Digitally-Enabled Corporate Sustainability Transformation
Case and Context for Green IT and Green IS

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Dedicated to all those who make things better.

All natural and technological processes proceed in such a way
that the availability of the remaining energy decreases.
In all energy exchanges, if no energy enters or leaves an isolated system,
the entropy of that system increases.
Energy continuously flows from being concentrated,
to becoming dispersed, spread out, wasted, and useless.
New energy cannot be created, and high-grade energy is being destroyed.
An economy based on endless growth is unsustainable.
- Muse; The 2nd Law: Unsustainable

One day a great fire broke out in the forest, threatening to destroy everything.
The animals of the forest ran out and stared at the burning trees as if paralyzed.
Only one little hummingbird said to himself, "I must do something about the fire."
He flew to the nearest river, took a drop of water in his beak, and dropped it over the fire.
Then he flew back, took the next drop, dropped it, flew back, took a drop, and so on.
All the other animals, much bigger than him, like the elephant with his long trunk, could
carry much more water, but all these animals stood helpless before the wall of fire.
They said to the hummingbird: "What do you think you can do? You are much too small.
The fire is too big. Your wings are too small,
and your beak is so narrow that you can only carry one drop of water at a time."
But as they continued to discourage him, he turned and, without wasting time, told them,
"I'm doing what I can. I'm doing the best I can."
- Wangari Maathai; The story of the hummingbird
(slightly modified)

Abstract

The effects of the global climate disruption become ever more severe. The digital transformation of businesses and the consequential ever-growing demand for Information Technologies (ITs) and Information Systems (IS) fuel this development. Their construction consumes vast amounts of physical resources, and their operation growing amounts of energy. However, increased use of Green IT and Green IS (innovative technologies and practices organizations can use to counteract and pro-actively manage their digital and sustainable transformation) can also solve these challenges.

Despite their potential, only a few companies seem yet to use Green IT and Green IS. We see and uncover three core reasons that we seek to address in this thesis: First, a misleading conceptual understanding of Green IT and Green IS. We see that both are treated as regular innovations through which their ecological ties are ignored. They are furthermore limited to their technical nature, and their socio-technical components are omitted. We address this by undertaking two literature analyses. The first uncovers that Green IT/IS adoption is influenced by not only organizational and individual but also environmental and societal factors. In the second, we find that primarily Green IT/IS capabilities enable initial but also more sophisticated sustainability changes.

Second, the low Green IT/IS adoption rate is an issue. Without these clear and visible demonstrations of internal and external benefits, neither companies continue to refrain from initial adoption. We address this issue by undertaking two quantitative studies and one literature review. We document that while only a few companies use Green IT/IS, those that do achieve various benefits on the four outlined levels. In the literature review, we catalog quick wins that companies can adopt quasi-costless while achieving relatively high sustainability benefits.

Third, certain managerial assumptions about sustainability and Green IT/IS negatively determine the respective corporate adoption decisions. We document some of these assumptions in three initial studies and then undertake an additional interview study to confront managers with our insights.

This dissertation contributes to the academic discourse by adding conceptual clarity to the Green IT/IS concepts and their adoption determinants, means, and outcomes. Corporate decision-makers also benefit from this improved understanding, as it gives them a clearer picture of the factors that need to be considered in initializing or advancing their organization's digitally-enabled sustainability transformation.

Keywords: *Green IT, Green IS, innovation adoption, corporate sustainability, sustainability transformation*

Preface

It is often said that when life gives you lemons, you can either bite into them or make lemonade out of them. But the way I see it, there are so many more options: Why not plant and grow a lemon tree out of one of them? Why not cut and share another with a friend over a shot of Tequila? Why not season a salad with them? Why not… there are so many possibilities. What I basically want to say is: Life is full of options. You get to choose every day. Is it easy? Probably not. Do you see the decision points? Unlikely. Is it easy to choose the right instead of the easy path? Definitely not. But there are days when you need to make a decision. When an opportunity to make a difference is in plain sight. Either in your life or in the life of another one. Often, you recognize it because it comes as an opportunity that seemed far out of reach. One that looks too big for you. One, you feel that others deserve far more than you. Yet, it is your opportunity. But you get it, and the decision is for you to make. You can take it or leave it. Say yes, or no. Dare it or spare it.

