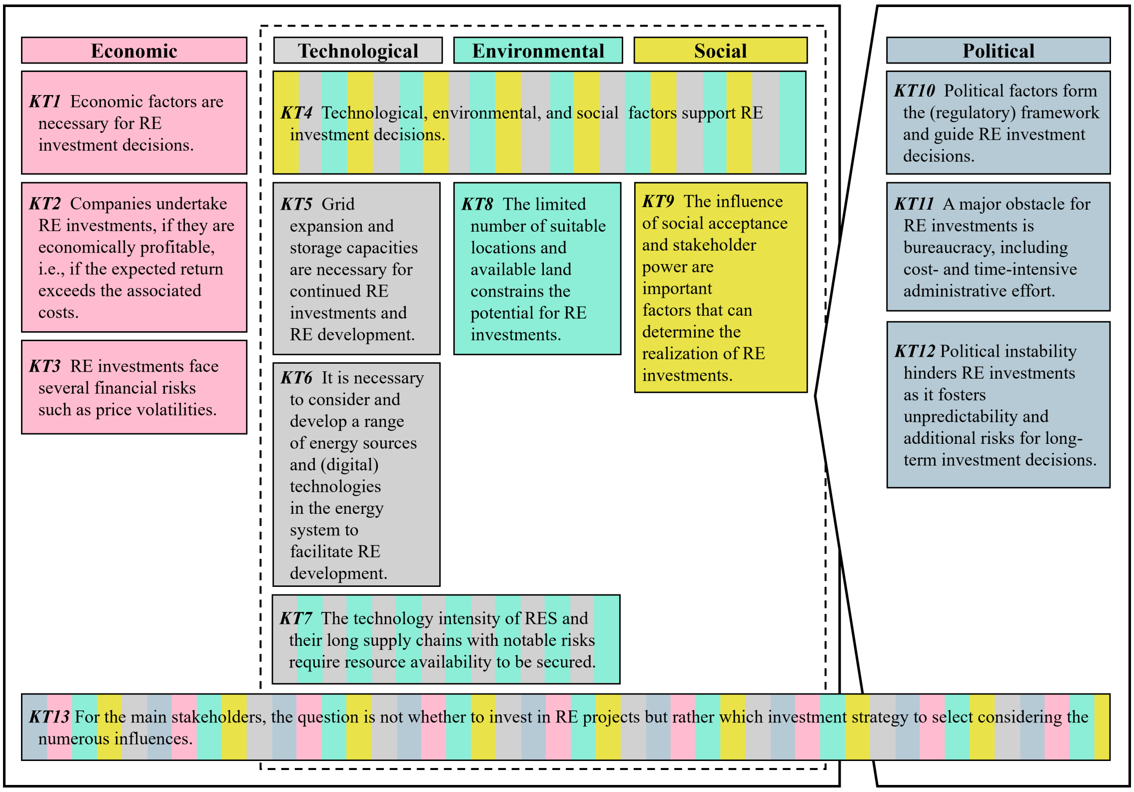


Figure 2.2: Key takeaways regarding the factors influencing RE investments and, consequently, RE development in Germany. *Source: Research Paper 1*

turning what was previously an uncompensated technical constraint into an economic opportunity. Similarly, Research Paper 5 examines how distributed power-to-X plants, enabled by digital platform-based business models, can generate additional revenue streams from electricity-based green hydrogen production. In this way, IS underpin the economic viability of decarbonization, extending well beyond operational support to create the market conditions under which RE investments pay off.

2.2 Pricing Signals, Market Design and Demand Flexibility

The growing penetration of RES also significantly reshapes the operational reality of electricity markets and the challenge of system management. This section examines a key market phenomenon that accompanies the energy transition: negative electricity prices. It discusses the causes and implications of negative prices, the role of demand flexibility, market design, and derives informational and infrastructural requirements for an efficient, decarbonized electricity system.

As the share of RES with near-zero marginal costs of generation increases, electricity prices on day-ahead and intraday markets are structurally pushed downward (Halbrügge et al., 2021; Ketterer, 2014). When renewable generation peaks, e.g. during windy nights or sunny spring days, and inflexible conventional plants cannot be ramped down sufficiently, supply exceeds demand at non-negative prices, causing market prices to fall below zero. Negative electricity prices have become an increasingly common phenomenon on European power exchanges such as the European Power Exchange SPOT (EPEX), particularly in periods of high wind generation (Ketterer, 2014; Traber & Kemfert, 2011; Wolff & Feuerriegel, 2017). In Germany, for instance, the number of negative-price hours grew substantially in the period up to early 2022, and as the RE share continues to expand in line with EU targets, such occurrences can be expected to increase further (Halbrügge et al., 2021). Negative electricity prices generally arise when generators bid below zero to remain in operation, owing to the prioritized infeed and fixed feed-in tariffs for RES, and to the high costs of ramping down inertial conventional plants (Bird et al., 2016; Härtel & Korpås, 2020). Figure 2.3 illustrates such an exemplary market situation where a high share of RES and negative price bids occur. The conventional interpretation treats negative prices as a signal of lacking flexibility. They indicate that not enough demand-side response, storage, or curtailment capacity is available to absorb surplus generation (Heffron et al., 2021; Lund et al., 2015).

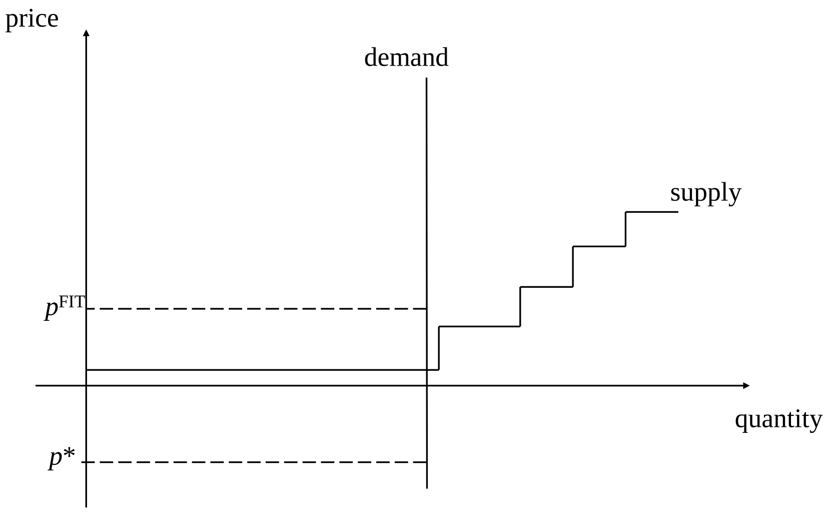
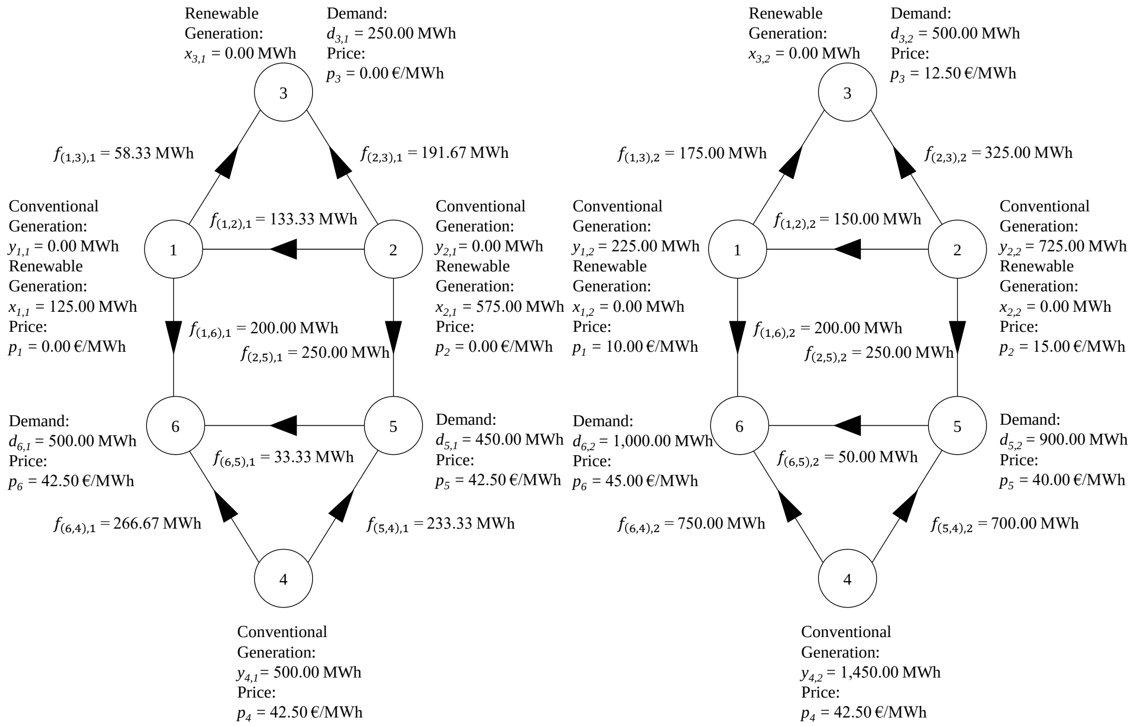


Figure 2.3: An exemplary merit order which leads to negative electricity prices with p^{FIT} representing the feed-in tariff and p^* the resulting negative equilibrium price. *Source: Research Paper 2*

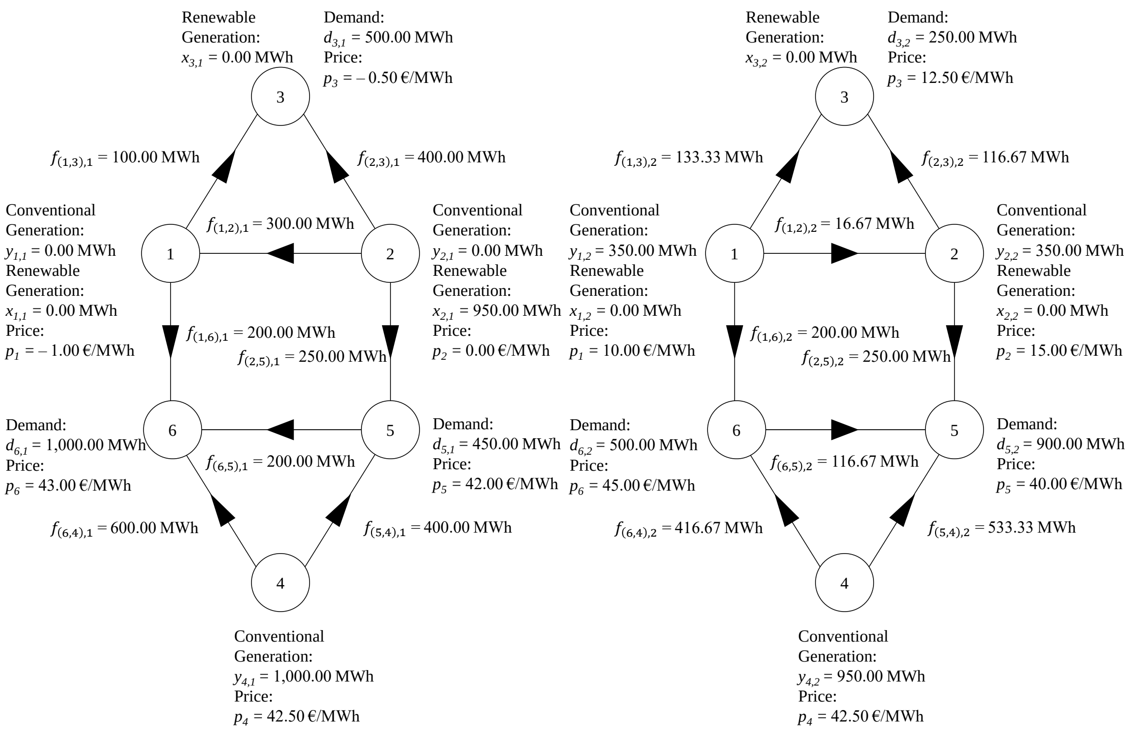
Research Paper 2 contributes a novel and more nuanced perspective. Using a nodal-pricing, energy-only spot market model formulated as a linear program and applied to a well-established six-node test network (Chao & Peck, 1996; Chao & Peck, 1998), the paper examines how active consumers, consumers capable of inter-temporally shifting their electricity demand, affect market prices. The central finding is that the temporal coupling of market clearing through demand-side load shifting can itself induce negative electricity prices, even in settings where, compared to inflexible demand (cf. Figure 2.4), more flexibility is available in the system. When consumers shift load from high-price to low-price periods, their optimization behavior creates inter-temporal dependencies between market-clearing outcomes. Under network constraints, specifically, loop-flow restrictions that limit the physical transfer of electricity across transmission lines, this temporal coupling can yield negative nodal prices at specific locations, even as overall system costs decline and RES utilization increases (cf. Figure 2.5). Research Paper 2 refers to this phenomenon as the paradox of flexibility. Greater demand-side participation does not eliminate negative prices but can, under certain grid conditions, amplify them.



(a) Period 1.   **(b)** Period 2.

Figure 2.4: Market outcomes for the reference case with inflexible demand of passive consumers. *Source: Research Paper 2*

This finding has important implications for how negative electricity prices are interpreted and how markets should be designed. As Research Paper 2 demonstrates, negative prices arising from demand flexibility are not a sign of market failure or inefficiency. On the contrary, they signal lower total system costs and identify times and locations where additional flexibility or investment would be most valuable. Negative nodal prices thus function as investment and dispatch signals for active consumers. They indicate where increased consumption, storage, or power-to-X applications are economically rational and contribute to system stability. Allowing negative prices in certain market designs, rather than administratively suppressing them, is therefore an important policy design choice.



(a) Period 1. **(b)** Period 2.

Figure 2.5: Market outcome for the case with flexible demand. *Source: Research Paper 2*

A critical insight from Research Paper 2 concerns the informational properties of different pricing regimes. In a nodal pricing system, locational price signals accurately reflect the marginal value of electricity at each network node, encoding information about transmission constraints, renewable surplus, and the opportunity cost of load shifting (Bohn et al., 1984; Holmberg, Lazarczyk, et al., 2015; Weibelzahl, 2017). These spatial and temporal price differentials are precisely the signals that guide efficient investment and operational decisions. In contrast, under the uniform or zonal pricing regimes currently dominant in European electricity markets, these price signals are averaged across large pricing zones, obscuring the true locational value of flexibility (Grimm et al., 2016; Trepper et al., 2015). Consumers and investors thus receive a blurred signal that leads to suboptimal investment decisions and missed efficiency gains. The choice of pricing regime is therefore an information architecture question with direct consequences for the pace and efficiency of the energy transition.

Beyond market design, Research Paper 2 highlights a set of infrastructural requirements for unlocking the potential of demand flexibility. Enabling active consumers to participate meaningfully in electricity markets requires, first, the physical infrastructure for flexible demand such as smart meters, controllable appliances, and energy management systems that can respond to price signals in real time (Gellings, 1985; Palensky & Dietrich, 2011). Second, and equally important, it requires the digital infrastructure through which price signals are communicated, flexibility bids are submitted, and transactions are settled with verifiable accuracy. Without smart metering infrastructure, consumers cannot receive the granular, real-time price information necessary to shift load in ways that benefit the system (Körner et al., 2022; Leinauer et al., 2022). Without secure and interoperable digital platforms, the flexibility potential of millions of distributed small-scale assets including heat pumps, electric vehicles, or battery systems cannot be aggregated, verified, and made available to market operators and grid operators. The integration of flexibility into electricity markets is thus a question of grid expansion as well as a question of digital infrastructure. It requires IS that make distributed flexibility accessible and verifiable for the energy system (Heffron et al., 2020; Körner et al., 2022).

Research Papers 1 and 2 together establish the system context for this dissertation. Research Paper 1 identifies the factors driving RE investment and demonstrates that digital technologies are a necessary enabler of the energy transition, both for managing the growing complexity of a distributed energy system and for enabling new business models that strengthen the economic case for RE deployment. Research Paper 2 illustrates that the electricity markets which must integrate this growing renewable capacity are characterized by new and complex price dynamics, in which demand flexibility plays a central role as both a cause and a solution of market imbalances, but only if appropriate price signals, smart infrastructure, and digital platforms are in place. Both perspectives converge on the same conclusion: the energy transition needs more than investment and grid expansion. It requires a digital information infrastructure that makes distributed generation, flexible consumption, and decentralized market participation operationally feasible, economically attractive, and verifiably trustworthy. Developing and leveraging such infrastructure is the subject of the remainder of this dissertation, beginning in Section 3 with the conceptual foundations of data sovereignty and privacy-preserving data sharing.

3 Digital Infrastructure for Verifiable & Sovereign Sustainability Data

Section 2 established that next to investment and grid expansion the energy transition also requires digital information infrastructure that makes distributed generation, flexible consumption, and decentralized market participation operationally feasible, economically attractive, and verifiably trustworthy (Fridgen et al., 2020; Kossahl et al., 2012; Watson et al., 2022). This section takes up that conclusion and examines the specific IS design challenge it entails. The overarching transition from fossil-fuel to RES-based systems creates an essential data sharing challenge. The coordination of sustainability transformation depends on information that is often sensitive to disclose, difficult to verify, and distributed across heterogeneous stakeholders who do not necessarily share identical interests (Bélanger & Crossler, 2011; Meckling & Jensen, 1976).

Electrification is one of the main mechanisms through which decarbonization proceeds. As heat pumps, electric vehicles, industrial processes, and data centers shift from fossil fuels to electricity, the electricity system becomes the backbone of a climate-neutral economy (Fridgen et al., 2020; Ramsebner et al., 2021). This structural shift creates two intertwined coordination problems that are at the core of this section. The first is the problem of flexibility integration: an electricity system increasingly fed by variable RE generation must balance supply and demand in real time, and the primary resource for doing so is the distributed flexibility embedded in the growing amount of electrified assets. To harness this flexibility, grid operators need accurate and timely information about the capabilities and states of millions of small-scale assets. The second is the problem of low-carbon market formation: buyers in global energy markets are willing to pay a premium for hydrogen or other sustainable products only if the sustainability claim can be credibly verified (White et al., 2021). Both problems require data about distributed, privately held resources or production processes in order to support coordination or market pricing decisions, yet the owners of those resources have legitimate concerns about what information they share and with whom. The IS design task, therefore, is to design digital infrastructures that make sustainability data sharing simultaneously verifiable and sovereign.

The challenge described above maps directly onto the information asymmetry problem in economic and organizational theory. Akerlof (1978) demonstrated that when one party to a transaction holds private information about product quality and the other cannot verify it, market mechanisms break down. Sellers of genuinely high-quality goods cannot credibly distinguish themselves from sellers of inferior goods, price premiums erode, and in the limit the market collapses entirely. This “market for lemons” logic applies with considerable force to sustainability markets. A buyer of low-carbon hydrogen, green electricity, or certified sustainable products cannot observe the production process, the energy inputs, or the upstream supply chain that determine the actual carbon footprint (Babel et al., 2022). Without mechanisms for credible verification, the premium that would reward genuine sustainability investments cannot be sustained (White et al., 2021).

Agency theory deepens this analysis by examining the relational dimension of information asymmetry (Eisenhardt, 1989; Meckling & Jensen, 1976). In the principal-agent framework, a principal (such as a grid operator or a product buyer) depends on an agent (such as a flexibility provider or a supplier) to take actions or reveal information on which the principal's decisions depend, while the agent possesses superior private knowledge. In redispatch, the grid operator needs to know whether an asset can actually deliver the promised flexibility, but direct access to asset-level data would compromise the asset owner's privacy, sovereignty, and potentially competitive position (Research Paper 3). In hydrogen supply chains, buyers and regulators need to know the carbon intensity of production, but suppliers may regard this as commercially sensitive process information (Research Paper 5). In both cases, the agent has incentives to over-claim capabilities or sustainability attributes, and the principal cannot easily distinguish honest from forged disclosure.

From an IS perspective, the standard organizational responses to information asymmetry, namely contractual monitoring, auditing, and certification, are insufficient or ill-suited to the scale and heterogeneity of distributed sustainability systems (Heffron et al., 2021; Watson et al., 2022). Traditional redispatch relied on a comparatively small number of large, dispatchable power plants whose output could be metered centrally and whose behavior could be verified through well-established procedures (Hirth & Glismann, 2018; Lind et al., 2019). Future redispatch must coordinate millions of small-scale assets, each embedded in private or organizational contexts, each generating operational data at high frequency, and each subject to privacy regulations that limit centralized data collection (Research Paper 3, Research Paper 4). Similarly, certifying the carbon footprint of a global hydrogen supply chain through manual auditing is prohibitively costly and slow, and is vulnerable to the very asymmetries it is meant to resolve (Research Paper 5).

This is the sustainability-data dilemma that runs through the present section and that connects the three research papers introduced at this point. The data that are needed for verification are often the data that stakeholders least want to disclose. Resolving this dilemma, hence, requires targeted data collection and a redesign of the information architecture, one that allows verification without full disclosure and balances privacy and traceability needs (Otto & Jarke, 2019; vom Brocke et al., 2013b; Watson et al., 2022).