For me, the day I was offered to do this dissertation was such a moment. It allowed me to challenge myself and embark on a path whose impact on my life I could not anticipate. Looking back at the way behind me, I see that many people have accompanied me. Some for longer, some for shorter. And very likely far too much to enumerate and name all of them individually. Nevertheless, I want to name and thank some of them explicitly.

First of all, I want to thank Prof. Dr. Frederik Ahlemann for giving me a chance to not only work at his chair as a student assistant but also to take up and pursue my doctoral studies. I am deeply grateful for his advice and support, the challenging but fruitful feedback, and the freedom he granted me while pursuing my work and research. My further sincere thanks go to Prof. Dr. Stefan Eicker for accepting the second supervision of my thesis.

Second, I want to thank all my colleagues at the Chair of Information Systems and Strategic IT Management at the University of Duisburg-Essen. I owe thanks and respect to any of you in one way or another. I want to specifically thank Kevin Rehring and Tim-Christopher Brée for making the time at the chair more enjoyable. Similarly, I want to thank Malte Greulich and Linda Kosmol for their inspiration, the fruitful discussions, and for being research partners.

Finally and most importantly, I want to express my sincerest and deepest gratitude to my wife, Nina. Without her love, patience, support, and understanding, this thesis would have never been completed. Special thanks also go to Sandra. For being her and for being there.

Dortmund, March 2023 Helge Alsdorf

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List of Publications

Preceding work or earlier versions of all research papers included in this thesis were published as full papers in conference proceedings or journal publications.

	Paper 1	Paper 2	Paper 3	Paper 4	Paper 5	Paper 6
Title	On Making a Difference: Towards an Integrative Framework for Green IT and Green IS Adoption	Why People and Processes Enable Sustainability and Not the Latest Techno-logy: On Achieving Green IT/IS Capability Maturity	Green IT Quick Wins How Companies can Achieve Long-Term Sustainability with Implementing Short-Term IT Measures	Green IS Does Not Just Save Energy Insights from a Survey on Organizations' Uses of Sustainable Technologies	Relevance and Significance of Sustainability – Green IT/IS as a Niche Topic in SMEs in the DACH Region	It' s Just Not Sexy: How Managerial Assumptions Adver-sely Affect Corporate Sustainability Engage-ment and Sustainable Technology Adoption
Outlet (Level [3])	HICSS, Conference (C)	PACIS, Conference (C)	HMD – Praxis der Wirtschaftsinformatik, Journal, (D)	HICSS, Conference (C)	HMD – Praxis der Wirtschaftsinformatik, Journal, (D)	Sustainability, Journal, (C)
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Method [1]	Literature Review	Literature Review	Literature Review	Quantitative Survey	Quantitative Survey	Qualitative Interview Study
Own Contri-bution	Idea generation; research design selection; literature collection & analysis; data collection & analysis; writing and review of manuscript; management of research process	Idea and research question generation, research design selection, revision of results, writing and review of manuscript; management of research process	Idea and research question generation, research design selection, revision of results, writing and review of manuscript; management of research process		Idea and research question generation; research design selection; literature collection & analysis; data collection & analysis; writing and review of manuscript; management of research process	Idea generation; research design selection; literature collection & analysis; data collection & analysis; writing and review of manuscript; management of research process

[1] According to the classification provided by Palvia et al. (2004, p. 529)
[2] Refers to additional assistance that did not qualify for co-authorship in the dissertation's included version (Deutsche Forschungsgemeinschaft, 2013, p. 29)
[3] VHB JQ3 ranking: https://vhbonline.org/vhb4you/vhb-jourqual/vhb-jourqual-3/gesamtliste

Publications Included in This Dissertation:

Schmermbeck, H. (2019). On Making a Difference: Towards an Integrative Framework for Green IT and Green IS Adoption. *HICSS 2019 Proceedings*, 2045–2054.

Schmermbeck, H., Thünnesen, J., Voss, N., & Ahlemann, F. (2020). Green IS Does Not Just Save Energy – Insights from a Survey on Organizations' Uses of Sustainable Technologies. *HICSS 2020 Proceedings*, 902–911.

Puvaneswaran, S., & Alsdorf, H. (2021). Why People and Processes Enable Sustainability and Not the Latest Technology: On Achieving Green IT/IS Capability Maturity. *PACIS 2021 Proceedings (PACIS)*, 163.

Gonserkewitz, P., Schmermbeck, H., & Ahlemann, F. (2021). Green IT Quick Wins: Wie Unternehmen durch kurzfristig umsetzbare IT-Maßnahmen langfristig mehr Nachhaltigkeit erreichen können. *HMD – Praxis der Wirtschaftsinformatik*, *58*(1), 167–180.

Alsdorf, H., Kosmol, L., & Rivera Fernandez, Z. (2022). Relevanz und Bedeutung der Nachhaltigkeit – Green IT/IS als Nischenthema in KMU der DACH-Region. *HMD – Praxis der Wirtschaftsinformatik*.

Alsdorf, H. (2022). It's Just Not Sexy: How Managerial Assumptions Adversely Affect Corporate Sustainability Engagement and Sustainable Technology Adoption. *Sustainability*, *14*, 33.

Notes

1. Their contribution to answering the research question (RQ) determines the order of the list of included publications: Papers 1, 2, and 3 answer RQ1, papers 4 and 5 answer RQ2, and paper 6 answers RQ3.
2. Papers 1, 3, and 4 were published under the author's birth name (Schmermbeck).

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Deutsche Forschungsgemeinschaft. (2013). *Sicherung guter wissenschaftlicher Praxis*. Weinheim, Germany: Wiley-VCH

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A

INTRODUCTION TO "DIGITALLY ENABLED CORPORATE SUSTAINABILITY TRANSFORMATION – CASE AND CONTEXT FOR GREEN IT AND GREEN IS"

Abstract

This introduction provides a general motivation and introduction to fundamental terms and concepts, like global climate disruption, sustainability, innovation adoption, and especially Green IT and Green IS. We then outline the prevalent problems in research and practice that this dissertation seeks to address and summarize them in an overarching research problem and three subsequent research questions. It also contains a detailed description of the research design in which we highlight our philosophical position. It has specific implications for the then-explained research process and the applied methods. The introduction concludes with the thesis structure and a summary of the included research papers with their most important results.

Keywords: Introduction, Research Design, Research Process

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1 Introduction

The negative effects that human activities have on the natural environment are becoming increasingly severe, and nearly all recently published sustainability reports and panels (e.g. IPCC, 2022) paint a troubling picture of the state of planet Earth. Harmful emissions that fuel the *global climate disruption* are continuing to rise (Malakoff, 2014, para. 1), while biodiversity gets lost, erosion, (toxic) waste, and contamination of water seems to continuously grow (Fernandez et al., 2020, p. 1; Lunardi et al., 2015, pp. 1–2).

It is therefore not surprising that *sustainability* – understood as a development that "meets the needs of the present without compromising the ability of future generations to meet their own needs" (Brundtland Commission, 1987, p. 24) – has become a moral and economic imperative of the 21st century. Many official institutions (e.g., United Nations) and societal movements (e.g., Fridays for Future) continue to work and fight for it (Dörr, 2020, p. 2) and demand a general shift of society and businesses away from primarily economic interests. Especially companies – whose actions were globally responsible for 59.1% of all emitted CO_2 emissions (EDGAR/JRC, 2022) – are put under increasing pressure to behave significantly more ecologically sustainable (Leidner et al., 2022, p. 591).