3.1 Decentralized Redispatch: A Multi-Agent Approach

The concept of data sovereignty provides the normative and conceptual anchor for the architectural redesign described in this section. Data sovereignty refers to an entity's ability to maintain meaningful control over its own data across the full lifecycle of data collection, processing, sharing, and use (Hummel et al., 2021; von Scherenberg et al., 2024). It serves as a relational and governance concept that specifies who has authority to determine how data are used, by whom, and for what purposes (Ernstberger et al., 2023; Hellmeier & von Scherenberg, 2023). In sustainability transformations, data sovereignty matters because participation in digital coordination mechanisms, whether flexibility markets or carbon traceability systems, requires asset owners and suppliers to contribute data that they may regard as sensitive and private. If participation entails giving up control over these data, many stakeholders will opt out, undermining the very scale and inclusivity that make the infrastructure valuable (Research Paper 3, Research Paper 5).

Data spaces or data ecosystems address the governance challenge at the inter-organizational level. A data space is a digital infrastructure in which multiple stakeholders share data for a common purpose while retaining individual control over what they share and with whom (Beverungen et al., 2022; Jarke et al., 2019; Otto & Jarke, 2019). Unlike conventional platform architectures, in which a central intermediary collects and redistributes data, data spaces implement data sovereignty through usage control policies and decentralized identity management that preserve the data provider's authority over downstream use (Beverungen et al., 2022; Möller et al., 2024). The International Data Spaces initiative and the European Gaia-X framework represent institutional attempts to instantiate this concept for industrial settings (Jarke et al., 2019; Otto & Jarke, 2019). For sustainability applications, the data-spaces model is attractive because it allows verification and coordination across organizational boundaries without requiring full transparency, thereby reconciling the competing interests of data providers and data consumers. Research in the data space and data ecosystem domain provides valuable guidance to design a trustworthy digital infrastructure that enables sovereign data sharing.

Trust is a central construct in the realm of verification and data ecosystems. In IS research, trust in data sharing has been studied as both a condition for participation and an outcome of system design (Agahari et al., 2022; Bélanger & Crossler, 2011). The review of Bélanger and Crossler (2011) about information privacy in IS established that individuals and organizations weigh the benefits of data sharing against perceived risks of loss of control. Agahari et al. (2022) extended this analysis to Multi-Party Computation (MPC) settings, demonstrating that trust depends on both privacy protection and control. Actors are more willing to share data when they retain meaningful authority over how it is used, even if the data become available to third parties. In the context of sustainability data infrastructures, this means that if stakeholders perceive participation as entailing irrevocable loss of control, they will not participate, despite any contractual protections. Another finding of Agahari et al. (2022) is that MPC might reduce the need for inter-organizational trust, however, requires trust into corresponding technology.

The IS contribution lies in designing technical and organizational mechanisms that make trust scalable without requiring it to rest entirely on interpersonal relationships or regulatory enforcement. Zero-Knowledge Proofs (ZKPs) and Self-Sovereign Identity (SSI) are two technologies that operationalize this design logic. ZKPs, originating in the work of Goldwasser et al. (2019), are cryptographic protocols that allow one party to prove the truth of a statement to another party without revealing any information beyond the fact that the statement is true. SSI frameworks allow individuals and organizations to manage their credentials in digital wallets and to share selectively verifiable claims with third parties, without relying on a central identity provider (Mühle et al., 2018; Sedlmeir et al., 2021). Together, these technologies make it possible to design sustainability data infrastructures in which verification does not require full disclosure. An asset owner can prove that an asset has a certain flexibility capacity without revealing its full operational profile, and a hydrogen producer can prove that its carbon intensity falls below a specified threshold without disclosing its proprietary production process.

Research Paper 3 addresses the flexibility integration challenge through a conceptual system design that combines a Multi-Agent System (MAS), SSI, and ZKPs. The paper is motivated by the observation that the integration of small-scale assets into grid management is beneficial to address the challenges of a volatile and decentralized energy system. Heat pumps, electric vehicles, rooftop photovoltaics, and battery systems are increasing in number, and their aggregate flexibility is essential for managing congestion in distribution networks that carry increasing shares of variable RE generation (Fridgen et al., 2020; Hirth & Glismann, 2018; Lind et al., 2019). Conventional redispatch processes were designed for large dispatchable plants and cannot scale to the heterogeneous, privacy-sensitive, and dynamically distributed landscape of prosumer resources (Research Paper 3).

The multi-agent component of the design enables distributed decision-making at the edge of the grid. Individual agents, operating as edge devices associated with specific assets, evaluate local flexibility, optimize device behavior according to owner preferences, and participate in coordination protocols without requiring a fully centralized control architecture (Research Paper 3). This matters because distributed flexibility assets are physically embedded in households, commercial buildings, and industrial sites, and their owners retain legitimate authority over their operation. A MAS architecture reflects the distributed nature of the problem and allows the system to be robust and scalable in settings with high-frequency, many-to-many interactions that would overwhelm centralized control (Research Paper 3).

The SSI component adds the sovereignty dimension. In the conceptual design, asset owners retain control over their credentials and operational data through digital wallets, which allow them to decide what information is shared, with whom, and for how long (Mühle et al., 2018; Sedlmeir et al., 2021). To clarify the underlying identity logic, the proposed architecture in Research Paper 3 builds on the SSI trust triangle depicted in Figure 3.1. In this paradigm, the holder, for example, an asset owner stores verifiable credentials in a digital wallet and decides which claims are disclosed to whom (Preukschat & Reed, 2021; Strüker et al., 2021). Those credentials are issued by a trusted issuer and can later be checked by a verifier through cryptographic signatures, so that the verifier can rely on the origin and correctness of the presented information without accessing the full underlying data set (Glöckler et al., 2023; Mühle et al., 2018). This is significant because the willingness of prosumers and small businesses to participate in formal redispatch arrangements depends critically on whether they perceive participation as compatible with their privacy interests. Research on consumer-centric electricity markets has found that privacy protection and data autonomy are essential design requirements for residential market participants (Michaelis et al., 2024; Parag & Sovacool, 2016). SSI operationalizes these requirements at the system level by ensuring that no central party accumulates operational data about asset owners without their explicit authorization.

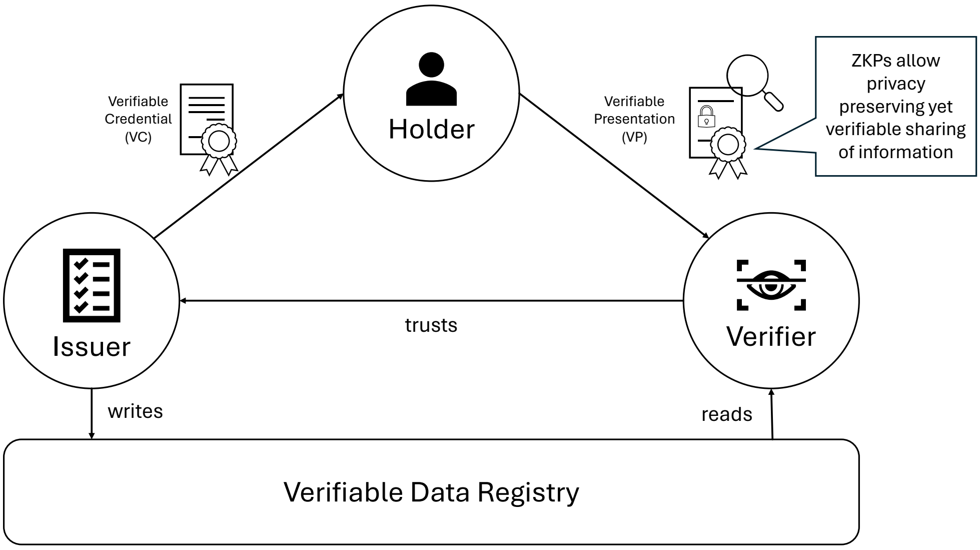


Figure 3.1: SSI trust triangle. *Source: Research Paper 3*

The ZKP component provides the verification layer that makes the sovereignty-preserving architecture credible to grid operators. ZKPs make it possible to prove claims about asset capabilities, such as the availability of a specific quantity of upward or downward flexibility within a defined time window, without revealing the underlying operational data that determine that capability (Goldwasser et al., 2019; Principato et al., 2023). In other words, ZKPs reduce the information burden on the asset owner while preserving enough evidential quality for the grid operator's dispatch decisions. This is the crucial IS design contribution of Paper 3. It demonstrates that trust between asset owners and grid operators does not need to rest on full data disclosure or on purely organizational relationships. Instead, trust can be partly substituted by cryptographic verifiability that is embedded directly in the data architecture.

Figure 3.2 illustrates the system design components and interfaces with the colored components and interfaces indicating the ones that have been developed as part of the system design within the research process, separated into MAS (green) and Robust Verifiability (yellow) enabled by ZKPs, SSIs and digital identities (Research Paper 3).

A case study included in the paper demonstrates the feasibility of the design, establishing how key sub-processes such as baseline optimization, aggregation, and disaggregation can be implemented in a realistic scenario involving distributed heating and electric vehicle assets (Research Paper 3). While the paper positions its contribution as conceptual, the prototype implementation provides initial evidence that the architecture is technically viable and that the privacy-verifiability trade-off can be managed through careful system design. The broader significance of Paper 3 lies in its contribution to the dissertation's golden thread. It explains how IS can make electrification operationally feasible at scale by designing the information infrastructure that al-

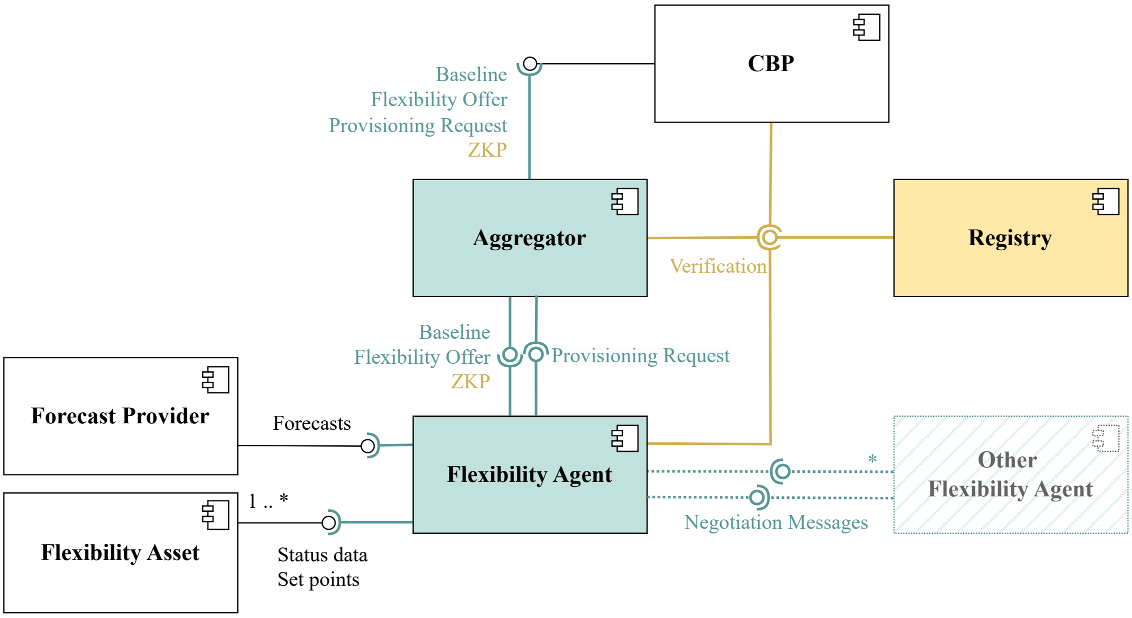


Figure 3.2: System design: components and interfaces. *Source: Research Paper 3*

lows distributed assets to be verified, mobilized, and remunerated fairly without forcing their owners to over-disclose sensitive information.

3.2 The Trust Diamond: Verifiability and Privacy in Energy Flexibility

Research Paper 4 develops the same problem from a complementary design-science angle (Babel et al., 2025). While Paper 3 proposes a conceptual system architecture, Paper 4 uses Action Design Research (ADR) based on Sein et al. (2011) to derive a more specific data-flow artifact and a set of design principles for energy flexibility provision. By working through a practical grid-management problem in collaboration with practitioners, the paper produces principles that can be evaluated and transferred to related settings beyond the original case and thus contributes more generally to design-science knowledge and data ecosystem research.

The paper's central conceptual contribution is the Trust Diamond, a framework that extends the familiar SSI trust triangle by explicitly incorporating the intermediary role of the aggregator (Mühle et al., 2018). The trust triangle in conventional SSI architectures involves three actors: an issuer, a holder, and a verifier (cf. Figure 3.1). In energy flexibility provision, a fourth actor, the aggregator, is structurally necessary. The aggregator bundles flexibility from multiple small-scale assets into market-ready products and communicates with grid operators on behalf of a portfolio of asset owners. The Trust Diamond illustrated in Figure 3.3 recognizes this four-actor structure and specifies how information flows among the parties in a way that satisfies the distinct information needs and privacy concerns of each.

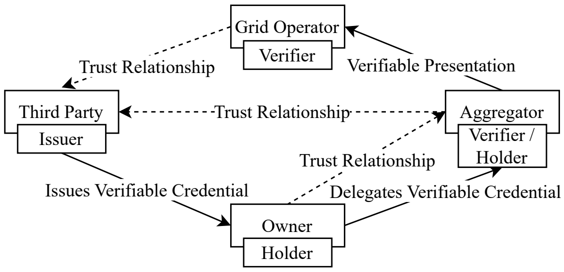


Figure 3.3: Trust diamond for energy flexibility provision. *Source: Research Paper 4*

The trust problem in this setting is inherently multi-stakeholder and cannot be addressed by a single bilateral architecture. Asset owners want privacy and autonomy; aggregators need operational coordination and accurate flexibility profiles; grid operators need verifiable information for secure dispatch decisions. These three sets of requirements are partially in conflict, and a one-size-fits-all transparency model cannot serve all of them simultaneously (Agahari et al., 2022). The Trust Diamond framework established in Research Paper 4 resolves this tension by structuring data sharing so that each actor receives only the information required for its functional role, while the rest remains hidden or abstracted through cryptographic means.

Two design principles are especially relevant in Research Paper 4. The first is Verifiability through Delegation: an aggregator can verify asset capabilities and forward trusted information to the grid operator without the grid operator directly accessing raw asset data. This design choice is conceptually notable because it shifts trust away from direct bilateral inspection toward a mediated architecture of authenticated delegation. The grid operator trusts the aggregator's attestation because it is cryptographically bound to verifiable credentials about the underlying assets, not because the grid operator has independent access to asset-level data. This is a new trust logic for IS. Trust is anchored in the architecture of verification rather than in access to raw information.

The second principle is Derived Sovereignty: data subjects retain control over their credentials, and downstream actors can only derive what has been explicitly authorized or cryptographically proved (Hummel et al., 2021). This principle operationalizes the data-sovereignty concept at the level of individual interactions within the system: each data-sharing event is bounded by the authorization structure encoded in the credential, and no actor can accumulate data beyond what is needed for its specified role. Together, these principles contribute to a new IS design concept for privacy-preserving coordination, one in which sovereignty does not undermine operational reliability and verifiability does not require full disclosure.

The ADR approach is also important theoretically because it turns a practical grid-management problem into generalized design knowledge that accumulates across the research program (Sein et al., 2011). The paper contributes to the broader IS discussion on trust, privacy, and data sharing in critical infrastructures (Agahari et al., 2022; Bélanger & Crossler, 2011; von Scherenberg et al., 2024). Beyond energy informatics, the Trust Diamond and its underlying principles are relevant to any multi-stakeholder data ecosystem in which a chain of delegated authority must be simultaneously trustworthy and privacy-preserving.

Papers 3 and 4 are best read together as a coherent research program on verifiable and sovereign energy data infrastructures. Paper 3 provides the system architecture; Paper 4 deepens the trust logic and makes the data flow explicit through design principles. Both papers target the same socio-technical tension: the need to mobilize distributed flexibility without forcing asset owners to over-disclose sensitive information. Their cumulative contribution to the dissertation's argument is that IS can mediate between verifiability and sovereignty, by designing architectures that achieve both simultaneously without the need to choose one over the other (Hummel et al., 2021).

3.3 Digital Product Passports for Hydrogen Supply Chains

Research Paper 5 shifts the application domain from electricity grids to hydrogen supply chains, but the underlying IS problem remains the same. In global low-carbon markets, buyers are willing to pay a premium for sustainable products only if those claims can be credibly verified (White et al., 2021). Without verification mechanisms, the market is exposed to the Akerlof lemons problem. If buyers cannot distinguish genuinely low-carbon products from conventional ones, they do not trust the quality of more costly products and are reluctant to pay a price premium (Akerlof, 1978). This dynamic is also observable in global hydrogen markets, where a lack of internationally recognized and technically credible certification schemes limits the willingness of buyers to pay premiums for low-carbon hydrogen and thereby weakens the investment case for electrolytic production powered by RES (White et al., 2021).

Hydrogen is especially interesting as low-carbon product because its carbon footprint is a latent attribute. It cannot be observed in the final product but depends on production pathways, energy inputs, conversion steps, transport modes, and storage conditions that are distributed across a long and geographically distributed supply chain (L. Li et al., 2019; Seo et al., 2020). Figure 3.4 illustrates different hydrogen supply chain options. This creates a multi-dimensional information asymmetry problem that challenges certification systems. Different certification standards are characterized by e.g. a different baseline for what counts as low-carbon hydrogen or a different understanding on where in the supply chain the carbon footprint is measured. Moreover, claimed carbon information is often based on average data that may not reflect actual operating conditions. The result is that sustainability claims are vulnerable to strategic misrepresentation and complicates the emergence of true low-carbon hydrogen markets (Research Paper 5).

Research Paper 5 develops six design principles for a hydrogen DPP through a structured literature review and expert interviews. DPPs in general are intended to serve as tools enabling the traceability of sustainability aspects (Adisorn et al., 2021), and thus enable sustainable supply chains (K. Berger et al., 2022). The principles for a hydrogen DPP established in Research Paper 5 are *holistic data capture, data privacy, decentralized data administration, forgery-proof data, automated passport processing*, and *interoperability*. Together, these principles describe what a sustainability-

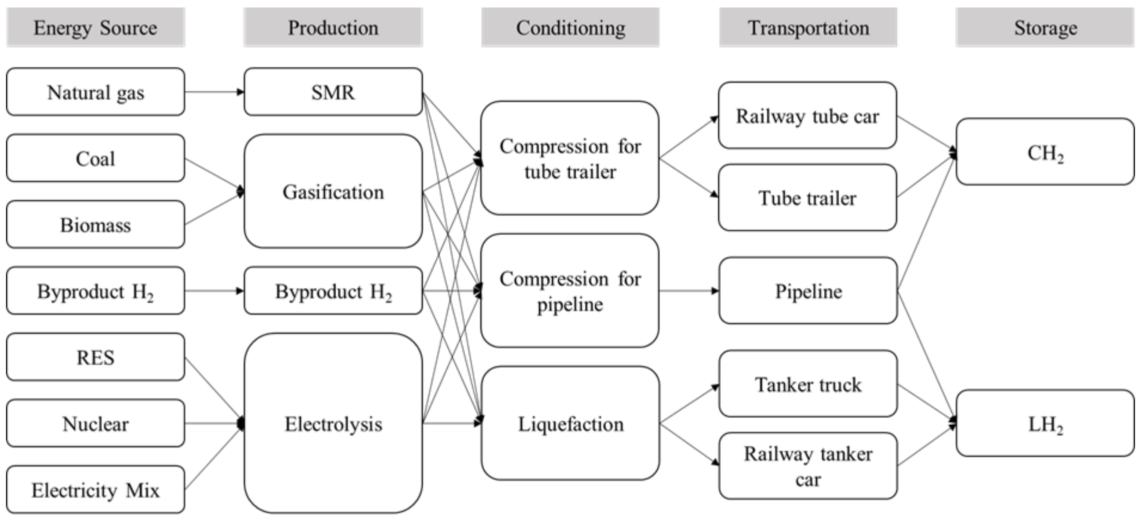


Figure 3.4: Hydrogen Supply Chain Options. *Source: Research Paper 5*

data infrastructure must do to overcome information asymmetries in supply chains. Holistic data capture ensures that relevant emissions data are collected along the full chain rather than only at selected nodes, addressing the coverage problem that makes point-in-time auditing inadequate. Data privacy preserves the willingness of actors to participate by limiting disclosure of sensitive process or cost information, applying the same sovereignty logic that underpins Papers 3 and 4. Decentralized data administration reduces dependence on a single trusted intermediary and lowers the risk of single points of failure, aligning with the data-spaces model of multi-party data governance (Beverungen et al., 2022; Otto & Jarke, 2019). Forgery-proof data and automated passport processing address data integrity and update reliability, reflecting the insight from cryptography and IS security research that technical tamper-resistance can substitute for organizational trust in settings where manual auditing is impractical. Interoperability ensures that the DPP can connect to existing systems and certification schemes, a requirement that becomes critical in a global hydrogen market in which buyers, sellers, and regulators operate under different national frameworks and standards (Jarke et al., 2019).