Many different branches and trends have an influence on the industrial CO2 footprint. Global air travel, for instance, is estimated to having a share of 3-4% on the global greenhouse gas (GHG) emissions. The production, usage, and disposal of Information Technologies (ITs) and Information Systems (IS), is estimated to having a 'footprint' of 2% – 4% (Dörr, 2020, p. 3; Hankel et al., 2019, p. 1). While this seems relatively low, the continuously growing digital transformation of businesses and society, and the consequential ever-increasing demand for digital technologies will very likely let the IT/IS footprint grow to a share between approx. 7% (linear progression) and approx.14% (exponential progression) in 2040 (Belkhir & Elmeligi, 2018, fig. 7). IT and IS, hence, can be seen as one of the key forces of the climate disruption and a key sustainability problem.

There are nevertheless not few who see that IT and IS can be a solution and sustainability enabler (Boudreau et al., 2008, p. 2; e.g. Brooks et al., 2010, p. 3; e.g. Tomlinson, 2010, p. 3). This accessibly counts only partially for the production, usage, and disposal of the respective technologies. These processes will always require certain resources and energy to be spent and can thus only be tried to be made as efficient as possible. It is ITs and ISs potential to increase the efficiency of intra- and inter-organizational processes (Brockhaus et al., 2017, tbl. 3; Loeser et al., 2017, p. 516), but also the consequent benefits for the corporate image and reputation (Nishant et al., 2013, p. 12) that can make them an essential pillar to any organizations sustainability initiative.

Digital and digitally-enabled technologies that seek to be part of the sustainability solution can be called *Green IT* and *Green IS*. Green IT has an almost exclusive technological focus and seeks ways to increase the efficiency and eco-sustainability of IT/IS production, operation, and disposal (Loeser, 2013, p. 6). Green IS extends this view by focusing on wider issue of addressing IT/IS governance, internal business and production processes, and end user product, or service issues (Loeser, 2013, p. 6). They therefore contribute to supporting greater corporate sustainability practices (Brezavšček et al., 2019, fig. 2), while pro-actively creating novel and additional (digital) corporate value (Dörr, 2020, p. 38), and thus contribute to the digital transformation.

As companies still are primarily driven by financial and economic interests, they need to consequently see Green IT/IS as an innovation along two dimensions: First, Green IT/IS are per se seen as something that is generally and technology-wise new to a company, as they are not familiar with it (Rogers, 2003, p. xvii). Second, Green IT/IS are also conceptually different from established technologies and concepts. They put a special emphasis on (ecological) sustainability – by for instance, significantly reducing global GHG emissions (Hankel et al., 2019, p. 1) – and therefore at least extend the determinants, adoption influencing factors, and outcomes companies are yet familiar with.

This is a two-fold challenge, for both practitioners, and researchers: First, established adoption literature lacks conceptual insights and results that specifically identify, outline, and thus clarify the explicit differences of sustainability-driven, and sustainability-enabling innovations, like Green IT/IS and traditional innovations. This is not only a shortcoming as such, but also leads to the conclusion that established adoption frameworks and models are insufficient and not satisfyingly useable for Green IT/IS adoption and maturation, as they remain blind on the nontraditional factors.

A better conceptual understanding of Green IT and Green IS is needed that can be beneficial for researchers, as it increases conceptual clarity – as the core aim of any research endeavor – but similarly for practitioners, as it gives them a better understanding of the extend of the changes needed to becoming more sustainable and making Green IT/IS a meaningful contribution to their corporate portfolio.

This flawed, or at least incomplete understanding leads to further and subsequent challenges, like low corporate Green IT/IS adoption rates (Hilpert et al., 2014, p. 12; Kotze et al., 2014, p. 939), and a consequential relatively low clarity of the tacit benefits and outcomes of corporate Green IT/IS usage (Singh & Sahu, 2020, pp. 6–7). It is not like there were no concepts or insights at all into the matter. Brezavšček et al. (2019, p. 1043), for instance, documented corporate (e.g. reduction of waste, transformation of business processes to paperless), social (e.g. higher level of social responsibility and employee environmental awareness), and

environmental benefits (e.g. reduction of emissions and energy consumption). Studies like these, however, are few, leaving a broad picture that a larger number of companies could benefit and generalize from open.