The theoretical significance of Paper 5 lies in its integration of traceability, data sharing, and privacy within a unified design framework. The DPP serves as a socio-technical artifact that enables compromise between competing stakeholder interests. Suppliers may fear disclosure of cost structures or proprietary production methods; buyers and regulators require credible evidence of emissions intensity; logistics providers have incentives to minimize the reporting burden (Agahari et al., 2022; Beverungen et al., 2022). The DPP design principles navigate these competing interests by specifying an architecture in which each stakeholder shares the minimum necessary data while the aggregate DPP provides sufficient evidence for pricing and regulatory purposes. The DPP-system therefore functions as an inter-organizational trust infrastructure that enables a market for low-carbon hydrogen by making the sustainability attributes of products both visible and verifiable.

3.4 Design Decisions for Verifiable Data Sharing

Research Papers 3 through 5 establish the following unified contribution: digital infrastructures can be designed to make sustainability data simultaneously verifiable and sovereign, thereby resolving the information asymmetries that otherwise limit participation, trust, and market formation in sustainability transformations. The Research Papers 3 and 4 explain how distributed energy flexibility can be coordinated through MAS, SSI, and ZKPs while preserving the privacy and sovereignty of asset owners. Research Paper 5 develops design principles which support supply-chain traceability in low-carbon markets. Across all three papers, the same design logic recurs: collect only what is necessary, verify what is claimed, and preserve control over what is disclosed. This logic is a direct IS response to the agency-theoretic problem identified by Eisenhardt (1989) and the market-failure dynamic analyzed by Akerlof (1978). When information asymmetries cannot be resolved by market mechanisms or organizational hierarchies, IS-based system designs can provide a third path through selective disclosure enabled by cryptographic verification.

Section 2 motivated the need for sustainable energy systems, identified digital infrastructure as a necessary enabler of the energy transition and called for suitable IS-solutions to among others enable the integration of flexibility assets. The present section addresses this call and specifies the IS design characteristics that such infrastructure must have. Decentralized data spaces in which multiple stakeholders share data for common sustainability goals while retaining sovereignty over their contributions; SSI-based identity management that binds verifiable claims to cryptographic credentials; and ZKP-based verification that allows truth to be demonstrated without revealing the data that support it.

The IS contribution lies precisely in designing socio-technical artifacts that align data governance, cryptographic mechanisms, and stakeholder incentives so that sustainability data can travel across organizational boundaries without losing credibility or violating sovereignty (Beverungen et al., 2022; Hummel et al., 2021; Otto & Jarke, 2019). This requires understanding the information-theoretic and organizational conditions under which selective disclosure is both technically feasible and institutionally accepted. The trust models developed in Papers 3 and 4, and the design principles articulated in Paper 5, collectively constitute a set of IS-grounded answers to this question.

Looking forward, this design logic also informs the subsequent sections of the dissertation. The verifiability and sovereignty principles developed here are not restricted to the use case of energy flexibility and hydrogen traceability. They are general conditions for data-driven sustainability transformation in any multi-stakeholder setting in which actors must contribute sensitive data to achieve collective sustainability goals. Digital decarbonization requires information infrastructures that enable privacy-preserving verification mechanisms, for which this section established a central foundation. Building on this, it is equally important to consider the necessary organizational capabilities in order to actually use the data collected through these established infrastructures.

4 Organizational Capabilities for Sustainability Data Use

The preceding section established that sustainability data infrastructures are a necessary condition for data-driven sustainability transformation. Nevertheless, the infrastructure alone is not a sufficient prerequisite to actually use the data to drive sustainability transformation. In IS research it has long been recognized that digital technologies and data do not create value by themselves; rather, value emerges when organizations develop the complementary capabilities to interpret, manage, and act on them (A. S. Bharadwaj, 2000). This insight connects closely to the IT productivity paradox literature, which established that technology investments do not automatically translate into performance gains unless they are accompanied by appropriate organizational and managerial capabilities (Brynjolfsson, 1993). In other words, infrastructure provides the informational potential, but capability turns potential into use.

This tension is also observable in the sustainability domain. Driven by regulatory pressure from the CSRD, the EU Taxonomy, and the Sustainable Finance Disclosure Regulation, many organizations have built sustainability data infrastructures that collect and report environmental, social, and governance information (Körner, Leinauer, et al., 2025). Yet the strategic potential of these data remains only partially realized. Much of the data is reported upward, archived in compliance systems, or fragmented across functions, while its use for e.g. investment steering, operational optimization, portfolio redesign, and new business model development remains limited (Püchel et al., 2024). The challenge is therefore to go beyond the collection of more sustainability data and to orchestrate it so that it becomes a meaningful organizational resource for decision-making and transformation (Research Paper 6, Research Paper 7).

This section marks the transition from Section 3 to Section 4 in the dissertation's overall argument. Section 3 focused on the design of data infrastructure, that is, on how sustainability data can be collected, verified, shared, and made technically accessible. Section 4 turns to the organizational side and asks how such data can actually be leveraged for value creation. The section therefore shifts from an IS design logic to an organizational capability logic, showing that the value of sustainability data depends on how organizations structure, bundle, and leverage it in practice (Research Paper 6, Research Paper 7).

4.1 Orchestrating Sustainability Data for Value Creation

Research Paper 6 addresses this problem through the lens of Resource Orchestration Theory (ROT), which extends the Resource Based View (RBV) by emphasizing not only the possession of valuable resources, but the managerial actions through which resources are structured, bundled, and leveraged to create value (Sirmon et al., 2007, 2011). In the classical RBV, sustained advantage depends on resources that are valuable, rare, imperfectly imitable, and non-substitutable (Barney, 1991). ROT adds a dynamic and processual perspective by showing that resources only become productive when managers actively configure them through structuring, bundling, and leveraging processes (Sirmon et al., 2007, 2011). Structuring refers to acquiring, accumulating, and divesting resources; bundling refers to stabilizing, enriching, and pioneering combinations of resources; and leveraging refers to mobilizing, coordinating, and deploying those resources in ways that create value.

Applied to sustainability data, this means that data should not be treated as an inert reporting output. Research Paper 6 conceptualizes sustainability data as a latent strategic resource whose value depends on the quality of orchestration. The paper argues that organizations often possess data that is potentially valuable, but which remains underutilized because the technological, managerial, and cultural conditions for use are missing or only partially developed. To address this gap, the paper develops the SDM-MM, which translates ROT into an organizational capability framework for sustainability data use as presented in Table 4.1.

The SDM-MM operationalizes orchestration through four interdependent capability dimensions: Infrastructure, Data, Management, and People (Research Paper 6). The Infrastructure dimension captures the technological foundations for collecting, storing, integrating, and automating sustainability data. The Data dimension concerns quality, comparability, access, analytics, and verification. The Management dimension addresses strategic anchoring, leadership commitment, governance, and accountability. The People dimension captures transformation management, data and sustainability literacy, interdisciplinary expertise, and organizational culture. The SDM-MM as a whole describes in which dimensions and capability areas organizations must mature in order to move from reactive, compliance-oriented data practices toward strategically embedded and transformation-oriented sustainability data management.

Research Paper 6 and its development of the SDM-MM contributes to ongoing IS debates about sustainability data management. Prior work in this area has either examined data management as a primarily technical and governance-oriented capability or assessed sustainability maturity at a strategic level without addressing the underlying data foundations (Kotlarsky et al., 2023; Krasikov & Legner, 2023; Püchel et al., 2024). By operationalizing ROT in the sustainability data domain, the SDM-MM bridges this fragmentation and provides an integrative artifact of how data is structured into a verifiable and adaptable resource portfolio, bundled with governance rules, analytical tools, and human expertise into socio-technical capabilities, and leveraged through strategic anchoring, leadership commitment, and incentive alignment to produce sustainability and business value (Research Paper 6). This also responds to the call by Püchel et al. (2024) for deeper understanding of how organizations can move beyond compliance-oriented reporting and leverage sustainability data as a driver of proactive transformation, a question that prior IS contributions focusing on specific system types or data governance mechanisms had left insufficiently addressed (Krasikov & Legner, 2023; Schoormann et al., 2022).

The maturity model also helps sharpen the dissertation's core argument. Organizations that treat sustainability data purely as a compliance resource remain in a reactive mode of action. They

Table 4.1: The SDM-MM enabling organizational sustainability. *Source: Research Paper 6*

	Capability Area	Question	Optimized Maturity
Infrastructure	**Digital Infrastructure & IT Systems**	How modern and scalable is your organization's IT infrastructure for collecting, storing, and managing sustainability data?	A fully centralized, cloud-based, scalable infrastructure is in place. All interfaces and data pipelines have been fully implemented.
	Connected Systems & Integration	To what extent are systems networked with each other to enable the integration of data across systems?	Systems are networked with each other and with internal and external data sources.
	Automation & Process Digitization	How extensively are sustainability-related processes mapped and automated in your organization?	All relevant sustainability processes have been fully digitized and automated.
Data	**Data Collection & Availability**	How systematically and consistently is sustainability data collected across all organizational units, and how readily available is this data for analysis?	All sustainability data is systematically and automatically collected from every unit. This data is standardized and made available in real time for analysis and decision-making purposes.
	Data Storage & Access Management	How clear and compliant is your organization's data storage and access management with regard to internal and external sustainability data?	Sustainability data is stored in secure, scalable systems. There are formal guidelines for versioning, archiving, and retention. Robust access management ensures seamless handling of internal and external approvals.
	Data Analytics & Presentation	How advanced and comprehensive are your organization's analytical activities with regard to sustainability data, and how is this data prepared for decision-making purposes?	Future-oriented analyzes are used systematically. The results are visualized in a user-friendly manner to support targeted decision-making at all levels.
	Data Quality & Verification	To what extent are data standards, verification procedures, and responsibilities for sustainability data established to ensure quality, consistency, and reliability?	Comprehensive data standards and verification procedures have been integrated. Clear responsibilities ensure the reliability of sustainability data.
Management	**Strategy**	To what extent are sustainability efforts anchored in strategic goals, and to what extent is data used for this purpose?	The use of sustainability data is firmly rooted in the strategy, which has clear objectives. Insights from this data guide long-term planning, innovation, and business model adjustments.
	Leadership	To what extent do managers promote sustainability data projects, for example by providing resources?	Managers actively promote a data-driven culture and allocate resources to develop advanced capabilities for using sustainability data in a value-adding way.
	Governance & Collaboration	How clearly are the roles, responsibilities, guidelines, and cooperation between data management and sustainability management defined?	Roles, responsibilities, and guidelines are clearly defined and transparently implemented. Data is shared systematically internally and externally to promote cross-functional collaboration, process improvements, and innovation.
People	**Transformation Management**	To what extent are sustainability data used and how are employees made aware of them, in order to identify and promote opportunities for improvement and transformation?	Sustainability data is an integral part of all improvement and transformation initiatives. Comprehensive change management increases employee awareness of these processes.
	Employees & Expertise	Do employees have sufficient expertise, and are there systematic recruiting and training measures in place to ensure that sustainability data is handled in a way that adds value?	Data literacy is broadly established. Experts and comprehensive training measures ensure data-driven decision-making and cross-functional linking of data and sustainability.
	Culture	To what extent does the organizational culture promote data-driven decisions for sustainability, and how important are data and transparency?	The organizational culture prioritizes data-driven sustainability decisions. Data and transparency are core values that promote trust and continuous improvement.

may satisfy disclosure requirements, but they do not fully address the information asymmetries that motivate this dissertation. Only when sustainability data is actively orchestrated as a strategic resource can it support benchmarking, comparison, learning, and action. In that sense, the SDM-MM demonstrates how organizations can convert sustainability data from a passive asset into an active resource for sustainability transformation (Research Paper 6).

Beyond its contributions to IS research, the SDM-MM carries direct practical implications. The paper provides 20 action recommendations, grouped along its four dimensions, that translate maturity assessments into targeted developmental steps. Across the Infrastructure dimension, the recommendations emphasize building a resilient and integration-ready data backbone, eliminating manual data handling through automation, and designing suitable interfaces for data to be actionable for its intended users. Within the Data dimension, the recommended actions focus on preventing selective data use, increasing comparability across time horizons and organizational units, translating sustainability metrics into decision-relevant insights, and systematically linking sustainability data with financial and operational data. At the Management level, the recommendations call for anchoring sustainability data initiatives in corporate strategy, demonstrating sustained leadership commitment, establishing clear data ownership and stewardship roles, and treating sustainability data governance as an ongoing organizational process rather than a one-off reporting exercise. The People dimension foregrounds transformation management, organization-wide data and sustainability literacy, cross-functional understanding of data interdependencies, and the creation of protected spaces for experimentation and learning. Considered collectively, these 20 actions in Research Paper 6 constitute a prescriptive developmental roadmap that complements the diagnostic function of the model and enables organizations to identify prioritized capability-building paths (Becker et al., 2009; Pöppelbuß & Röglinger, 2011).

4.2 Resourcing ESG Data in Practice

Research Paper 7 complements the prescriptive logic of ROT with a more practice-oriented contribution of how sustainability data becomes valuable in organizational life. Its theoretical lens is the resourcing perspective, which emphasizes that resources are not fixed objects but are constituted through ongoing organizational action (Feldman, 2004; Howard-Grenville, 2007). In the resourcing view, value does not reside in the data itself, nor simply in its ownership. Rather, value emerges through the ways actors enact data in routines, interpretive schemas, and coordinated practices (Feldman, 2004).

Where Research Paper 6 applies the ROT-lens to highlight the need of orchestration of resources for value creation, the resourcing theory in Research Paper 7 provides the perspective to assume that data is not even a resource until it becomes one through organizational practices. The paper uses this lens in a single case study of *ESG-Data&Analytics*, a shared digital platform within the Genossenschaftliche FinanzGruppe (GFG), a cooperative network of around 672 financial institutions. Following the case study approach based on (Yin, 2014), the research case examines how ESG data, initially collected for compliance purposes, is repurposed through coordinated practices into a resource for strategic decision-making and sustainability transformation.

The empirical findings of Research Paper 7 reveal that the platform does not create value simply by aggregating ESG data. Rather, value emerges through network-level data practices such as standardized KPI definitions, peer benchmarking, scenario simulation, and shared visualization. These practices transform distributed and fragmented data points into a centralized and comparable information base. This enables financial institutions to reassess climate-related financial risks, develop decarbonization roadmaps, and inform lending and investment decisions in a more anticipatory way. In that sense, the platform under study shifts ESG data from a retrospective reporting input to a forward-looking strategic resource (Research Paper 7).

This finding demonstrates that compliance-driven data infrastructures can be repurposed for e.g. strategic risk management and economic sustainability. The case illustrates that infrastructures originally established for reporting can be made productive for sustainability management when they are embedded in routines that support transparency, interpretation, and target-oriented action. Research Paper 7 presents the adjusted resourcing model based on previous work of Auschra and Sydow (2023) and adapts it to ESG data purposes as illustrated in Figure 4.1

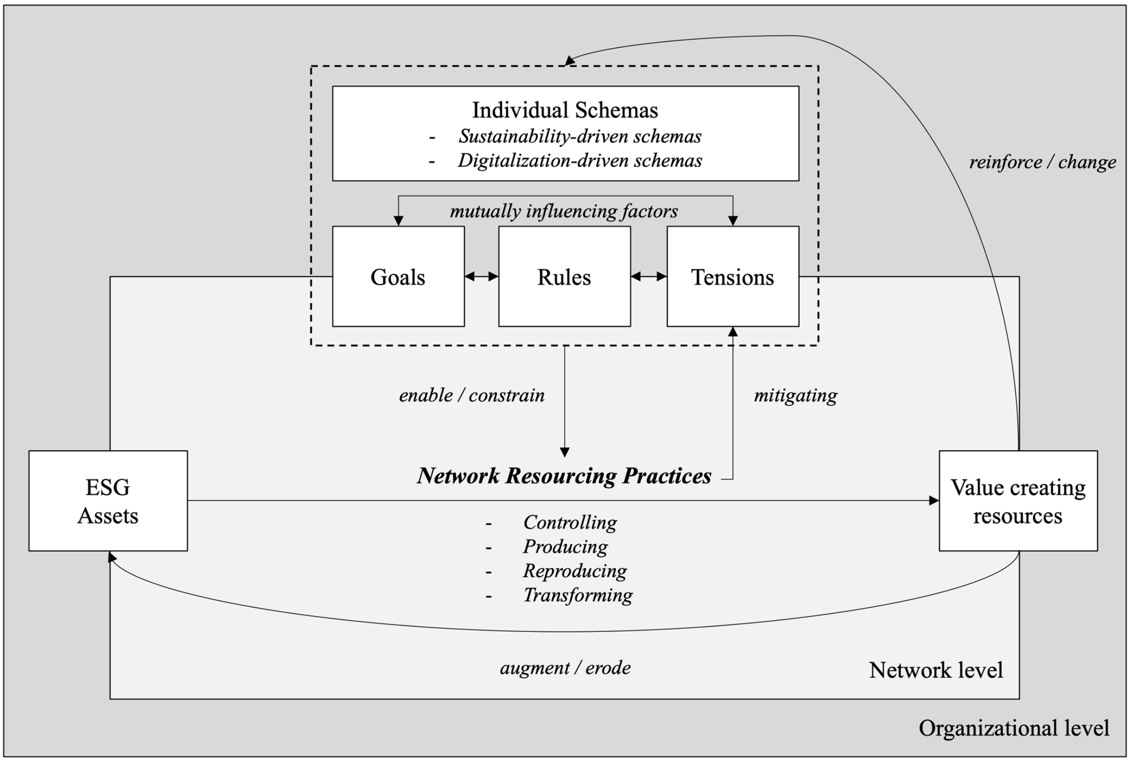


Figure 4.1: The Model of ESG-Data Resourcing. *Source: Research Paper 7*

In practical terms, this means that the strategic value of ESG data depends less on the mere existence of data but rather on whether it is mobilized across organizational boundaries in ways that enable common standards, shared learning, and strategic decision-making. The resourcing perspective thus explains how value is created and why similar data infrastructures may produce very different outcomes across organizations depending on their resourcing practices.

A second contribution of the case concerns the role of the network. In the cooperative financial network, individual institutions cannot easily create strategic value from ESG data on their own because the data is distributed, heterogeneous, and only partially comparable. The shared platform becomes valuable precisely because it enables network-level coordination. Standardization, shared governance, and collective data practices allow the institutions to compare themselves, identify risks, and align actions (Auschra & Sydow, 2023). This is a crucial extension of the sustainability data discussion, because it demonstrates that value creation may depend on interorganizational orchestration rather than individual firm-level capability.

The case also highlights the social dimension of resourcing. Research Paper 7 reveals that data literacy, trust in technology, and sustainability values shape whether ESG data is actually mobilized for strategic purposes. Thus, even in a digitally mediated network, data value is not purely technical. It depends on how actors perceive the reliability, relevance, and legitimacy of data outputs, and on whether they are willing to use them in decision-making. This aligns well with broader IS research on how sensemaking, affordances, and socio-technical practices shape sustainable organizing (Seidel et al., 2013).

4.3 Sustainability Data as Valuable Resources

Taken together, Research Paper 6 and Research Paper 7 offer complementary theoretical views on organizational capability for sustainability data use. ROT, as used in Research Paper 6, offers a prescriptive framework that specifies what kinds of capabilities organizations need and how those capabilities can be systematically developed over time in order to orchestrate data as value creating resources and leverage their potential (Sirmon et al., 2011). The SDM-MM is especially useful for diagnosing maturity gaps, supporting capability development, and relating sustainability data management to broader strategic value creation.

The resourcing perspective, as used in Research Paper 7, provides a perspective on how value actually emerges from data in practice (Feldman, 2004; Howard-Grenville, 2007). It explains how routines, shared interpretations, and coordinated practices transform data from a formal compliance asset into a usable and valuable resource. It therefore functions as the social mechanism behind value creation.

The two lenses are especially powerful when considered together. ROT foregrounds the organization as an intentional actor that orchestrates resources, while resourcing theory foregrounds the necessary practices and routines through which resources gain meaning and utility (Research Paper 6, Research Paper 7). Collectively, the theory lenses provide relevant insights to understand how to leverage and mobilize sustainability data in organizations for value creation and sustainability transformation.

This complementarity also strengthens the dissertation's central argument. The information asymmetries discussed in earlier sections need a suitable digital infrastructure and the corresponding necessary capabilities to make use of this infrastructure. Infrastructure for privacy-preserving data sharing creates the possibility of access and verification while accounting for the need of sovereignty and confidentiality. Additionally, organizations still need the capability to interpret, compare, and act on sustainability data strategically. Research Paper 6 and Research paper 7 demonstrate that this capability can be developed through deliberate and coordinated effort. At the organizational level, maturity must increase through better infrastructure, data management, leadership, and culture (Research Paper 6). At the network level, data must be enacted through shared routines, common metrics, and collective sensemaking (Research Paper 7).

This leads directly to the transition into Section 5. Once infrastructure and capability are both understood, the dissertation can move to the question of how IS contribute to sustainability transformation when applied by capability-mature organizations. Section 5 therefore integrates the infrastructural perspective of Section 3 with the organizational capability perspective developed here. The next step is to establish how IS, when embedded in mature organizational settings, enable sustainability transformation in more concrete ways.

5 IS-enabled Sustainability Transformation & Digital Decarbonization

As demonstrated in the previous sections, the dissertation explores different layers of how IS support sustainability. Section 3 exhibited that sustainability transformation depends on verifiable, sovereign data infrastructures capable of reducing information asymmetries across energy systems, hydrogen supply chains, and digitally documented products. Section 4 then shifted attention to the organizational side of this challenge, demonstrating that infrastructure alone is insufficient. Organizations must also develop the capabilities to orchestrate sustainability data as a strategic resource and to enact it through shared routines, governance structures, and collective sensemaking. Section 5 builds on both of these foundations. It examines how specific digital technologies, applied within capability-mature organizations and embedded in trustworthy data architectures, enable sustainability transformation in concrete practice. This final analytical section therefore integrates the infrastructural perspective of Section 3 with the capability perspective of Section 4, and extends both toward a broader understanding of IS-enabled sustainability transformation.

5.1 IS as Enablers of Sustainability Transformation

Sustainability transformation is not only a matter of setting targets or generating data. It depends on whether organizations can turn sustainability-related information into shared understanding, target-oriented action, and changed work practices. This is where IS become central (Kotlarsky et al., 2023; Watson et al., 2022). They help reduce information asymmetries by making sustainability-relevant data visible, comparable, and actionable across organizational levels and between actors who would not otherwise have access to the same information (Research Paper 5).

This argument builds directly on the dissertation's earlier sections. Section 3 illustrated that data often remains fragmented across systems, functions, and organizational boundaries, and that this fragmentation limits the emergence of new markets (e.g. for flexibility or low-carbon products) as well as the ability of organizations to assess their performance, learn from it, and act on it strategically (Breiter et al., 2024). In response, the dissertation argued for digital infrastructures and organizational capabilities that make sustainability data verifiable and usable beyond regulatory reporting (Püchel et al., 2024). The present section takes this argument one step further by focusing on how IS enable sustainability transformation through the conditions under which information asymmetries are reduced and sustainability-relevant decisions can be made on a more informed basis.

This perspective is consistent with foundational Green IS research. Prior work demonstrates that IS contribute to sustainability through efficiency gains and through their role in changing beliefs, decisions, and practices. Melville (2010) establishes the belief-action-outcome framework which links information to sustainability outcomes through the way it shapes beliefs, enables actions, and makes results visible. Seidel et al. (2013) extend this view by illustrating that IS create functional affordances that support reflective disclosure, information democratization, output management, and delocalization. These affordances are analytically important because they clarify how IS can alter what organizations know, who can access that knowledge, and how it is used in practice.

For this dissertation, the key point is that these affordances also help reduce information asymmetries of the kind that Section 3 addressed at the infrastructure level. Disclosure improves visibility into current processes and their environmental consequences and enables the integration of stakeholders in certain markets. Privacy-preserving data sharing facilitates the integration of small-scale flexibility units, thereby increasing the share of RES in modern energy systems (Research Paper 3, Research Paper 4). DPPs support the verification of sustainability claims about goods, fostering the emergence of low-carbon markets, and drive product and process design improvements across value chains through enhanced information availability (Research Paper 5). When organizations gain visibility into the ESG impacts of their portfolios and can assess their relative standing against industry benchmarks, they are better positioned to manage risks and pursue a coherent long-term investment strategy aligned with sustainability objectives (Research Paper 7). Together, these mechanisms make sustainability transformation more feasible by connecting information flows with organizational change across boundaries.

This is also where the twin transformation perspective becomes relevant. Organizations undergoing sustainability transformations do not face digital and sustainability challenges in isolation. Both transformations interact. Digital capabilities raise the ambition level of what sustainability programs can achieve, while sustainability goals provide concrete direction for digital investment (Breiter et al., 2024; Christmann et al., 2024). The dissertation's papers reflect this interaction throughout. Research Papers 3 and 4 established that verifiable data sharing architectures create the market conditions under which distributed energy assets can be monetized and flexibility can be coordinated at scale. Research Paper 5 demonstrated that DPPs enable not only regulatory transparency but also new forms of competitive differentiation in low-carbon markets. Research Papers 6 and 7 revealed that organizational maturity in sustainability data management is both a digital capability and a sustainability capability, and that the two should be developed integratively. Section 5 integrates these insights by treating IS-enabled sustainability transformation as a socio-technical process in which digital infrastructure and organizational capability work together.

The more recent sustainability data literature reinforces this framing. Studies on ESG data management find that organizations frequently have access to large amounts of potentially useful sustainability data, but struggle to integrate, standardize, and govern it in ways that support action (Krasikov & Legner, 2023; Püchel et al., 2024). These findings reinforce the dissertation's central argument. The primary challenge lies not solely in the availability of data, but rather in the organizational capability to transform this data into knowledge and subsequently act upon it. The importance of IS lies in its role in facilitating data sharing and providing organizations with the support they need to make informed decisions regarding transformation.

Against this background, the present section introduces Research Paper 8 and develops the next analytical step. If sustainability transformation depends on reducing information asymmetries through both infrastructure and capability, then the relevant question is how specific digital technologies operationalize this process in concrete business contexts. This shifts attention from sustainability data as a reporting resource to IS as transformation infrastructures that reach into the daily operations of organizations. It also provides the bridge to the question of how IS-enabled sustainability data management and process-level analytics create strategic value by improving transparency, coordination, and decision support across organizational and sectoral contexts (Püchel et al., 2024; Ströher et al., 2025).

5.2 Process Mining for ESG Use Cases

Process mining is a technology discipline that leverages digital event logs from enterprise systems, and workflow platforms to reconstruct, analyze, and improve actual business processes. Its foundational promise is to discover, monitor, and improve real processes rather than assumed ones by extracting knowledge from the event data that organizations already generate as part of routine operations (Grisold et al., 2020). This makes process mining especially relevant for sustainability, because many ESG-relevant processes leave rich digital traces that are rarely analyzed for sustainability purposes. Procurement, logistics, maintenance, HR, compliance, and reporting processes all generate data that can be used to identify inefficiencies, deviations, and patterns with ESG relevance (Püchel et al., 2024; vom Brocke et al., 2013a). In this sense, process mining extends classical business process management by turning operational execution data into a source of sustainability intelligence.

Research Paper 8 advances this perspective through a six-round Delphi study with 24 experts from academia and industry across nine countries. The study identified and evaluated 30 distinct process mining use cases for ESG, rated according to desirability, feasibility, and viability. The empirical contribution is significant because it moves the discussion beyond isolated demonstrations toward a more systematic understanding of how process mining can support ESG management across all three sustainability dimensions.

The environmental dimension contains use cases that show how process mining can support resource optimization, emissions monitoring, and environmental compliance. Examples include reducing resource consumption in processes, monitoring water usage, minimizing energy consumption, reducing manufacturing waste, optimizing maintenance cycles, reducing logistics-related emissions, and determining the carbon footprint and greenhouse gas emissions of specific products. These cases are compelling because they build directly on process data that organizations already possess, and because many environmental impacts are operationally embedded in process execution. Process mining can, for instance, reveal energy-intensive process steps, inefficiencies in machine usage, or excessive transport emissions, and it can thereby support targeted decisions about when, where, and how to intervene. This connects closely to the dissertation's Section 3, because environmental process transparency becomes substantially stronger when process mining is combined with verifiable sustainability data architectures such as DPPs and digitally traceable reporting infrastructures (Research Paper 5, Research Paper 8).

The social dimension broadens the scope of process mining beyond traditional environmental use cases. The Delphi panel identified use cases related to employee well-being, fair process auditing, and social compliance in supply chains. These include enhancing workplace health and safety, improving employee job satisfaction, optimizing workload and task distribution, advancing diversity, equity, and inclusion, and monitoring compliance with human rights and labor standards. These use cases illustrate that apart from environmental aspects process mining for sustainability also encompasses labor conditions, fairness, and the protection of people within and across organizational processes. At the same time, the study finds that social use cases are often more difficult to implement because they require sensitive data, more complex stakeholder constellations, and more careful legal and ethical handling.

The governance dimension reveals a further major area of opportunity. The identified use cases include process compliance monitoring, anti-corruption and anti-fraud detection, transparency enhancement, and ESG reporting accuracy. Concrete examples are detecting financial fraud, preventing corruption, improving compliance with standards and regulations, strengthening data privacy and security practices, and facilitating more accurate ESG reporting. These cases demonstrate that process mining is also useful for strengthening the reliability and credibility of governance structures. This is valuable in sustainability contexts, where organizations increasingly face scrutiny over whether their reported ESG claims are supported by actual process behavior. Process mining can therefore function as a control and verification mechanism that supports trustworthy governance, reinforcing the verifiability logic developed in Section 3 at the operational process level.

A central finding of Research Paper 8 is that experts rated process mining use cases as highly desirable across all ESG dimensions, while feasibility and viability varied considerably, as illustrated in Figure 5.1. In that figure, dot size reflects the degree of desirability, with larger dots corresponding to even higher ratings. Feasibility and viability, by contrast, are represented along the respective axes. The panel strongly recognized the relevance of process mining for ESG goals yet also identified meaningful implementation constraints. Environmental use cases were generally judged more feasible and more viable than social and governance use cases, which aligns with the fact that environmental process data are often more readily available and less legally sensitive. The study also found a strong positive correlation between feasibility and viability, and it grouped the use cases into three categories: Quick Wins, Happy Medium, and Long Shots. This classification is especially useful for the dissertation because it operationalizes a key insight from the capability chapters in Section 4. Desirability alone does not produce transformation. Data availability, organizational readiness, governance arrangements, and cross-functional alignment determine whether a sustainability technology can actually be deployed. Organizations should therefore begin with Quick Wins that combine high desirability with relatively strong feasibility and viability, particularly in environmental process areas where data are often already available, and build toward more complex social and governance use cases as their data governance and organizational maturity increase (Research Paper 6, Research Paper 7, Research Paper 8).

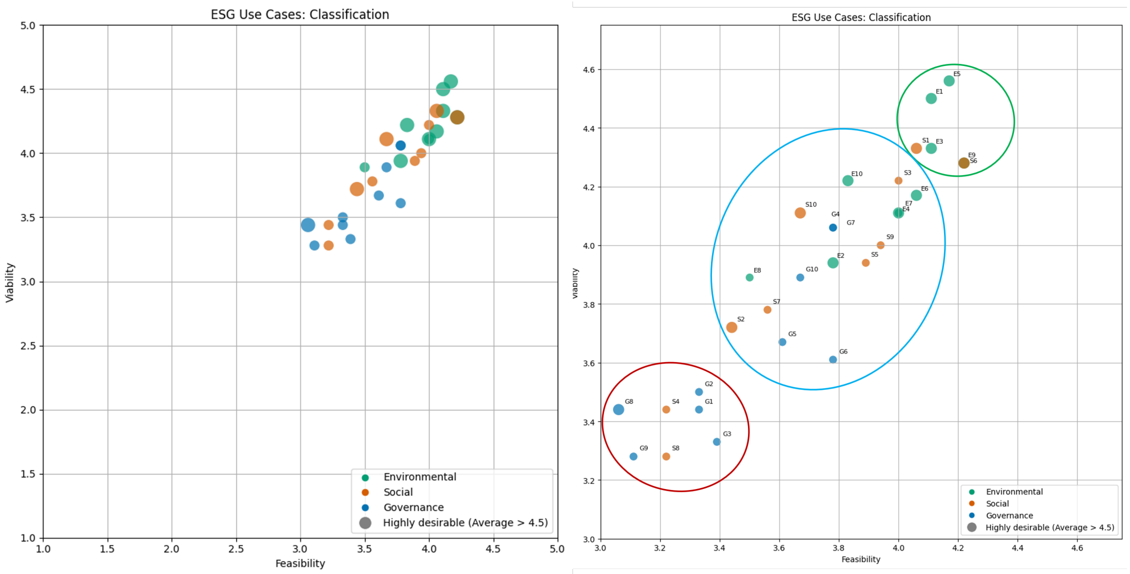


Figure 5.1: Overview of ratings and resulting clusters in all three ESG dimensions (right-hand side is zoomed in). *Source: Research Paper 8*

5.3 Broader Domains of IS-enabled Sustainability Transformation

The process mining analysis in Research Paper 8 illustrates what is possible when operational process data is combined with analytical capability and mature data governance. This potential, however, extends well beyond process mining as a single technology. The dissertation's broader argument is that IS-enabled sustainability transformation follows a generalizable logic across diverse application domains: verifiable and interoperable data architectures reduce information asymmetries between actors, organizational capabilities convert data into usable knowledge, and digital technologies operationalize sustainability in concrete processes. The following examples illustrate how this logic applies across several domains that are central to the decarbonization agenda, and in doing so they position the dissertation's contributions within a broader landscape of IS-driven sustainability change.

Circular economy transitions represent one of the most demanding sustainability transformations in terms of information requirements. Designing products for disassembly, enabling remanufacturing, and closing material loops across multiple actors and product generations all require detailed, verifiable, and persistent product-level data that follows materials across their entire lifecycle (Zeiss et al., 2021). This is precisely the problem that DPPs, as developed in Research Paper 5, are designed to address. Beyond hydrogen supply chains, DPPs are increasingly discussed as a digital backbone for circular economy governance more broadly, enabling recyclers, remanufacturers, and regulators to access the material composition, component history, and environmental footprint of products that were manufactured years or decades earlier (Jensen et al., 2024; Reich et al., 2025; Singh et al., 2026). The information asymmetry between those who produced a product and those who later process it at end-of-life is one of the central barriers to realizing circular economy ambitions. IS that store, share, and verify this information in a trusted and privacy-preserving way are therefore necessary infrastructure for a circular economy. The design principles established in Research Papers 4 and 5 apply directly: holistic data capture, selective disclosure, and interoperability between actors are just as important for circular material flows as they are for energy flexibility or hydrogen certification.

In a similar context, sustainable supply chain management represents a further major domain in which IS perform a central enabling role. Global value chains generate complex and layered information asymmetries between buyers, suppliers, logistics providers, auditors, and regulators (Asante et al., 2022; Saberi et al., 2019). Carbon footprint verification, labor standard compliance, and raw material provenance are all difficult to establish without reliable digital traceability. As the discussion of Research Paper 5 showed, even technically sophisticated supply chains struggle to document and verify sustainability performance when data remains siloed and unstandardized. This problem is amplified in multi-tier supply chains where second- and third-tier suppliers are often invisible to the final assembler. IS that enable selective and verifiable data sharing across supply chain tiers, without requiring full transparency that would compromise commercial confidentiality, are therefore strategically important. Standardized data models, shared interoperability protocols, and trust architectures of the kind discussed in Sections 3.1 and 3.2 create the conditions under which supply chain sustainability can be monitored, reported, and improved in a credible way. The organizational capabilities developed in Section 4 are equally necessary. Supply chain sustainability data has value only when it is actively governed, interpreted, and embedded in procurement decisions and supplier relationships.

Energy efficiency and flexibility in industrial and commercial settings constitutes a third domain where IS-enabled transformation is both urgent and well-supported by digital infrastructure (Heffron et al., 2020; Leinauer et al., 2022). The dissertation's Section 2 established that the integration of distributed RE generation and flexible demand assets is foundational to a decarbonized and resilient energy system. This integration depends on IS that can coordinate the behavior of heterogeneous and geographically distributed assets in real time, as Research Papers 3 and 4 illustrated for redispatch and flexibility market participation. The same logic applies at the building and facility level. Smart metering systems, building energy management platforms, and IoT-based monitoring infrastructures make energy consumption visible at the process and equipment level, enabling the identification and analysis of inefficiencies, nudging for energy-saving behavior and target-oriented retrofit investments (M. Berger et al., 2025; Konhäuser et al., 2022; Werner et al., 2026). Where energy consumption data can be collected reliably and linked to process-level activity logs, process mining techniques of the kind described in Research Paper 8 can further extend this capability by connecting energy use to specific operational decisions and workflows.

Sustainable mobility is a fourth domain undergoing fundamental transformation in which IS play a critical role. The electrification of vehicle fleets, the optimization of public transit networks, and the development of intermodal mobility platforms all generate substantial sustainability gains, but their realization depends on digital coordination mechanisms (Cascajo et al., 2019; L. Valett et al., 2024). Fleet electrification, for example, creates new flexibility assets in the form of vehicle batteries that can absorb renewable electricity during periods of surplus, as discussed in Section 2 or by Tan et al. (2022) and implicit in the flexibility market design of Research Papers 3 and 4. The economic viability of vehicle-to-grid services depends directly on IS design: on the ability of platform operators to aggregate, verify, and schedule the charging and discharging behavior of many individual vehicles without requiring full disclosure of the owners' schedules or locations. This is again a problem of designing trusted data architectures that balance transparency with privacy, the central design challenge of the dissertation's third section. Beyond vehicle integration, digital platforms for shared and on-demand mobility reduce the total vehicle stock required to meet mobility needs, thereby lowering emissions, while data analytics can optimize route planning and modal choice in ways that reduce energy consumption per passenger kilometer (Baumgarte et al., 2022; Cascajo et al., 2019).

Sustainable production and manufacturing processes represent a fifth domain where the capabilities developed throughout this dissertation apply directly. Modern manufacturing generates enormous amounts of operational process data through sensor networks, machine control systems, and production planning platforms. This data can be analyzed to identify waste, reduce energy intensity, optimize material flows, and improve maintenance scheduling in ways that simultaneously reduce cost and environmental impact (Couckuyt & Van Looy, 2019; Reiter et al., 2014; Roohy Gohar & Indulska, 2020). The process mining use cases identified in Research Paper 8 in the areas of waste reduction, energy consumption optimization, and maintenance cycle optimization map directly onto this manufacturing context. What the dissertation adds to these well-known efficiency arguments is the importance of governance and capability. Process data is only analytically useful when it is structured, governed, and interpreted within organizational processes that connect operational findings to strategic decisions. The maturity model logic of Research Paper 6 and the resourcing perspective of Research Paper 7 apply equally to production data management. The ability to turn manufacturing event logs into sustainability intelligence is a capability that must be built deliberately, and that depends on infrastructure, literacy, and shared organizational routines as much as on analytical tools.

Across all of these domains, a consistent pattern is visible. IS contribute to sustainability transformation by creating or improving the conditions under which sustainability-relevant decisions can be made, verified, and coordinated across organizational and sectoral boundaries. This always involves three interacting elements that correspond to the three sections of this dissertation. First, verifiable and interoperable data architectures reduce the information asymmetries that prevent actors from trusting each other, aligning incentives, or monitoring progress. Second, organizational capabilities to manage, govern, and interpret sustainability data determine whether the information that infrastructure makes available is actually converted into action. Third, specific digital technologies, applied within mature organizational settings, operationalize sustainability in concrete processes, whether through process mining, smart grid coordination, digital passports, or platform-based mobility management. The common denominator across all domains is the reduction of information asymmetries as the precondition for collective and effective sustainability action.

6 Conclusion

6.1 Summary and Contributions

This dissertation set out to investigate how IS can reduce sustainability-related information asymmetries and thereby enable digital decarbonization. The motivating observation was that sustainability is beyond an engineering or financial challenge also an information problem. The actors whose coordination is required for decarbonized energy systems, low-carbon supply chains, and responsible investment decisions are separated by information barriers that prevent trust, market formation, and strategic action. Drawing on Green IS scholarship, data ecosystem research, organizational capability theory, and business process management, the dissertation develops the concept of IS-enabled sustainability as a coherent response to this problem, instantiated across eight research papers organized into four thematic sections.

Section 2 established the system context by examining the macro-level conditions of the sustainability transformation. Research Paper 1 mapped the political, economic, environmental, social, and technological factors shaping RE investments, demonstrating that while economic profitability remains the necessary driver of capital deployment, digital technologies function as structural prerequisites for an efficient and integrated energy system. Research Paper 2 examined the market-level consequences of growing renewable penetration, demonstrating through a six-node-model that demand-side flexibility, rather than eliminating negative electricity prices, can itself generate negative price episodes as a signal of system-level efficiency gains. Both papers support the problematization that the information infrastructure of electricity markets is poorly adapted to the distributed and variable character of a RES-based system, and the resulting price and coordination failures create the very inefficiencies that better IS design can resolve.

Section 3 responded to this diagnosis by developing three design artifacts that address the verifiability and sovereignty challenges inherent in distributed sustainability data sharing. Research Paper 3 introduced a multi-agent system architecture combining SSI and ZKPs to enable small-scale asset owners to participate verifiably in redispatch markets without surrendering sovereignty over sensitive data. Research Paper 4 generalized this design logic through the Trust Diamond, a conceptual framework that maps the structural tension between data verifiability and privacy in energy flexibility provision and derives the design principles of Verifiability through Delegation and Derived Sovereignty for wallet-based identity management. Research Paper 5 extended the argument to supply chains, conceptualizing how DPPs for low-carbon hydrogen can reduce carbon-footprint information asymmetries across complex international supply chains while preserving the sovereignty of individual data contributors. Across these papers, the section demonstrates that verifiable and sovereign data sharing is an institutional necessity. Without it, legitimate privacy concerns will continue to exclude small-scale actors from flexibility markets and undermine the credibility of low-carbon product claims (Kotlarsky et al., 2023; Krasikov & Legner, 2023).