Corporate decision-makers would clearly benefit from further and detailed insights and experiences from Green IT/IS adopting and using companies. It would offer them a prime way to learn and try to replicate the achieved benefits. These could also give sustainability managers additional arguments for choosing a strategically different path and to evolutionarily rely on established and relatively well-known technologies, but to deviate from it and choose a more risky way of experimenting and adopting a potentially disruptive technologies, like Green IT/IS.

Additional insights into empirical benefits of corporate Green IT/IS usage would be useful for researchers as these could not only provide insights into the reciprocal or rebound effects of the achieved eco-sustainability benefits and traditional benefits (Arnfalk et al., 2016, p. 9), but also how these could systemically be integrated into a company and its strategy (Hankel et al., 2019, p. 19). It would set a prime foundation for additional research on how these outcomes can be achieved, manifested and matured.

This dissertation hence seeks to contribute to the ongoing discussion and add not only further conceptual insights into Green IT and Green IS but also create a clearer picture of their outcomes and benefits. We regard these two areas not so much as separate or individual gaps, but as two aspects of a greater more fundamental problem that is based on a flawed or incomplete conceptual of understanding of Green IT/IS. As the consequential adoption (or not thereof) is not only a matter of altering or adjusting organizational processes but especially managerial views and perceptions, we see it necessary to complete the picture and investigate the problem also from this angle. We therefore seek to shed light on managerial perceptions and views on sustainability and sustainability-enabling innovations, like Green IT/IS, and this aim for conceptual, organizational-level, and individual level goals.

Following the cumulative tradition of IS research (Hirschheim & Klein, 2012, p. 218), this dissertation consists of six published research papers. The following chapter 2 presents the conceptual foundation of this dissertation. It sets this dissertation into context with certain fundamental academic, environmental, and (socio-) technological developments and presents the research gap and research questions that we chose to address. Chapter 3 contains the research design. We specifically outline our meta-theoretical assumptions, the research process, and the applied methods. Chapter 4 presents the thesis structure and the included research papers. We also present how each paper contributes to answering the research questions as well its contributions, limitations, and opportunities for further research.

2 Conceptual Foundation

In the following chapter, we present the conceptual foundation of this dissertation. We not only present, define, and discuss relevant terminology, but also present certain environmental, societal, and corporate challenges and developments that set the context of this thesis.

We start by presenting our view of the global climate disruption, the associated sustainability concept (section 2.1), how the increased usage of IT and IS contributes to the global sustainability challenge (section 2.2), and how both development continue to affect corporate actions (section 2.3). We then argue that innovation adoption (section 2.4) and especially the adoption of Green IT and Green IS, are a prime way to address corporate sustainability challenges (section 2.5). The chapter concludes with an explicit presentation of the overall research problem and the consequential research questions (section 2.7).

2.1 The Global Climate Disruption as the Fundamental Challenge

This dissertation stands in the grand context of certain environmental developments that are significantly influenced and caused by corporate actions. As there are a variety of terms that describe these developments, we see it necessary, to position us in this discussion.

Climate change is one of the most frequently referred to global problems, to which also IT and IS have a significant and growing impact (Belkhir & Elmeligi, 2018, fig. 7). The term and concept are generally and frequently used in the public discussion but also in academic publications. It describes that there are some changes in weather phenomena as well as in the observed temperatures. Dedrick (Dedrick, 2010, p. 175), for instance, uses it in his work on Green IT and IS and how both can help solve it, as well as Zaung Nau and Marinova (2020, p. 240) in their bibliometric literature review on Green IT and Green IS.

The term is frequently associated and linked to the concept of *global warming* (i.e., a description of the phenomenon that the average recorded atmospheric and oceanic temperatures around the globe are rising, and planet earth thus is heating up (Riebeek & Simmon, 2010)) and often both are indistinctively and interchangeably used (Malakoff, 2014).

There are, of course, some voices that doubt that both climate change, as well as global warming, are real. Pierre (2022, para. 4), for instance, reports that nearly 10% of the adults in the United States of America do not believe that global warming is real, and nearly 25% do not believe that human action contributed to or led to it. We thus conclude that both terms, climate change, and global warming – though scientifically correct – might not be ideal terms to be used in works like these.