Section 4 shifted the analytical focus from infrastructure design to the organizational capabilities required to generate value from sustainability data. Research Paper 6 developed the SDM-MM, drawing on resource orchestration theory to conceptualize sustainability data as a latent strategic resource that yields value only through deliberate organizational structuring, bundling, and leveraging (Püchel et al., 2024; Sirmon et al., 2007, 2011). Evaluated across three organizational cases, the model reveals a developmental trajectory from fragmented, compliance-oriented data practices toward integrated, institutionalized, and transformation-oriented sustainability data management. Research Paper 7 examined how ESG data can be mobilized within a cooperative financial network, applying a resourcing perspective to demonstrate how coordinated, network-level data practices transform ESG data from compliance assets into shared resources for benchmarking, scenario analysis, and decarbonization planning (Auschra & Sydow, 2023). Consequently, these papers advance the central argument of the dissertation that digital infrastructure for data sharing is a necessary but insufficient condition for sustainability transformation. The realization of data's transformative potential depends on capability development and organizational practices that enable data to be a driver of sustainable value creation.

Section 5 synthesized the insights of the preceding sections by examining IS-enabled sustainability transformation at the process level. Research Paper 8 conducted a Delphi study with experts in business process management, process mining, and sustainability, identifying and evaluating 30 process mining use cases for ESG enhancement. The findings reveal that process mining holds substantial potential for operationalizing sustainability data within organizations, particularly in resource optimization, compliance monitoring, and employee well-being, while also confirming that data sensitivity and infrastructure maturity remain binding constraints. This paper connects the dissertation's earlier contributions. The data infrastructures developed in Section 3 and the organizational capabilities examined in Section 4 are preconditions for the process-level sustainability analytics that Section 5 envisions. The full chain from market design through verifiable infrastructure, organizational capability, and process analytics constitutes what this dissertation calls IS-enabled sustainability transformation.

The dissertation makes interconnected scientific contributions across four streams of IS research. With respect to Green IS and sustainability transformation, the dissertation moves beyond the general claim that IS can support sustainability and specifies the mechanisms through which they do so. Building on foundational work in this field (Melville, 2010; Seidel et al., 2013; Watson et al., 2010, 2022), the dissertation instantiates these mechanisms in two empirically concrete domains: decentralized energy markets and cross-organizational sustainability data management. The concept of IS-enabled sustainability provides a theoretically grounded framework that connects the IS-based reduction of information asymmetries to decarbonization outcomes, responding to calls for IS research to engage more directly with the structural conditions of digital decarbonization (Boh et al., 2026; Kotlarsky et al., 2023). By demonstrating that sustainability transformation requires institutional legitimacy, data sovereignty, and organizational capability alongside technology adoption, the dissertation extends the Green IS field and contributes to the perspective of IS as enabler of sustainable markets and practices (Püchel et al., 2024; Zeiss et al., 2021).

With respect to design science, the dissertation makes a cumulative contribution by developing and evaluating a family of IS artifacts targeted at sustainability-related information asymmetries (Gregor & Hevner, 2013; Hevner et al., 2004). The multi-agent redispatch system, the Trust Diamond, the DPP design principles, and the SDM-MM each respond to specified design problems and are evaluated through a combination of prototype demonstrations and expert interviews. The Trust Diamond and the DPP design principles contribute to IS design knowledge by operationalizing the tension between verifiability and privacy as a first-class design concern and deriving principles applicable to analogous sustainability settings. The SDM-MM contributes a theoretically grounded maturity model that operationalizes resource orchestration theory for the sustainability data domain, extending the maturity model tradition in IS research (Becker et al., 2009; Pöppelbuß & Röglinger, 2011) with an explicit capability-stage logic.

With respect to organizational capability and resource perspectives, Research Papers 6 and 7 advance IS research on value creation from data. By applying resource orchestration theory, Research Paper 6 provides a theoretically grounded perspective of how data becomes a strategic resource through deliberate organizational action (Barney, 1991; Sirmon et al., 2007, 2011). Research Paper 7 extends the resourcing perspective to interorganizational settings, demonstrating how digital platforms can function as imaginative infrastructures that shape how sustainability futures are envisioned and enacted in cooperative networks (Auschra & Sydow, 2023). Together these papers establish sustainability data management as a distinct IS sub-domain with its own capability logic, contributing to the broader literature on IS-enabled value creation from data (Bindeeba et al., 2025; Püchel et al., 2024).

With respect to information asymmetry theory, the dissertation finds that Akerlof's market-for-lemons problem and principal-agent theory retain explanatory power in the context of digital decarbonization (Akerlof, 1978; Eisenhardt, 1989; Meckling & Jensen, 1976). More importantly, it establishes that IS artifacts can serve to resolve these asymmetries through selective disclosure. ZKPs allow asset owners to prove the correctness of claimed flexibility without revealing private operational data, while DPPs allow supply chain stakeholders to demonstrate carbon-intensity claims without disclosing sensitive production information. This IS-enabled resolution of the verifiability-privacy tension is a distinct theoretical contribution to the literature on trust and data sharing in digital ecosystems (Körner, Leinauer, et al., 2025; Krasikov & Legner, 2023).

6.2 Limitations and Directions for Future Research

The dissertation's contributions are bounded by several limitations that point, in turn, to new directions for future IS research.

The empirical work is concentrated in European, and particularly German, regulatory and market contexts. The CSRD framework, German redispatch regulations, and European hydrogen market dynamics shaped the design problems addressed throughout (European Commission, 2021, 2022). While the underlying design principles, theoretical frameworks, and capability models are developed with generalization in mind, their applicability in non-EU jurisdictions with different regulatory architectures, grid structures, or sustainability disclosure regimes has not been empirically examined. Future comparative studies that test the dissertation's design artifacts and capability frameworks in, for example, North American or Southeast Asian energy and reporting contexts would substantially strengthen the external validity of the findings and reveal how regulatory environment shapes both the demand for IS-based sustainability infrastructure and the organizational conditions of its adoption.

The multi-method, cumulative dissertation design generates breadth across eight papers but necessarily constrains the depth achievable within any single study. The design science papers in Section 3 provide conceptual system designs rather than full empirical evaluations in production environments. Field-level evidence for the performance of the multi-agent redispatch system at market scale, or for the adoption of DPP standards in live hydrogen trading, remains a direction for future research. Longitudinal field studies of the multi-agent redispatch architecture in live grid environments would test whether the verifiability and sovereignty properties demonstrated in controlled scenarios hold under the operational complexity of real energy markets, including adversarial stakeholders, regulatory intervention, and network externalities. Similarly, as EU regulations such as the Battery Regulation and the Ecodesign for Sustainable Products Regulation begin to mandate DPPs across product categories, research opportunities will arise to study adoption dynamics, interoperability challenges, and the conditions under which DPP standards generate the trust and coordination benefits the design theory anticipates.

Several enabling technologies on which the design artifacts rely, including SSI, ZKP, and interoperable DPP standards, are still maturing. While the dissertation treats these as technically feasible, scalability, standardization, and system-level adoption present challenges that extend beyond what IS design research can resolve unilaterally. The findings should therefore be read as establishing the institutional and organizational logic of IS-enabled data sovereignty rather than as endorsements of specific technology implementations.

The capability frameworks in Section 4 are grounded in empirical work conducted at a relatively early stage of organizational sustainability data practice. The SDM-MM was evaluated across three organizational cases, and the ESG data resourcing model was developed from a single in-depth case study. While both studies employed rigorous qualitative methods and achieved theoretical saturation within their scope, longitudinal evidence linking maturity levels or resourcing configurations to measurable sustainability performance outcomes remains a gap that only panel or longitudinal studies can close. A multi-industry panel study linking SDM-MM maturity scores to ESG ratings or decarbonization strategies would allow researchers to test whether the resource orchestration mechanisms theorized in the model predict sustainability outcomes in practice (Püchel et al., 2024; Sirmon et al., 2011). The cooperative ESG platform studied in Research Paper 7 similarly invites follow-up research on the network economics of shared sustainability data infrastructures: how the governance arrangements, ownership structures, and boundary conditions of cooperative digital platforms shape the distribution of value created through shared ESG analytics is a question that longitudinal case research or field experiments would be well suited to address.

The process mining work in Research Paper 8 identified 30 ESG use cases but evaluated them primarily in terms of expert-rated desirability, feasibility, and viability. A natural extension is the operationalization and empirical evaluation of priority use cases in organizational settings. The use cases rated as Quick Wins, explicitly those targeting resource consumption and emissions monitoring in production processes, offer the most tractable starting points for IS researchers interested in measuring the sustainability impact of process-level analytics (Badakhshan et al., 2022; Costache et al., 2025; van der Aalst, 2016). Scope 3 emissions monitoring across supply chains represents a particularly important but technically demanding use case, as it requires linking process event logs across organizational boundaries, which connects directly to the data sovereignty challenges addressed in Section 3.

More broadly, the dissertation's contribution invites future IS research to treat sustainability transformation as a system-level phenomenon rather than a collection of independent technological interventions. IS scholarship has the analytical tools to study how these layers interact: how infrastructure maturity enables capability development, how capability development enables process-level analytics, and how the resulting feedback loops accelerate or inhibit decarbonization trajectories at the organizational and system level. The emerging research programs on digital measuring, reporting, and verification (Körner, Leinauer, et al., 2025) and on IS-enabled circular economy transitions (Zeiss et al., 2021) converge on similar questions and suggest that an integrated theory of IS-enabled sustainability transformation is within reach.

Finally, this dissertation concludes by referring to its title. *The Mitigation of Information Asymmetries: Digital Infrastructures and Organizational Capabilities in Sustainability Data Contexts*: In sustainability and energy contexts, information asymmetries carry real costs that fall on actors who are often not the ones withholding the information. A grid operator who cannot verify the actual flexibility of distributed assets may curtail renewable generation unnecessarily, wasting clean energy and imposing system costs that consumers ultimately bear. An investor who cannot distinguish credible low-carbon hydrogen from greenwashed certificates will either overpay for unverified claims or withdraw from the market entirely, starving genuine decarbonization projects of capital. An organization that lacks visibility into its own sustainability data cannot identify where emissions reductions are feasible, cannot demonstrate progress to regulators or partners, and cannot make the strategic decisions that transformation requires. A financial institution that cannot assess the climate-related risks embedded in its loan portfolio is exposed to losses it does not see coming. In each of these cases, the absence of reliable, verifiable, and actionable information does not simply create inconvenience; it distorts incentives, misallocates resources, erodes trust, and ultimately slows or reverses the decarbonization trajectory that the energy system and the broader economy urgently need to follow. Reducing these information asymmetries is therefore not a secondary concern that follows once the engineering and financial preconditions of sustainability are in place. It is a primary condition for those preconditions themselves to function. Markets for flexibility, low-carbon products, and sustainable investment can only operate if the claims on which they rest can be verified; organizational transformation can only proceed if the data needed to navigate it are available, trustworthy, and interpretable. This is precisely why IS occupy a central position in the sustainability transformation, and why the work of making data verifiable, sovereign, and actionable is, at its core, work in service of a livable future.

Bibliography

Adisorn, T., Tholen, L., & Götz, T. (2021). Towards a digital product passport fit for contributing to a circular economy. *Energies*, *14*(8), 2289. https://doi.org/10.3390/en14082289

Agahari, W., Ofe, H., & de Reuver, M. (2022). It is not (only) about privacy: How multi-party computation redefines control, trust, and risk in data sharing. *Electronic Markets*, *32*(3), 1577–1602. https://doi.org/10.1007/s12525-022-00572-w

Akerlof, G. A. (1978). The market for "lemons": Quality uncertainty and the market mechanism. In P. Diamond & M. Rothschild (Eds.), *Uncertainty in economics* (pp. 235–251). Academic Press. https://doi.org/10.1016/B978-0-12-214850-7.50022-X

Asante, M., Epiphaniou, G., Maple, C., Al-Khateeb, H., Bottarelli, M., & Ghafoor, K. Z. (2022). Distributed ledger technologies in supply chain security management: A comprehensive survey. *IEEE Transactions on Engineering Management*, 1–27. https://doi.org/10.1109/TEM.2021.3053655

Auschra, C., & Sydow, J. (2023). Resourcing goal-directed networks: Toward a practice-based perspective. *Journal of Public Administration Research and Theory*, *33*(2), 232–245. https://doi.org/10.1093/jopart/muac023

Babel, M., Gramlich, V., Körner, M.-F., Sedlmeir, J., Strüker, J., & Zwede, T. (2022). Enabling end-to-end digital carbon emission tracing with shielded NFTs. *Energy Informatics*, *5*(Suppl 1), 27. https://doi.org/10.1186/s42162-022-00199-3

Badakhshan, P., Wurm, B., Grisold, T., Geyer-Klingenberg, J., Mendling, J., & vom Brocke, J. (2022). Creating business value with process mining. *The Journal of Strategic Information Systems*, *31*(4), 101745. https://doi.org/10.1016/j.jsis.2022.101745

Bamati, N., & Raoofi, A. (2020). Development level and the impact of technological factor on renewable energy production. *Renewable Energy*, *151*, 946–955. https://doi.org/10.1016/j.renene.2019.11.098

Barney, J. (1991). Firm resources and sustained competitive advantage. *Journal of management*, *17*(1), 99–120.

Baumgarte, F., Keller, R., Röhrich, F., Valett, L., & Zinsbacher, D. (2022). Revealing influences on carsharing users' trip distance in small urban areas. *Transportation Research Part D: Transport and Environment*, *105*, 103252. https://doi.org/10.1016/j.trd.2022.103252

Becker, J., Knackstedt, R., & Pöppelbuß, J. (2009). Developing maturity models for it management: A procedure model and its application. *Business & information systems engineering*, *1*(3), 213–222. https://doi.org/10.1007/s12599-009-0044-5

Bélanger, F., & Crossler, R. E. (2011). Privacy in the digital age: A review of information privacy research in information systems. *MIS Quarterly*, *35*(4), 1017–1041. https://doi.org/10.2307/41409971

Berger, K., Schöggl, J.-P., & Baumgartner, R. J. (2022). Digital battery passports to enable circular and sustainable value chains: Conceptualization and use cases. *Journal of Cleaner Production*, *353*, 131492. https://doi.org/10.1016/j.jclepro.2022.131492

Berger, M., Gimpel, H., Schnaak, F., & Wolf, L. (2025). Can feedback nudges enhance user satisfaction? Kano analysis for different eco-feedback nudge features in a smart home app. *Electronic Markets*, *35*(1), 29. https://doi.org/10.1007/s12525-025-00763-1

Beverungen, D., Hess, T., Köster, A., & Lehrer, C. (2022). From private digital platforms to public data spaces: Implications for the digital transformation. *Electronic Markets*, *32*(2), 493–501. https://doi.org/10.1007/s12525-022-00553-z

Bharadwaj, A., El Sawy, O. A., Pavlou, P. A., & Venkatraman, N. (2013). Digital business strategy: Toward a next generation of insights. *MIS Quarterly*, *37*(2), 471–482. https://doi.org/10.25300/MISQ/2013/37:2.3

Bharadwaj, A. S. (2000). A resource-based perspective on information technology capability and firm performance: An empirical investigation. *MIS Quarterly*, *24*(1), 169–196. https://doi.org/10.2307/3250983

Bindeeba, D. S., Tukamushaba, E. K., & Bakashaba, R. (2025). Digital levers for sustainability: A meta-analytic review of digital transformation's influence on ESG performance. *Cogent Business & Management*, *12*(1), 2564919. https://doi.org/10.1080/23311975.2025.2564919

Bird, L., Lew, D., Milligan, M., Carlini, E. M., Estanqueiro, A., Flynn, D., Gomez-Lazaro, E., Holttinen, H., Menemenlis, N., Orths, A., et al. (2016). Wind and solar energy curtailment: A review of international experience. *Renewable and Sustainable Energy Reviews*, *65*, 577–586. https://doi.org/10.1016/j.rser.2016.06.082

Boh, W. F., Melville, N. P., Baptista, J., Chasin, F., Horita, F., Ixmeier, A., Johnson, S. L., Ketter, W., Kranz, J., Miranda, S., et al. (2026). Digital resilience for the climate crisis: A multi-perspective analysis. *MIS Quarterly*, *50*(1), 1–34. https://doi.org/10.25300/MISQ/2025/18779

Bohn, R. E., Caramanis, M. C., & Schweppe, F. C. (1984). Optimal pricing in electrical networks over space and time. *The Rand Journal of Economics*, 360–376. https://doi.org/10.2307/2555444

Breiter, K., Crome, C., Oberländer, A. M., & Schnaak, F. (2024). Dynamic capabilities for the twin transformation climb: A capability maturity model. *Information systems frontiers*, *26*(6), 2205–2226. https://doi.org/10.1007/s10796-024-10520-y

Brynjolfsson, E. (1993). The productivity paradox of information technology. *Communications of the ACM*, *36*(12), 66–77.

Cascajo, R., Lopez, E., Herrero, F., & Monzon, A. (2019). User perception of transfers in multimodal urban trips: A qualitative study. *International Journal of Sustainable Transportation*, *13*(6), 393–406. https://doi.org/10.1080/15568318.2018.1476632

Çelik, D., Meral, M. E., & Waseem, M. (2022). Investigation and analysis of effective approaches, opportunities, bottlenecks and future potential capabilities for digitalization of energy systems and sustainable development goals. *Electric Power Systems Research*, *211*, 108251. https://doi.org/10.1016/j.epsr.2022.108251

Chao, H.-P., & Peck, S. (1996). A market mechanism for electric power transmission. *Journal of regulatory economics*, *10*(1), 25–59. https://doi.org/10.1007/BF00133357

Chao, H.-P., & Peck, S. C. (1998). Reliability Management in Competitive Electricity Markets. *Journal of Regulatory Economics*, *1998*. https://doi.org/10.1023/A:1008061319181

Christmann, A.-S., Crome, C., Graf-Drasch, V., Oberländer, A. M., & Schmidt, L. (2024). The Twin Transformation Butterfly: Capabilities for an Integrated Digital and Sustainability Transformation. *Business & Information Systems Engineering*, *66*(4), 489–505. https://doi.org/10.1007/s12599-023-00847-2

Costache, I., Turetken, O., Aysolmaz, B., & Winter, K. (2025). Process mining guidelines for greenhouse gas emission management in production processes. In A. Delgado & T. Slaats (Eds.), *Process mining workshops* (pp. 711–724). Springer Nature Switzerland. https://doi.org/10.1007/978-3-031-82225-4_52

Couckuyt, D., & Van Looy, A. (2019). Green BPM as a Business-Oriented Discipline: A Systematic Mapping Study and Research Agenda. *Sustainability*, *11*(15), 4200. https://doi.org/10.3390/su11154200

Eisenhardt, K. M. (1989). Agency theory: An assessment and review. *Academy of management review*, *14*(1), 57–74.

Ernstberger, J., Lauinger, J., Elsheimy, F., Zhou, L., Steinhorst, S., Canetti, R., Miller, A., Gervais, A., & Song, D. (2023). SoK: Data sovereignty. *8th European Symposium on Security and Privacy*, 122–143. https://doi.org/10.1109/EuroSP57164.2023.00017

European Commission. (2021). Proposal for a DIRECTIVE of the EUROPEAN PARLIAMENT and of the COUNCIL amending directive 2013/34/EU, directive 2004/109/EC, directive 2006/43/EC and regulation (EU) no 537/2014, as regards corporate sustainability reporting.

European Commission. (2022). Directive (eu) 2022/2464 of the european parliament and the council (Official Journal of the European Union, Ed.). https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32022L2464

European Commission. (2024). *Renewable energy targets* [Accessed 2026-04-25]. https://energy.ec.europa.eu/topics/renewable-energy/renewable-energy-directive-targets-and-rules/renewable-energy-targets_en

European Environment Agency. (2025). *Share of energy consumption from renewable sources in europe* [Accessed 2026-04-25]. https://www.eea.europa.eu/en/analysis/indicators/share-of-energy-consumption-from

Eurostat. (2024). *Renewables account for 24.5% of eu energy use in 2023* [Accessed 2026-04-25]. https://ec.europa.eu/eurostat/de/web/products-eurostat-news/w/ddn-20241219-3

Feldman, M. S. (2004). Resources in emerging structures and processes of change. *Organization Science*, *15*(3), 295–309. https://doi.org/10.1287/orsc.1040.0073

Fridgen, G., Keller, R., Körner, M.-F., & Schöpf, M. (2020). A holistic view on sector coupling. *Energy Policy*, *147*, 111913. https://doi.org/10.1016/j.enpol.2020.111913

Fuss, S., & Szolgayová, J. (2010). Fuel price and technological uncertainty in a real options model for electricity planning. *Applied Energy*, *87*(9), 2938–2944. https://doi.org/10.1016/j.apenergy.2009.05.020

Gamel, J., Menrad, K., & Decker, T. (2017). Which factors influence retail investors' attitudes towards investments in renewable energies? *Sustainable Production and Consumption*, *12*, 90–103. https://doi.org/10.1016/j.spc.2017.06.001

Gellings, C. W. (1985). The concept of demand-side management for electric utilities. *Proceedings of the IEEE*, *73*(10), 1468–1470. https://doi.org/10.1109/PROC.1985.13318

Gerry, J., Richard, W., Patrick, R., Kevan, S., & Duncan, A. (2017). *Exploring strategy.* (Vol. Eleventh edition). Pearson Education. https://research.ebsco.com/c/mslh3b/search/details/v6wevbrb3r?request-context=plink&db=nlebk

Gholami, R., Watson, R. T., Hasan, H., Molla, A., & Bjorn-Andersen-Niels. (2016). Information systems solutions for environmental sustainability: How can we do more? *Journal of the Association for Information Systems*, *17*(8). https://doi.org/10.17705/1jais.00435

Glöckler, J., Sedlmeir, J., Frank, M., & Fridgen, G. (2023). Publisher correction: A systematic review of identity and access management requirements in enterprises and potential contributions of self-sovereign identity. *Business & Information Systems Engineering*. https://doi.org/10.1007/s12599-023-00830-x

Goldwasser, S., Micali, S., & Rackoff, C. (2019). The knowledge complexity of interactive proof-systems. In *Providing sound foundations for cryptography: On the work of Shafi Goldwasser and Silvio Micali* (pp. 203–225). https://doi.org/10.1145/3335741.3335750

Gregor, S., & Hevner, A. R. (2013). Positioning and presenting design science research for maximum impact. *MIS Quarterly*, *37*(2), 337–355. https://doi.org/10.25300/MISQ/2013/37.2.01

Grimm, V., Martin, A., Weibelzahl, M., & Zöttl, G. (2016). On the long run effects of market splitting: Why more price zones might decrease welfare. *Energy Policy*, *94*, 453–467. https://doi.org/10.1016/j.enpol.2015.11.010

Grisold, T., Mendling, J., Otto, M., & vom Brocke, J. (2020). Adoption, use and management of process mining in practice. *Business Process Management Journal*, *27*(2), 369–387. https://doi.org/10.1108/BPMJ-03-2020-0112

Halbrügge, S., Schott, P., Weibelzahl, M., Buhl, H. U., Fridgen, G., & Schöpf, M. (2021). How did the german and other european electricity systems react to the covid-19 pandemic? *Applied Energy*, *285*, 116370. https://doi.org/10.1016/j.apenergy.2020.116370

Härtel, P., & Korpås, M. (2020). Demystifying market clearing and price setting effects in low-carbon energy systems. *Energy Economics*, 105051. https://doi.org/10.1016/j.eneco.2020.105051

Hartmann, J., Inkpen, A. C., & Ramaswamy, K. (2021). Different shades of green: Global oil and gas companies and renewable energy. *Journal of International Business Studies*, *52*(5), 879–903. https://doi.org/10.1057/s41267-020-00326-w

Heeß, P., Körner, M.-F., Strüker, J., Valett, L., Wolf, L., Pulvermüller, B., & Richard, P. (2024). Grundlagen und Bedeutung von Datenräumen für die Energiewirtschaft.

Heeß, P. A., Valett, L., & Weibelzahl, M. (2024). Smart Negotiations for Climate Protection: Can Information Systems Save Our Planet? *Proceedings of the 32nd European Conference on Information Systems (ECIS)*.

Heffron, R., Körner, M.-F., Schöpf, M., Wagner, J., & Weibelzahl, M. (2021). The role of flexibility in the light of the covid-19 pandemic and beyond: Contributing to a sustainable and resilient energy future in europe. *Renewable and Sustainable Energy Reviews*, *140*, 110743. https://doi.org/10.1016/j.rser.2021.110743

Heffron, R., Körner, M.-F., Wagner, J., Weibelzahl, M., & Fridgen, G. (2020). Industrial demand-side flexibility: A key element of a just energy transition and industrial development. *Applied Energy*, *269*, 115026. https://doi.org/10.1016/j.apenergy.2020.115026

Hellmeier, M., & von Scherenberg, F. (2023). A delimitation of data sovereignty from digital and technological sovereignty. In M. Aanestad, S. Klein, M. Tarafdar, S. Han, S. Laumer, & I. Ramos (Eds.), *Proceedings of the 31st european conference on information systems* (pp. 1–19).

Hevner, A. R., March, S. T., Park, J., & Ram, S. (2004). Design science in information systems research. *MIS Quarterly*, *28*(1), 75–105. https://doi.org/10.2307/25148625

Hinings, B., Gegenhuber, T., & Greenwood, R. (2018). Digital transformation and institutional change. *Information and Organization*, *28*(1), 52–61. https://doi.org/10.1016/j.infoandorg.2018.02.004

Hirth, L., & Glismann, S. (2018). *Congestion management: From physics to regulatory instruments* (tech. rep.). Kiel, Hamburg, ZBW – Leibniz Information Centre for Economics.

Holmberg, P., Lazarczyk, E., et al. (2015). Comparison of congestion management techniques: Nodal, zonal and discriminatory pricing. *Energy Journal*, *36*(2), 145–166. https://doi.org/10.5547/01956574.36.

Howard-Grenville, J. A. (2007). Developing issue-selling effectiveness over time: Issue selling as resourcing. *Organization Science*, *18*(4), 560–577. https://doi.org/10.1287/orsc.1070.0266

Hummel, P., Braun, M., Tretter, M., & Dabrock, P. (2021). Data sovereignty: A review. *Big Data & Society*, *8*(1), 1–17. https://doi.org/10.1177/2053951720982012

IEA. (2023a). World Energy Investment 2023. *IEA Paris*. https://www.iea.org/reports/world-energy-investment-2023

IEA. (2023b). World energy outlook [icence: CC BY 4.0 (report); CC BY NC SA 4.0 (Annex A)]. *IEA, Paris*. https://www.iea.org/reports/world-energy-outlook-2023

IPCC. (2023). *Climate change 2023: Synthesis report. contribution of working groups I, II and III to the sixth assessment report of the intergovernmental panel on climate change* (tech. rep.) (Core Writing Team: Lee, H. and Romero, J. (eds.)). Intergovernmental Panel on Climate Change (IPCC). Geneva, Switzerland. https://doi.org/10.59327/IPCC/AR6-9789291691647

Jarke, M., Otto, B., & Ram, S. (2019). Data sovereignty and data space ecosystems. *Business & Information Systems Engineering*, *61*(5), 549–550. https://doi.org/10.1007/s12599-019-00614-2

Jensen, S. F., Kristensen, J. H., Christensen, A., & Waehrens, B. V. (2024). An ecosystem orchestration framework for the design of digital product passports in a circular economy. *Business Strategy and the Environment*, *33*(7), 7100–7117. https://doi.org/10.1002/bse.3868

Ketterer, J. C. (2014). The impact of wind power generation on the electricity price in Germany. *Energy Economics*, *44*, 270–280. https://doi.org/10.1016/j.eneco.2014.04.003

Konhäuser, K., Wenninger, S., Werner, T., & Wiethe, C. (2022). Leveraging advanced ensemble models to increase building energy performance prediction accuracy in the residential building sector. *Energy and Buildings*, *269*, 112242. https://doi.org/10.1016/j.enbuild.2022.112242

Körner, M.-F., Leinauer, C., Ströher, T., & Strüker, J. (2025). Digital Measuring, Reporting, and Verification (dMRV) for Decarbonization. *Business & Information Systems Engineering*. https://doi.org/10.1007/s12599-025-00953-3

Körner, M.-F., Nolting, L., Babel, M., Ehaus, M., Heeß, P., Lautenschlager, J., Radtke, M., Schick, L., Strüker, J., Wiedemann, S., et al. (2025). A digital infrastructure for integrating decentralized assets into redispatch. Decentralized Redispatch (DEER): Interfaces for providing flexibility.

Körner, M.-F., Sedlmeir, J., Weibelzahl, M., Fridgen, G., Heine, M., & Neumann, C. (2022). Systemic risks in electricity systems: A perspective on the potential of digital technologies. *Energy Policy*, *164*, 112901. https://doi.org/10.1016/j.enpol.2022.112901

Kossahl, J., Busse, S., & Kolbe, L. M. (2012). The evolvement of energy informatics in the information systems community - a literature analysis and research agenda. *ECIS 2012 Proceedings*.

Kotlarsky, J., Oshri, I., & Sekulic, N. (2023). Digital sustainability in information systems research: Conceptual foundations and future directions. *Journal of the Association for Information Systems*, *24*(4), 936–952. https://doi.org/10.17705/1jais.00825

Krasikov, P., & Legner, C. (2023). Introducing a Data Perspective to Sustainability: How Companies Develop Data Sourcing Practices for Sustainability Initiatives. *Communications of the Association for Information Systems*, *53*, 162–188. https://doi.org/10.17705/1CAIS.05307

Kul, C., Zhang, L., & Solangi, Y. A. (2020). Assessing the renewable energy investment risk factors for sustainable development in turkey. *Journal of Cleaner Production*, *276*, 124164. https://doi.org/10.1016/j.jclepro.2020.124164

Legner, C., Eymann, T., Hess, T., Matt, C., Böhmann, T., Drews, P., Mäedche, A., Urbach, N., & Ahlemann, F. (2017). Digitalization: Opportunity and challenge for the business and information systems engineering community. *Business & Information Systems Engineering*, *59*(4), 301–308. https://doi.org/10.1007/s12599-017-0484-2

Leinauer, C., Schott, P., Fridgen, G., Keller, R., Ollig, P., & Weibelzahl, M. (2022). Obstacles to demand response: Why industrial companies do not adapt their power consumption to volatile power generation. *Energy Policy*, *165*, 112876. https://doi.org/10.1016/j.enpol.2022.112876

Li, F., Cao, X., & Ou, R. (2021). A network-based evolutionary analysis of the diffusion of cleaner energy substitution in enterprises: The roles of pest factors. *Energy Policy*, *156*, 112385. https://doi.org/10.1016/j.enpol.2021.112385

Li, L., Manier, H., & Manier, M.-A. (2019). Hydrogen supply chain network design: An optimization-oriented review. *Renewable and Sustainable Energy Reviews*, *103*, 342–360. https://doi.org/10.1016/j.rser.2018.12.060

Lin, B., & Huang, C. (2023). Promoting variable renewable energy integration: The moderating effect of digitalization. *Applied Energy*, *337*, 120891. https://doi.org/10.1016/j.apenergy.2023.120891

Lind, L., Cossent, R., Chaves-Ávila, J. P., & Gómez San Román, T. (2019). Transmission and distribution coordination in power systems with high shares of distributed energy resources providing balancing and congestion management services. *Wiley Interdisciplinary Reviews: Energy and Environment*, *8*(6), e357. https://doi.org/10.1002/wene.357

Lipp, J. (2007). Lessons for effective renewable electricity policy from denmark, germany and the united kingdom. *Energy Policy*, *35*(11), 5481–5495. https://doi.org/10.1016/j.enpol.2007.05.015

Lund, P. D., Lindgren, J., Mikkola, J., & Salpakari, J. (2015). Review of energy system flexibility measures to enable high levels of variable renewable electricity. *Renewable and Sustainable Energy Reviews*, *45*, 785–807. https://doi.org/10.1016/j.rser.2015.01.057

Masini, A., & Menichetti, E. (2012). The impact of behavioural factors in the renewable energy investment decision making process: Conceptual framework and empirical findings. *Energy Policy*, *40*, 28–38. https://doi.org/10.1016/j.enpol.2010.06.062

Meckling, W. H., & Jensen, M. C. (1976). Theory of the firm. *Managerial Behavior, Agency Costs and Ownership Structure*.

Melville, N. (2010). Information systems innovation for environmental sustainability. *MIS Quarterly*, *34*(1), 1. https://doi.org/10.2307/20721412

Michaelis, A., Hanny, L., Körner, M.-F., Strüker, J., & Weibelzahl, M. (2024). Consumer-centric electricity markets: Six design principles. *Renewable and Sustainable Energy Reviews*, *191*, 113817. https://doi.org/10.1016/j.rser.2023.113817

Möller, F., Jussen, I., Springer, V., Gieß, A., Schweihoff, J. C., Gelhaar, J., Guggenberger, T., & Otto, B. (2024). Industrial data ecosystems and data spaces. *Electronic Markets*, *34*(1), 41. https://doi.org/10.1007/s12525-024-00724-0

Mühle, A., Grüner, A., Gayvoronskaya, T., & Meinel, C. (2018). A survey on essential components of a self-sovereign identity. *Computer Science Review*, *30*, 80–86. https://doi.org/10.1016/j.cosrev.2018.10.002

Olabi, A., Abdelkareem, M. A., & Jouhara, H. (2023). Energy digitalization: Main categories, applications, merits, and barriers. *Energy*, *271*, 126899. https://doi.org/10.1016/j.energy.2023.126899

Otto, B., & Jarke, M. (2019). Designing a multi-sided data platform: Findings from the international data spaces case. *Electronic Markets*, *29*(4), 561–580. https://doi.org/10.1007/s12525-019-00362-x

Palensky, P., & Dietrich, D. (2011). Demand side management: Demand response, intelligent energy systems, and smart loads. *IEEE transactions on industrial informatics*, *7*(3), 381–388. https://doi.org/10.1109/TII.2011.2158841

Parag, Y., & Sovacool, B. K. (2016). Electricity market design for the prosumer era. *Nature energy*, *1*(4), 1–6. https://doi.org/10.1038/nenergy.2016.32

Polzin, F., Migendt, M., Täube, F. A., & von Flotow, P. (2015). Public policy influence on renewable energy investments—a panel data study across oecd countries. *Energy Policy*, *80*, 98–111. https://doi.org/10.1016/j.enpol.2015.01.026

Pöppelbuß, J., & Röglinger, M. (2011). What makes a useful maturity model? a framework of general design principles for maturity models and its demonstration in business process management. *ECIS 2011 Proceedings*, (28).

Preukschat, A., & Reed, D. (2021). *Self-sovereign identity: Decentralized digital identity and verifiable credentials*. Manning Publications.

Principato, M., Babel, M., Guggenberger, T., Kropp, J., & Mertel, S. (2023). Towards solving the blockchain trilemma: An exploration of zero-knowledge proofs. *ECIS Proceedings 2023*.

Püchel, L., Wang, C., Buhmann, K., Brandt, T., Von Schweinitz, F., Edinger-Schons, L. M., vom Brocke, J., Legner, C., Teracino, E., & Mardahl, T. D. (2024). On the Pivotal Role of Data in Sustainability Transformations: Challenges and Opportunities. *Business & Information Systems Engineering*, *66*(6), 831–848. https://doi.org/10.1007/s12599-024-00904-4

Ramsebner, J., Haas, R., Ajanovic, A., & Wietschel, M. (2021). The sector coupling concept: A critical review. *Wiley interdisciplinary reviews: energy and environment*, *10*(4), e396. https://doi.org/10.1002/wene.396

Reich, R. H., Alaerts, L., & Van Acker, K. (2025). Beyond compliance: Designing value-creating, service-oriented, and integrated product passports that contribute to the circular economy. *Procedia CIRP*, *135*, 997–1002. https://doi.org/10.1016/j.procir.2024.12.120

Reiter, M., Fettke, P., & Loos, P. (2014). Towards Green Business Process Management: Concept and Implementation of an Artifact to Reduce the Energy Consumption of Business Processes. *2014 47th Hawaii International Conference on System Sciences*, 885–894. https://doi.org/10.1109/HICSS.2014.117

Roohy Gohar, S., & Indulska, M. (2020). Environmental Sustainability through Green Business Process Management. *Australasian Journal of Information Systems*, *24*. https://doi.org/10.3127/ajis.v24i0.2057

Saberi, S., Kouhizadeh, M., Sarkis, J., & Shen, L. (2019). Blockchain technology and its relationships to sustainable supply chain management. *International Journal of Production Research*, *57*(7), 2117–2135. https://doi.org/10.1080/00207543.2018.1533261

Schoormann, T., Stadtländer, M., & Knackstedt, R. (2022). Designing business model development tools for sustainability—a design science study. *Electronic Markets*, *32*(2), 645–667. https://doi.org/10.1007/s12525-021-00466-3

Schreuder, W., & Horlings, L. G. (2022). Transforming places together: Transformative community strategies responding to climate change and sustainability challenges. *Climate Action*, *1*(24). https://doi.org/10.1007/s44168-022-00024-3

Sedlmeir, J., Smethurst, R., Rieger, A., & Fridgen, G. (2021). Digital identities and verifiable credentials. *Business & Information Systems Engineering*, *63*(5), 603–613. https://doi.org/10.1007/s12599-021-00722-y

Seidel, S., Recker, J., & vom Brocke, J. (2013). Sensemaking and sustainable practicing: Functional affordances of information systems in green transformations. *MIS Quarterly*, *37*(4), 1275–1299. https://doi.org/10.25300/MISQ/2013/37.4.13

Sein, M. K., Henfridsson, O., Purao, S., Rossi, M., & Lindgren, R. (2011). Action design research. *MIS Quarterly*, *35*(1), 37–56. https://doi.org/10.2307/23043488

Seo, S.-K., Yun, D.-Y., & Lee, C.-J. (2020). Design and optimization of a hydrogen supply chain using a centralized storage model. *Applied Energy*, *262*, 114452. https://doi.org/10.1016/j.apenergy.2019.114452

Singh, A., Ramtiyal, B., Jain, V., Vijayvargy, L., & Khan, S. B. (2026). Examining circular economy principles to transform public sector pharmaceutical supply chains for flexibility: A multi-method approach. *Technological Forecasting and Social Change*, *223*, 124410. https://doi.org/10.1016/j.techfore.2025.124410

Sirmon, D. G., Hitt, M. A., & Ireland, R. D. (2007). Managing firm resources in dynamic environments to create value: Looking inside the black box. *Academy of management review*, *32*(1), 273–292. https://doi.org/10.5465/amr.2007.23466005

Sirmon, D. G., Hitt, M. A., Ireland, R. D., & Gilbert, B. A. (2011). Resource orchestration to create competitive advantage: Breadth, depth, and life cycle effects. *Journal of management*, *37*(5), 1390–1412. https://doi.org/10.1177/0149206310385

Ströher, T., Körner, M.-F., Paetzold, F., & Strüker, J. (2025). Bridging carbon data's organizational boundaries: Toward automated data sharing in sustainable supply chains. *Electronic Markets*, *35*(1), 1–22. https://doi.org/10.1007/s12525-025-00779-7

Strüker, J., Urbach, N., Guggenberger, T., Lautenschlager, J., Ruhland, N., Schlatt, V., Sedlmeir, J., Stoetzer, J.-C., & Völter, F. (2021). Self-Sovereign Identity: Grundlagen, Anwendungen und Potenziale portabler digitaler Identitäten.

Tan, W., Sun, Y., Ding, Z., & Lee, W.-J. (2022). Fleet management and charging scheduling for shared mobility-on-demand system: A systematic review. *IEEE Open Access Journal of Power and Energy*, *9*, 425–436. https://doi.org/10.1109/OAJPE.2022.3215865

Traber, T., & Kemfert, C. (2011). Gone with the wind?—electricity market prices and incentives to invest in thermal power plants under increasing wind energy supply. *Energy Economics*, *33*(2), 249–256. https://doi.org/10.1016/j.eneco.2010.07.002

Trepper, K., Bucksteeg, M., & Weber, C. (2015). Market splitting in germany–new evidence from a three-stage numerical model of europe. *Energy Policy*, *87*, 199–215. https://doi.org/10.1016/j.enpol.2015.08.016

Umweltbundesamt. (2025a). *Indicator: Share of renewables in gross electricity consumption* [Accessed 2026-04-25]. https://www.umweltbundesamt.de/en/indicator-share-of-renewables-in-gross-electricity

Umweltbundesamt. (2025b). *Indicator: Share of renewables in gross final energy consumption* [Accessed 2026-04-25]. https://www.umweltbundesamt.de/en/data/environmental-indicators/indicator-renewable-energy

UNDESA. (2025, April). New UN report warns of global social crisis driven by insecurity, inequality, and distrust [Full name: United Nations Department of Economic and Social Affairs. Accessed: April 19, 2026]. https://www.un.org/sustainabledevelopment/blog/2025/04/wsr25-press-release/

Valett, L., Bollenbach, J., & Keller, R. (2024). Empowering sustainable hotels: A guest-centric optimization for vehicle-to-building integration. *Energy Informatics*, *7*(1), 91. https://doi.org/10.1186/s42162-024-00400-9

Valett, L. M., Heeß, P., Kopp, T., Niever, M., Moock, P., & Strüker, J. (2026). Digitale und nachhaltige Transformation in der Praxis.

van der Aalst, W. M. P. (2016). *Process Mining: Data Science in Action*. Springer Berlin Heidelberg. https://doi.org/10.1007/978-3-662-49851-4

Vial, G. (2019). Understanding digital transformation: A review and a research agenda. *The Journal of Strategic Information Systems*, *28*(2), 118–144. https://doi.org/10.1016/j.jsis.2019.01.003

vom Brocke, J., Loos, P., Seidel, S., & Watson, R. T. (2013a). Green IS: Information Systems for Environmental Sustainability. *Business & Information Systems Engineering*, *5*(5), 295–297. https://doi.org/10.1007/s12599-013-0288-y

vom Brocke, J., Seidel, S., & Recker, J. (Eds.). (2012). *Green Business Process Management: Towards the Sustainable Enterprise*. Springer Berlin Heidelberg. https://doi.org/10.1007/978-3-642-27488-6

vom Brocke, J., Watson, R. T., Dwyer, C., Elliot, S., & Melville, N. (2013b). Green information systems: Directives for the is discipline. *Communications of the Association for Information Systems*, *33*. https://doi.org/10.17705/1CAIS.03330

von Scherenberg, F., Hellmeier, M., & Otto, B. (2024). Data sovereignty in information systems. *Electronic Markets*, *34*(15), 1–11. https://doi.org/10.1007/s12525-024-00693-4

Watson, R. T., Boudreau, M.-C., & Chen, A. J. (2010). Information Systems and Environmentally Sustainable Development: Energy Informatics and New Directions for the IS Community. *MIS Quarterly*, *34*(1), 23–38. https://doi.org/10.2307/20721413

Watson, R. T., Ketter, W., Recker, J., & Seidel, S. (2022). Sustainable Energy Transition: Intermittency Policy Based on Digital Mirror Actions. *Journal of the Association for Information Systems*, *23*(3), 631–638. https://doi.org/10.17705/1jais.00752

WEF. (2023). The Global Risks Report 2023 18th Edition. *World Economic Forum Cologny/Geneva*. https://www3.weforum.org/docs/WEF_Global_Risks_Report_2023.pdf

Weibelzahl, M. (2017). Nodal, zonal, or uniform electricity pricing: How to deal with network congestion. *Frontiers in Energy*, *11*(2), 210–232. https://doi.org/10.1007/s11708-017-0460-z

Werner, T., Konhäuser, K., & Schwarz, N. (2026). Evaluating strategic retrofit measures for energy-efficient residential buildings with artificial intelligence. *Energy and Buildings*, 117205. https://doi.org/10.1016/j.enbuild.2026.117205

White, L. V., Fazeli, R., Cheng, W., Aisbett, E., Beck, F. J., Baldwin, K. G., Howarth, P., & O'Neill, L. (2021). Towards emissions certification systems for international trade in hydrogen: The policy challenge of defining boundaries for emissions accounting. *Energy*, *215*, 119139. https://doi.org/10.1016/j.energy.2020.119139

Wolff, G., & Feuerriegel, S. (2017). Short-term dynamics of day-ahead and intraday electricity prices. *International Journal of Energy Sector Management*. https://doi.org/10.1108/IJESM-05-2016-0009

Wüstenhagen, R., & Menichetti, E. (2012). Strategic choices for renewable energy investment: Conceptual framework and opportunities for further research. *Energy Policy*, *40*, 1–10. https://doi.org/10.1016/j.enpol.2011.06.050

Wüstenhagen, R., Wolsink, M., & Bürer, M. J. (2007). Social acceptance of renewable energy innovation: An introduction to the concept. *Energy Policy*, *35*(5), 2683–2691. https://doi.org/10.1016/j.enpol.2006.12.001

Yin, R. K. (2014). *Case study research: Design and methods* (5th ed.). Sage.

Yoo, Y., Henfridsson, O., & Lyytinen, K. (2010). Research commentary—the new organizing logic of digital innovation: An agenda for information systems research. *Information Systems Research*, *21*(4), 724–735. https://doi.org/10.1287/isre.1100.0322

Zeiss, R., Ixmeier, A., Recker, J., & Kranz, J. (2021). Mobilising information systems scholarship for a circular economy: Review, synthesis, and directions for future research. *Information Systems Journal*, *31*(1), 148–183. https://doi.org/10.1111/isj.12305

Zwede, T., Ehaus, M., Babel, M., Heeß, P., Schick, L., Körner, M.-F., & Strüker, J. (2025). Designing and implementing the trust diamond for verifiable and privacy-preserving data sharing: engineering energy flexibility provision. *Energy Informatics*, *8*(1), 143. https://doi.org/10.1186/s42162-025-00603-8

A Appendix

A.1 Overview of Research Papers

A.1.1 Research Papers Included in This Dissertation

Research Paper 1: Navigating the energy transition: A review of factors influencing renewable energy investments
Heeß, P., Schönecker, J., Weibelzahl, M., & Wolf, L. (2026). Navigating the energy transition: A review of factors influencing renewable energy investments. *Renewable and Sustainable Energy Reviews*, *228*, 116416
(VHB-JQ3[1]: B; VHB-R2024[2]: B)

Research Paper 2: Negative electricity prices as a signal for lacking flexibility? On the effects of demand flexibility on electricity prices
Halbrügge, S., Heeß, P., Schott, P., & Weibelzahl, M. (2024). Negative electricity prices as a signal for lacking flexibility? on the effects of demand flexibility on electricity prices. *International Journal of Energy Sector Management*, *18*(3), 596–616
(VHB-JQ3: B; VHB-R2024: C)

Research Paper 3: A multi-agent approach with verifiable and data-sovereign information flows for decentralizing redispatch in distributed energy systems
Heeß, P., Holly, S., Körner, M.-F., Nieße, A., Radtke, M., Schick, L., Stark, S., Strüker, J., & Zwede, T. (2025). A multi-agent approach with verifiable and data-sovereign information flows for decentralizing redispatch in distributed energy systems. *Energy Informatics*, *8*(1), 24
(VHB-JQ3: -; VHB-R2024: C)

Research Paper 4: Introducing the Trust Diamond for Energy Flexibility Provision: On the Tension of Data Verifiability and Privacy
Babel, M., Ehaus, M., Heeß, P., Körner, M.-F., Schick, L., & Strüker, J. (2025). Introducing the Trust Diamond for Energy Flexibility Provision: On the Tension of Data Verifiability and Privacy. *58th Hawaii International Conference on System Sciences (HICSS)*
(VHB-JQ3: C; VHB-R2024: B)

Research Paper 5: Enhancing trust in global supply chains: Conceptualizing Digital Product Passports for a low-carbon hydrogen market
Heeß, P., Rockstuhl, J., Körner, M.-F., & Strüker, J. (2024). Enhancing trust in global supply chains: Conceptualizing Digital Product Passports for a low-carbon hydrogen market. *Electronic Markets*, *34*(1), 10
(VHB-JQ3: B; VHB-R2024: B)

[1] VHB-JQ3: VHB-JOURQUAL3
[2] VHB-R2024: VHB-Rating 2024

Research Paper 6: Leveraging Sustainability Data in Organizations: A Maturity Model Approach

Heeß, P., Körner, M.-F., Strüker, J., & Valett, L. (2026). Leveraging Sustainability Data in Organizations: A Maturity Model Approach. *Outlet hidden due to the double-blind review process*

Research Paper 7: Turning ESG-Data into Value: A Case Study from the European Financial Sector

Auweiler, S., Heeß, P., Körner, M.-F., Strüker, J., & Valett, L. (2026). Turning ESG-Data into Value: A Case Study from the European Financial Sector. *Outlet hidden due to the double-blind review process*

Research Paper 8: Enhancing Process Mining for Sustainability: A Delphi Study Approach

Dechert, F., Heeß, P., Hermann, J., Körner, M.-F., Kratsch, W., Röglinger, M., & Strüker, J. (2026). Enhancing Process Mining for Sustainability: A Delphi Study Approach. *Outlet hidden due to the double-blind review process*

A.1.2 Index of Further Papers

Over the course of the dissertation, I also authored and co-authored the following research papers, studies, and reports. These papers are not part of this dissertation.

Heeß, P. A., Valett, L., & Weibelzahl, M. (2024). Smart Negotiations for Climate Protection: Can Information Systems Save Our Planet? *Proceedings of the 32nd European Conference on Information Systems (ECIS)*
(VHB-JQ3: B; VHB-R2024: A)

Zwede, T., Ehaus, M., Babel, M., Heeß, P., Schick, L., Körner, M.-F., & Strüker, J. (2025). Designing and implementing the trust diamond for verifiable and privacy-preserving data sharing: engineering energy flexibility provision. *Energy Informatics*, *8*(1), 143. https://doi.org/10.1186/s42162-025-00603-8
(VHB-JQ3: -; VHB-R2024: C)

Körner, M.-F., Nolting, L., Babel, M., Ehaus, M., Heeß, P., Lautenschlager, J., Radtke, M., Schick, L., Strüker, J., Wiedemann, S., et al. (2025). A digital infrastructure for integrating decentralized assets into redispatch. Decentralized Redispatch (DEER): Interfaces for providing flexibility

Valett, L. M., Heeß, P., Kopp, T., Niever, M., Moock, P., & Strüker, J. (2026). Digitale und nachhaltige Transformation in der Praxis

Heeß, P., Körner, M.-F., Strüker, J., Valett, L., Wolf, L., Pulvermüller, B., & Richard, P. (2024). Grundlagen und Bedeutung von Datenräumen für die Energiewirtschaft

A.1.3 Individual Contribution to the Included Research Papers

This cumulative dissertation comprises eight research papers, all co-authored with multiple collaborators. This section details the context and outlines my contributions to each of the papers.

Research Paper 1 entitled "Navigating the energy transition: A review of factors influencing renewable energy investments" (P. Heeß, Schönecker, et al., 2026, Section A.2) was written by a team of four authors. I contributed to this paper in a supervisory capacity. Specifically, I supported the identification of the research topic and the selection of an appropriate research method, and participated in ongoing discussions of the findings with the author responsible for data collection as well as with the remaining co-authors throughout the research process. Furthermore, I revised the initial draft, provided detailed feedback on the manuscript's content and structure, and made final adjustments to the paper prior to submission. The remaining co-authors contributed through data collection, analysis, and the drafting of the manuscript under my guidance.

Research Paper 2 entitled "Negative electricity prices as a signal for lacking flexibility? On the effects of demand flexibility on electricity prices" (Halbrügge et al., 2024, Section A.3) was written by a team of four authors. I acted as one of the main authors and initiated and coordinated the research project. My contribution spanned all core phases of the work, including the development of the optimization problem, the execution of the underlying calculations, the writing of the initial draft, and the integration of supervisory feedback into subsequent revisions. The remaining co-authors contributed by critically challenging the model assumptions, supporting the interpretation of the results, and assisting in the writing of selected sections of the paper.

Research Paper 3 entitled "A multi-agent approach with verifiable and data-sovereign information flows for decentralizing redispatch in distributed energy systems" (P. Heeß et al., 2025, Section A.4) was written by a team of nine authors organized into two sub-teams. A group of five authors focused on data-sovereign data flows, while a group of four authors concentrated on the multi-agent system. I served as a lead contributor and coordinator within the project team and was significantly involved in the development of the research results focusing on data-sovereign data flows. In addition, I contributed substantially to the writing of the paper and integrated the feedback provided by the supervising co-authors into successive revisions of the manuscript. The supervising co-authors provided scientific guidance and continuous feedback throughout the project, while the remaining team members contributed to the implementation and documentation within their respective sub-teams.

Research Paper 4 entitled "Introducing the Trust Diamond for Energy Flexibility Provision: On the Tension of Data Verifiability and Privacy" (Babel et al., 2025, Section A.5) was written by a team of six authors. I contributed as part of the core author group responsible for developing the research results and the final artifact. While a co-author served as the primary driver of the conceptual design, I actively engaged in discussions regarding the artifact's structure and direction and contributed a substantial share of the writing for the corresponding paper. The remaining co-authors provided feedback, participated in research discussions, and offered supervisory guidance throughout the project.

Research Paper 5 entitled "Enhancing trust in global supply chains: Conceptualizing Digital Product Passports for a low-carbon hydrogen market" (P. Heeß, Rockstuhl, et al., 2024, Section A.6) was written by a team of four authors. I initiated and coordinated the research project and acted as one of the main authors. My contribution encompassed the development of the core research idea, conducting the literature review and expert interviews, the writing of the initial draft, and the integration of final feedback into the manuscript. Two co-authors were closely involved throughout the research process, providing detailed and continuous feedback on the content and structure of the paper and contributing to the writing of selected sections. The remaining co-author provided supervisory guidance and scientific feedback throughout the project.

Research Paper 6 entitled "Leveraging Sustainability Data in Organizations: A Maturity Model Approach" (P. Heeß, Körner, Strüker, and Valett, 2026, Section A.7) was written by a team of four authors. I acted as the lead author and initiated and coordinated the research project. Together with one co-author, I jointly developed the core research idea and the overall research design, and both of us shared the workload of the literature review. I conducted the majority of the expert interviews and contributed a substantial share of the writing of the manuscript. The same co-author further supported the writing and development of the paper throughout the process. The remaining two co-authors provided supervision and continuous scientific feedback.

Research Paper 7 entitled "Turning ESG-Data into Value: A Case Study from the European Financial Sector" (Auweiler et al., 2026, Section A.8) was written by a team of five authors. I contributed to this paper in a supervisory capacity. My involvement included supporting the establishment of the research idea, providing continuous feedback on the manuscript throughout the research process, and assisting in the writing of the paper. The remaining co-authors were responsible for the primary execution of the research, including the conceptualization, data collection, analysis, and the drafting of the manuscript.

Research Paper 8 entitled "Enhancing Process Mining for Sustainability: A Delphi Study Approach" (Dechert et al., 2026, Section A.9) was written by a team of seven authors. Together with two other co-authors, I served as one of three main authors of the paper. My contribution encompassed the development of the core research idea, the conduction and analysis of the Delphi study, the visualization of the results, the writing of major parts of the manuscript, and the integration of feedback provided by the remaining co-authors into successive revisions. The two other lead authors contributed equally across these same phases. The remaining four co-authors participated in providing scientific feedback, engaging in research discussions, and offering supervisory guidance throughout the project.

A.2 Research Paper 1: Navigating the energy transition: A review of factors influencing renewable energy investments

Authors:
P. Heeß, J. Schönecker, M. Weibelzahl, and L. Wolf

Published as:
Heeß, P., Schönecker, J., Weibelzahl, M., & Wolf, L. (2026). Navigating the energy transition: A review of factors influencing renewable energy investments. *Renewable and Sustainable Energy Reviews*, *228*, 116416

Abstract:
As global electricity consumption rises, energy systems face increasing challenges, highlighting the urgent need for a reliable energy supply with minimal (socio-)ecological impact. In response, policymakers set ambitious targets for the sustainable energy transition, requiring substantial growth in renewable energy (RE) investments. However, recent socio-economic challenges—such as the COVID-19 pandemic, geopolitical conflicts, economic uncertainties, and evolving climate movements—have significant influence on the investment landscape. These disruptions underscore the necessity of continuously reassessing the factors influencing RE investments to ensure that research and policy decisions are based on current realities. This paper provides an updated analysis of the political, economic, environmental, social, and technological (PEEST) factors shaping RE investments. Using a systematic literature review and expert interviews, we examine 37 PEEST factors affecting investment decisions. Our findings indicate that economic factors, particularly profitability and financial risk, remain the necessary drivers of RE investments, while political factors significantly shape the regulatory framework, either facilitating or constraining RE development. Although environmental, social, and technological factors are supporting factors in direct investment decisions, they influence economic considerations and long-term market stability. By offering a contemporary and dynamic assessment of RE investment factors, this study provides 13 key takeaways for policymakers, investors, and researchers, ensuring that energy transition strategies are grounded in up-to-date realities rather than past assumptions.

Keywords:
Renewable Energy; Renewable Energy Investments; Energy Transition; Influencing Factors; Expert Interviews; Systematic Literature Review

A.3 Research Paper 2: Negative electricity prices as a signal for lacking flexibility? On the effects of demand flexibility on electricity prices

Authors:
S. Halbrügge, P. Heeß, P. Schott, and M. Weibelzahl

Published as:
Halbrügge, S., Heeß, P., Schott, P., & Weibelzahl, M. (2024). Negative electricity prices as a signal for lacking flexibility? on the effects of demand flexibility on electricity prices. *International Journal of Energy Sector Management*, *18*(3), 596–616

Abstract:
Purpose – The purpose of this paper is to examine how active consumers, i.e., consumers that can inter-temporally shift their load, can influence electricity prices. As we demonstrate, inter-temporal load shifting can induce negative electricity prices, a recurring phenomenon on power exchanges.
Design/methodology/approach – The paper presents a novel electricity-market model assuming a nodal-pricing, energy-only spot market with active consumers. We formulate an economic equilibrium problem as a linear program, and use an established six-node case study to compare equilibrium prices of a model with inflexible demand to a model with flexible demand of active consumers.
Findings – We illustrate that temporal coupling of hourly market clearing through load shifting of active consumers can cause negative electricity prices that are not observed in a model with ceteris paribus inflexible demand. In such situations, where compared to the case of inflexible demand more flexibility is available in the system, negative electricity prices signal lower total system costs. These negative prices result from the use of demand flexibility, which, however, cannot be fully exploited due to limited transmission capacities, respectively loop-flow restrictions.
Originality – Literature indicates that negative electricity prices result from lacking flexibility. Our results illustrate that active consumers and their additional flexibility can lead to negative electricity prices in temporally coupled markets, which in general contributes to increased system efficiency as well as increased use of renewable energy sources.These findings extend existing research in both the area of energy flexibility and causes for negative electricity prices. Therefore, policymakers should be aware of such (temporal coupling) effects and, e.g., continue to allow negative electricity prices in the future that can serve as investment signals for active consumers.

Keywords:
Electricity Pricing; Renewable Energy Sources; Demand Flexibility; Nodal Pricing; Market Design; Case Study

A.4 Research Paper 3: A multi-agent approach with verifiable and data-sovereign information flows for decentralizing redispatch in distributed energy systems

Authors:
P. Heeß, S. Holly, M.-F. Körner, A. Nieße, M. Radtke, L. Schick, S. Stark, J. Strüker, and T. Zwede

Published as:
Heeß, P., Holly, S., Körner, M.-F., Nieße, A., Radtke, M., Schick, L., Stark, S., Strüker, J., & Zwede, T. (2025). A multi-agent approach with verifiable and data-sovereign information flows for decentralizing redispatch in distributed energy systems. *Energy Informatics*, *8*(1), 24

Abstract:
The need to harness the flexibility of small-scale assets for system stabilization, including redispatch, is growing rapidly with the increasing prevalence of distributed generation, such as photovoltaic systems and heavy loads, in particular heat pumps and electric vehicles. Integrating these resources into the redispatch process presents special requirements: On the one hand, building trust with the owners of such assets requires privacy and a reasonable degree of autonomy and engagement. On the other hand, besides the system's scalability and robustness, the verifiability and traceability of provided data are essential for grid operators who depend on the reliable provision of redispatch services. To date, research and practice have encountered significant challenges in defining a system that enables the inclusion of decentralized flexibilities while satisfying necessary requirements. To that end, we present a novel conceptual system design that addresses these challenges by combining a MAS approach with verifiable information flows through digital SSIs and ZKPs. Single agents, as edge devices, operate locally and autonomously, respecting customer preferences, while MAS provide the ability to design robust, reliable, and scalable systems. SSI enables agents to manage their data autonomously, while ZKPs are used to protect users' privacy through selective data disclosure which allows the verification of the correctness of information without disclosing the underlying data. To validate the feasibility of this design, a case study is included to demonstrate the functionality of key sub-processes, such as baseline optimization, aggregation, and disaggregation, in a realistic scenario. This case study, supported by a prototype implementation, provides initial evidence of the concept's soundness and lays the groundwork for future evaluation through extensive simulations and field testing. Together, the technologies included in the conceptual system design balance full transparency for grid operators with autonomy and data economy for asset owners

Keywords:
Decentralized Redispatch; Small-scale Flexibility; Data-Sovereignty

A.5 Research Paper 4: Introducing the Trust Diamond for Energy Flexibility Provision: On the Tension of Data Verifiability and Privacy

Authors:
M. Babel, M. Ehaus, P. Heeß, M.-F. Körner, L. Schick, and J. Strüker

Published as:
Babel, M., Ehaus, M., Heeß, P., Körner, M.-F., Schick, L., & Strüker, J. (2025). Introducing the Trust Diamond for Energy Flexibility Provision: On the Tension of Data Verifiability and Privacy. *58th Hawaii International Conference on System Sciences (HICSS)*

Abstract:
Data sharing in a digitalized world is increasingly important, but its inherent tension between data verfiability and privacy limits stakeholders engagement. Data consumers need to confirm the data's authenticity while providers fear privacy breaches. In the course of the sustainable energy transition, this tension also hinders the integration of small-scale flexibility devices in electricity grids. Grid Operators must rely on verifiable data for secure operations, while device owners seek to ensure data protection and thus privacy. Based on Action Design Research, we develop a *Flexibility Provision Data Flow* and propose a conceptual *Trust Diamond* that leverages wallet-based identity management to ensure verifiability and privacy-preserving data sharing. We derive the design principles of *Verifiability through Delegation* and *Derived Sovereignty* and show their applicability for optimized grid operations. This study highlights the importance of Information Systems-based solutions to enhance data sharing and address trust concerns between stakeholders.

Keywords:
Digital Energy Services and Analytics; Action Design Research; Data Sharing; Flexibility Markets; Privacy,Verifiability

A.6 Research Paper 5: Enhancing trust in global supply chains: Conceptualizing Digital Product Passports for a low-carbon hydrogen market

Authors:
P. Heeß, J. Rockstuhl, M.-F. Körner, and J. Strüker

Published as:
Heeß, P., Rockstuhl, J., Körner, M.-F., & Strüker, J. (2024). Enhancing trust in global supply chains: Conceptualizing Digital Product Passports for a low-carbon hydrogen market. *Electronic Markets*, *34*(1), 10

Abstract:
Industries and energy markets around the world are facing mounting pressure to decarbonize, prompting them to transform processes and supply chains towards sustainability. However, a lack of credible sustainability data proves to be a considerable barrier for emerging markets for sustainable products: Against the background of complex and globalized supply chains, it is necessary to verify the sustainability claim of products in order to demand price premiums for sustainable products in the long run. To enable this, it is necessary that stakeholders in globalized supply chains are willing to share relevant data along the entire supply chain for increasing traceability and reducing information asymmetries. Using the example of international hydrogen supply chains, we study how data can be shared between different stakeholders using Digital Product Passports while addressing stakeholders' concerns about data privacy and disclosure. In our work, we develop design principles that provide insight into how a Digital Product Passport should be designed to verify the hydrogen's carbon footprint in a reliable way and to ensure the willingness of stakeholders to share their data. We follow a multi-step approach with a structured literature review followed by expert interviews and qualitative content analysis for a synthesis of design principles. Our research illustrates that a Digital Product Passport must collect data comprehensively and automatically, process it in a decentralised and tamper-proof manner, protect privacy and sovereignty of stakeholders, and ensure interoperability.

Keywords:
Data economy; Decarbonization; Digital Product Passports; Hydrogen; Supply chains; Verification

A.7 Research Paper 6: Leveraging Sustainability Data in Organizations: A Maturity Model Approach

Authors:
P. Heeß, M.-F. Körner, J. Strüker, and L. Valett

Submitted to:
Outlet hidden due to the double-blind review process

Abstract:
Amid ongoing policy debates on the prioritization of sustainability measures, increasing regulatory requirements compel organizations to systematically collect and report sustainability data (Körner et al., 2025). Beyond compliance, these data offer opportunities to enhance transparency, support managerial decision-making, and enable sustainability-oriented innovation and new business models (Krasikov & Legner, 2023). Yet many firms fail to translate sustainability data into strategic value, as data remain fragmented across systems, inconsistently defined, and difficult to integrate, leading organizations to use them primarily for backward-looking, compliance-oriented reporting rather than proactive transformation (Püchel et al., 2024). While information systems (IS) research has long emphasized the role of IS in advancing environmental and social objectives (Gholami et al., 2016), it provides limited guidance on how organizations can systematically develop the capabilities required to strategically manage and leverage sustainability data as an integrative resource. Drawing on Resource Orchestration Theory (ROT) (Sirmon et al., 2007, 2011), which extends the Resource Based View (RBV) (Barney, 1991) and resonates with dynamic capabilities theory (Teece et al., 1997), this study conceptualizes sustainability data as a latent strategic resource whose value depends on effective orchestration through technological, managerial, and cultural capabilities.

The development of a Sustainability Data Management Maturity Model (SDM-MM) operationalizes this perspective. Following the established maturity model development approach of Becker et al. (2009), grounded in design science research principles (Hevner et al., 2004), the model was developed and evaluated through a multi-method, iterative process. A systematic literature review conducted in line with Webster and Watson (2002) screened relevant papers on data-related maturity models, providing the conceptual foundation for an initial model structure. Building on this foundation, a focus group with seven experts from IT and sustainability consulting and academia, following the procedure of Wilkinson (1998), informed an Alpha version of the model, which was subsequently refined across two rounds of semi-structured expert interviews with eleven experts from academic, consulting, and corporate sustainability contexts (Myers & Newman, 2007). Interview data were analyzed through iterative qualitative coding, progressively transforming the model into Beta and Gamma versions. The resulting SDM-MM was implemented as an interactive online self-assessment tool and evaluated in three organizational use cases spanning commercial real estate, coffee wholesale, and housing management, each combining a structured maturity assessment with follow-up interviews to contextualize results and

assess practical utility.

The SDM-MM comprises four interrelated dimensions – *Infrastructure, Data, Management,* and *People* – that jointly determine an organization's ability to harness sustainability data, and specifies five maturity stages ranging from *Initial* to *Optimized* that describe organizations' progression from fragmented, reactive data practices toward institutionalized, transformation-oriented sustainability data management. Building on these findings, the study derives 20 concrete action recommendations, grouped by dimension, that provide organizations with prioritized starting points for capability development. Together, the model and its accompanying recommendations enable firms to move from retrospective compliance reporting toward proactive and strategic sustainability action through advanced sustainability data maturity. By linking ROT with sustainability data management, this study contributes a theoretically grounded, empirically evaluated maturity model and practical guidance for data-driven sustainability transformation and value creation.

Barney, J. (1991). Firm resources and sustained competitive advantage. *Journal of management*, *17*(1), 99–120.

Becker, J., Knackstedt, R., & Pöppelbuß, J. (2009). Developing maturity models for it management: A procedure model and its application. *Business & information systems engineering*, *1*(3), 213–222. https://doi.org/10.1007/s12599-009-0044-5

Gholami, R., Watson, R., Hasan, H., Molla, A., & Bjorn-Andersen, N. (2016). Information Systems Solutions for Environmental Sustainability: How Can We Do More? *Journal of the Association for Information Systems*, *17*(8), 521–536. https://doi.org/10.17705/1jais.00435

Heeß, P., Körner, M.-F., Strüker, J., & Valett, L. (2026). Leveraging Sustainability Data in Organizations: A Maturity Model Approach. *Outlet hidden due to the double-blind review process*.

Hevner, A. R., March, S. T., Park, J., & Ram, S. (2004). Design science in information systems research. *MIS Quarterly*, *28*(1), 75–105. https://doi.org/10.2307/25148625

Körner, M.-F., Leinauer, C., Ströher, T., & Strüker, J. (2025). Digital measuring, reporting, and verification (dmrv) for decarbonization. *Business & Information Systems Engineering*, 1–13.

Krasikov, P., & Legner, C. (2023). Introducing a Data Perspective to Sustainability: How Companies Develop Data Sourcing Practices for Sustainability Initiatives. *Communications of the Association for Information Systems*, *53*, 162–188. https://doi.org/10.17705/1CAIS.05307

Myers, M. D., & Newman, M. (2007). The qualitative interview in is research: Examining the craft. *Information and organization*, *17*(1), 2–26. https://doi.org/10.1016/j.infoandorg.2006.11.001

Püchel, L., Wang, C., Buhmann, K., Brandt, T., Von Schweinitz, F., Edinger-Schons, L. M., vom Brocke, J., Legner, C., Teracino, E., & Mardahl, T. D. (2024). On the Pivotal Role of Data in Sustainability Transformations: Challenges and Opportunities. *Business & Information Systems Engineering*, *66*(6), 831–848. https://doi.org/10.1007/s12599-024-00904-4

Sirmon, D. G., Hitt, M. A., & Ireland, R. D. (2007). Managing firm resources in dynamic environments to create value: Looking inside the black box. *Academy of management review*, *32*(1), 273–292. https://doi.org/10.5465/amr.2007.23466005

Sirmon, D. G., Hitt, M. A., Ireland, R. D., & Gilbert, B. A. (2011). Resource orchestration to create competitive advantage: Breadth, depth, and life cycle effects. *Journal of management*, *37*(5), 1390–1412. https://doi.org/10.1177/0149206310385

Teece, D. J., Pisano, G., & Shuen, A. (1997). Dynamic capabilities and strategic management. *Strategic management journal*, *18*(7), 509–533. https://doi.org/10.1002/(SICI)1097-0266(199708)18:7%3C509::AID-SMJ882%3E3.0.CO;2-Z

Webster, J., & Watson, R. T. (2002). Analyzing the past to prepare for the future: Writing a literature review. *MIS Quarterly*, *26*(2), xiii–xxiii. Retrieved October 23, 2025, from http://www.jstor.org/stable/4132319

Wilkinson, S. (1998). Focus group methodology: A review. *International journal of social research methodology*, *1*(3), 181–203. https://doi.org/10.1080/13645579.1998.10846874

Keywords:

Maturity model; Data management; Resource orchestration theory; Sustainability; Capabilities

A.8 Research Paper 7: Turning ESG-Data into Value: A Case Study from the European Financial Sector

Authors:
S. Auweiler, P. Heeß, M.-F. Körner, J. Strüker, and L. Valett

Submitted to:
Outlet hidden due to the double-blind review process

Abstract:
As central actors in capital allocation and risk management, European financial institutions have collected environmental, social, and governance (ESG) data in recent years primarily in response to regulatory guidelines (Ballnat et al., 2025; Bundesanstalt für Finanzdienstleistungsaufsicht, 2024; European Commission, 2022). Despite ongoing political debates around sustainability and ESG, the existing data infrastructures and processes hold untapped potential, raising the question of how to create strategic value from this data beyond regulatory compliance (Ixmeier et al., 2024; Püchel et al., 2024). By applying a resourcing perspective (Feldman, 2004; Howard-Grenville, 2007), extended to network-level contexts (Auschra & Sydow, 2023), we examine how ESG-data can enable transformative sustainable organizing.

We do so by conducting a single case study (Benbasat et al., 1987; X. Wang et al., 2024) of *ESG-Data&Analytics*, a shared digital platform within the Genossenschaftliche FinanzGruppe, a co-operative network of 672 financial institutions. Following established multi-source case study procedures (Eisenhardt, 1989; J. Wang et al., 2024), we draw on rich empirical insights from 11 semi-structured interviews with stakeholders across project partners, technology providers, and member banks, complemented by focus groups, practice-talk sessions, and extensive project documentation collected over a 12-month engagement. Data were analyzed following the three-step Gioia methodology (Gioia et al., 2013), moving iteratively from first-order concepts to theoretically grounded second-order themes and aggregate dimensions, with saturation assessed in line with established qualitative research standards (Charmaz, 2014).

Our findings show that coordinated, network-level data practices which we conceptualize as controlling, producing, reproducing, and transforming (Auschra & Sydow, 2023) transform ESG-data from dispersed assets into value-creating resources. This is achieved, for example, through standardized KPIs, peer benchmarking, and scenario-based simulations, allowing institutions to reassess climate-related financial risks and develop decarbonization roadmaps. By repurposing ESG-data infrastructures originally established for compliance, institutions enact new ways of sustainability management that challenge dominant reporting-oriented approaches (Krasikov & Legner, 2023) and open space for more anticipatory, future-oriented forms of transformative organizing (Gümüsay & Reinecke, 2024).

Theoretically, our study extends the resourcing perspective by conceptualizing digital ESG platforms as imaginative infrastructures that shape how sustainability futures are envisioned and enacted in organizational networks. We further show that individual digitalization- and sustainability-

driven schemas such as data literacy, trust in technology, and sustainability values mediate whether ESG-data is mobilized for strategic value creation and transformative change, thereby introducing an individual-level dimension into network resourcing theory that complements its predominantly network-level focus (Auschra & Sydow, 2023). Overall, the study demonstrates how European financial institutions can mobilize ESG-data infrastructures to align economic decision-making with more desirable and sustainable futures.

Auschra, C., & Sydow, J. (2023). Resourcing goal-directed networks: Toward a practice-based perspective. *Journal of Public Administration Research and Theory*, *33*(2), 232–245. https://doi.org/10.1093/jopart/muac023

Auweiler, S., Heeß, P., Körner, M.-F., Strüker, J., & Valett, L. (2026). Turning ESG-Data into Value: A Case Study from the European Financial Sector. *Outlet hidden due to the double-blind review process*.

Ballnat, A., Festing, M., Sahakiants, I., & Steger, T. (2025). The role of mandatory non-financial reporting in corporate sustainability: A qualitative study on HRM in German corporations. *European Management Journal*. https://doi.org/10.1016/j.emj.2025.01.002

Benbasat, I., Goldstein, D. K., & Mead, M. (1987). The case research strategy in studies of information systems. *MIS Quarterly*, *11*(3), 369. https://doi.org/10.2307/248684

Bundesanstalt für Finanzdienstleistungsaufsicht. (2024). Rundschreiben 06/2024 (ba) - marisk: Mindestanforderungen an das risikomanagement (Bundesanstalt für Finanzdienstleistungsaufsicht, Ed.). https://www.bafin.de/SharedDocs/Downloads/DE/Rundschreiben/dl_rs_06_2024_MaRisk_pdf_BA.html

Charmaz, K. (2014). *Constructing grounded theory* (2nd ed.). Sage.

Eisenhardt, K. M. (1989). Building theories from case study research. *The Academy of Management Review*, *14*(4), 532. https://doi.org/10.3280/SO2008-002004

European Commission. (2022). Directive (eu) 2022/2464 of the european parliament and the council (Official Journal of the European Union, Ed.). https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32022L2464

Feldman, M. S. (2004). Resources in emerging structures and processes of change. *Organization Science*, *15*(3), 295–309. https://doi.org/10.1287/orsc.1040.0073

Gioia, D. A., Corley, K. G., & Hamilton, A. L. (2013). Seeking qualitative rigor in inductive research. *Organizational Research Methods*, *16*(1), 15–31. https://doi.org/10.1177/1094428112452151

Gümüsay, A. A., & Reinecke, J. (2024). Imagining desirable futures: A call for prospective theorizing with speculative rigour. *Organization Theory*, *5*(1). https://doi.org/10.1177/26317877241235939

Howard-Grenville, J. A. (2007). Developing issue-selling effectiveness over time: Issue selling as resourcing. *Organization Science*, *18*(4), 560–577. https://doi.org/10.1287/orsc.1070.0266

Ixmeier, A., Wagner, F., & Kranz, J. (2024). Leveraging information systems for environmental sustainability and business value. *MIS Quarterly Executive*, 57–75.

Krasikov, P., & Legner, C. (2023). Introducing a Data Perspective to Sustainability: How Companies Develop Data Sourcing Practices for Sustainability Initiatives. *Communications of the Association for Information Systems*, *53*, 162–188. https://doi.org/10.17705/1CAIS.05307

Püchel, L., Wang, C., Buhmann, K., Brandt, T., Von Schweinitz, F., Edinger-Schons, L. M., vom Brocke, J., Legner, C., Teracino, E., & Mardahl, T. D. (2024). On the Pivotal Role of Data in Sustainability Transformations: Challenges and Opportunities. *Business & Information Systems Engineering*, *66*(6), 831–848. https://doi.org/10.1007/s12599-024-00904-4

Wang, J., Teracino, E., & Legner, C. (2024). Towards data management for navigating the dynamic landscape of sustainability regulations and standards. *ICIS 2024 Proceedings*, *15*.

Wang, X., Yuan, M., Suo, X., Yu, M., Huang, P., & Lin, H. (2024). Strategic Imperatives of ESG in Fostering Corporate Digital Innovation: a Resource-Based View. *Journal of the Knowledge Economy*. https://doi.org/10.1007/s13132-024-02542-3

Keywords:

ESG-data; Sustainable organizing; Digital infrastructures,Resourcing perspective,Strategic value creation,Cooperative networks

A.9 Research Paper 8: Enhancing Process Mining for Sustainability: A Delphi Study Approach

Authors:

F. Dechert, P. Heeß, J. Hermann, M.-F. Körner, W. Kratsch, M. Röglinger, and J. Strüker

Submitted to:

Outlet hidden due to the double-blind review process

Abstract:

With the rising pressure for sustainable business practices and the deliberate choice of many organizations to anchor sustainability in their strategy and operations, the integration of environmental, social, and governance (ESG) criteria into business processes has gained prominence and calls for innovative approaches to embed sustainability more systematically (Li et al., 2021; Zumente & Bistrova, 2021). Process mining offers promising possibilities to support ESG efforts by enabling data-driven analysis and continuous process improvement, building on its established capacity to discover, monitor, and improve real processes by extracting knowledge from event logs (Badakhshan et al., 2022; van der Aalst et al., 2012), and extending prior work on green business process management that has so far focused predominantly on the environmental dimension (Opitz et al., 2014). To explore this potential, we conducted a Delphi study with experts in business process management, process mining, and sustainability. Following established Delphi study design principles (Linstone & Turoff, 2011; Paré et al., 2013; von der Gracht, 2012), the study was carried out over six rounds with 24 academic and industry experts from nine countries, progressing through structured phases of brainstorming, narrowing-down, and multi-criteria rating (Keeney et al., 2001; Schmidt, 1997). The study identified and evaluated 30 distinct process mining use cases for ESG, ten in each of the environmental, social, and governance dimensions, rated according to their feasibility, viability, and desirability. The findings reveal significant opportunities to leverage process mining for advancing ESG objectives, particularly in areas such as resource optimization, compliance monitoring, and employee well-being, with use cases consistently rated as highly desirable across all three dimensions. At the same time, feasibility and viability ratings varied systematically, with environmental use cases assessed as more readily implementable than social and governance use cases, reflecting greater sensitivity, fragmentation, and regulatory heterogeneity of the underlying data, allowing the use cases to be clustered into "Quick Wins," "Happy Medium," and "Long Shot" categories that support prioritization in practice. The results highlight substantial potential for process mining to support ESG adoption and drive competitive advantage, particularly by providing a structured and theoretically informed perspective on its role as a digital capability for ESG improvement, responding to calls within the information systems community for research that more concretely addresses the societal relevance of digital technologies (Gholami et al., 2016; vom Brocke et al., 2013) and the essential role of data in sustainability transformation (Krasikov & Legner, 2023; Püchel et al., 2024). This perspective offers a foundation for future research and theory development at the intersection of process mining, information systems, and sustainability.

Badakhshan, P., Wurm, B., Grisold, T., Geyer-Klingenberg, J., Mendling, J., & vom Brocke, J. (2022). Creating business value with process mining. *The Journal of Strategic Information Systems*, *31*(4), 101745. https://doi.org/10.1016/j.jsis.2022.101745

Dechert, F., Heeß, P., Hermann, J., Körner, M.-F., Kratsch, W., Röglinger, M., & Strüker, J. (2026). Enhancing Process Mining for Sustainability: A Delphi Study Approach. *Outlet hidden due to the double-blind review process*.

Gholami, R., Watson, R., Hasan, H., Molla, A., & Bjorn-Andersen, N. (2016). Information Systems Solutions for Environmental Sustainability: How Can We Do More? *Journal of the Association for Information Systems*, *17*(8), 521–536. https://doi.org/10.17705/1jais.00435

Keeney, S., Hasson, F., & McKenna, H. P. (2001). A critical review of the Delphi technique as a research methodology for nursing. *International Journal of Nursing Studies*, *38*(2), 195–200. https://doi.org/10.1016/S0020-7489(00)00044-4

Krasikov, P., & Legner, C. (2023). Introducing a Data Perspective to Sustainability: How Companies Develop Data Sourcing Practices for Sustainability Initiatives. *Communications of the Association for Information Systems*, *53*, 162–188. https://doi.org/10.17705/1CAIS.05307

Li, T.-T., Wang, K., Sueyoshi, T., & Wang, D. D. (2021). ESG: Research Progress and Future Prospects. *Sustainability*, *13*(21), 11663. https://doi.org/10.3390/su132111663

Linstone, H. A., & Turoff, M. (2011). Delphi: A brief look backward and forward. *Technological Forecasting and Social Change*, *78*(9), 1712–1719. https://doi.org/10.1016/j.techfore.2010.09.011

Opitz, N., Krup, H., & Kolbe, L. M. (2014). Green Business Process Management – A Definition and Research Framework. *2014 47th Hawaii International Conference on System Sciences*, 3808–3817. https://doi.org/10.1109/HICSS.2014.473

Paré, G., Cameron, A.-F., Poba-Nzaou, P., & Templier, M. (2013). A systematic assessment of rigor in information systems ranking-type Delphi studies. *Information & Management*, *50*(5), 207–217. https://doi.org/10.1016/j.im.2013.03.003

Püchel, L., Wang, C., Buhmann, K., Brandt, T., Von Schweinitz, F., Edinger-Schons, L. M., vom Brocke, J., Legner, C., Teracino, E., & Mardahl, T. D. (2024). On the Pivotal Role of Data in Sustainability Transformations: Challenges and Opportunities. *Business & Information Systems Engineering*, *66*(6), 831–848. https://doi.org/10.1007/s12599-024-00904-4

Schmidt, R. C. (1997). Managing Delphi Surveys Using Nonparametric Statistical Techniques*. *Decision Sciences*, *28*(3), 763–774. https://doi.org/10.1111/j.1540-5915.1997.tb01330.x

van der Aalst, W. M. P., Adriansyah, A., de Medeiros, A. K. A., Arcieri, F., Baier, T., Blickle, T., Bose, J. C., van den Brand, P., Brandtjen, R., Buijs, J., Burattin, A., Carmona, J., Castellanos, M., Claes, J., Cook, J., Costantini, N., Curbera, F., Damiani, E., de Leoni, M., … Wynn, M. (2012, August). Process Mining Manifesto. In F. Daniel, K. Barkaoui, & S. Dustdar (Eds.), *Business Process Management Workshops* (pp. 169–194, Vol. 99). Springer Berlin Heidelberg.

vom Brocke, J., Loos, P., Seidel, S., & Watson, R. T. (2013). Green IS: Information Systems for Environmental Sustainability. *Business & Information Systems Engineering*, *5*(5), 295–297. https://doi.org/10.1007/s12599-013-0288-y von der Gracht, H. A. (2012). Consensus measurement in Delphi studies. *Technological Forecasting and Social Change*, *79*(8), 1525–1536. https://doi.org/10.1016/j.techfore.2012.04.013

Zumente, I., & Bistrova, J. (2021). ESG Importance for Long-Term Shareholder Value Creation: Literature vs. Practice. *Journal of Open Innovation: Technology, Market, and Complexity*, *7*(2), 127. https://doi.org/10.3390/joitmc7020127

Keywords:

Process mining; Business process management; Sustainability; ESG; Use cases