Consequently, we refrain from using both terms and prefer to refer to these developments *(human-made) global climate disruption* (Malakoff, 2014). The term, in our view, summarizes that the global climate of planet Earth is evolving in a way that is existentially threatening for the current biosphere. It also anticipates a disruptive development which – similar to disruptive technologies (Bower & Christensen, 1995, p. 49) – first develops without being hardly noticed, before picking up pace and in the end fully overpowering and replacing an established system. The term, therefore, not only relates very well to the ever more severe consequences of climate change (IPCC, 2022, pt. B; Riebeek & Simmon, 2010, para. 2) and reflects the disruptive and irreversible potential of this phenomenon.

2.2 The Impact of Digital Technologies on Sustainability

The advent of IT and IS in the early 20th century had, and still has, a huge impact on society and business (R. Watson et al., 2012, p. 5). They enabled companies to significantly optimize and automate their production, and improve packaging and transport processes (Patón-Romero et al., 2021, p. 2; Schwab, 2018). The internet made it possible to connect digital devices and offer digital services around the globe through which the potential for economic value creation and corporate advancement skyrocketed (Bajarin, 2015, para. 1; Ovans, 2015).

While in an economic perspective, the upsides of using digital technologies far outweigh the downsides, in regard to sustainability, they rather are a double-edged sword. In this section, we shortly outline our view on this and elaborate that i) digital technologies – on the one side – are an undeniable burden to the ecological biosphere as their production, usage, and disposal is a key contributor to the global climate disruption (Tomlinson, 2010, pp. 75–76), and ii) that they can also be a key tool to mitigating and solving corporate sustainability issues in the short and long-term (Loeser et al., 2017, p. 516; Murugesan & Gangadharan, 2012, p. 376).

Looking on the downside, their production requires a significant amount of physical resources. For instance, the average computer consists of 29% steel, 22% glass, and 19% plastics, 10% aluminum, 8% lead, 7% copper, and 3% zinc (Center for Sustainable Systems, 2022, p. 1) – regulated as well as hazardous materials (Butler & Daly, 2008, p. 1). Furthermore, their production also has a significant GHG output. A recent study, for instance, found that the manufacturing of one laptop leads to approximately 330kg of CO_2 emissions; which is equivalent to between 75% and 85% of the overall CO_2 footprint over its lifespan (Haughton, 2021, sec. 3).

Operating IT consumes electric energy and its global demand seems to be ever increasing (Butler & Daly, 2008, p. 1). In 2021, it was, for instance, estimated that data centers and data transmission networks alone were responsible for about 1 – 1.5% of the world's energy demand (Kamiya, 2022, para. 1). In terms of greenhouse gasses (GHG), this translates to IT/IS

being responsible for approximately 4 % of the global GHG emissions (see Table 1), which is similar to the global aviation (approx. 2-3%) (Dörr, 2020, p. 4; Molla et al., 2009, p. 4). This trend is proposed to continue, and some prognoses estimate that by 2040, IT/IS usage will cause 14% of the global CO_2 emission (Podder et al., 2020, para. 4), especially because end-user devices –many also used for corporate purposes – are responsible for 1.5 to 2 times the amount of GHG than data centers (McKinsey, 2022, fig. 2).

Table 1. Overview of the estimated contribution of IT/IS to the global GHG emissions

Year	GHG	Reference
2007	1.3 – 1.5 %	(Malmodin et al., 2010, p. 770; Podder et al., 2020, p. 4)
2009	2.0 %	(Molla et al., 2009, p. 4)
2019	2.0 %	(Hankel et al., 2019, p. 1)
2020	4.0 %	(Dörr, 2020, p. 3)
2040	14.0 %	(Belkhir & Elmeligi, 2018, p. 458; Podder et al., 2020, p. 4)

Two examples may illustrate and underline this tendency: For one, there is an increased global demand for smartphones. There has been an extreme growth in demand and usage for smartphones (2.5 billion devices in 2016 to projected 4.5 billion devices in 2024 (Statista, 2023)), which also resulted in a similar growth of the equivalent GHG emissions (17 million tons of equivalent CO_2 emissions (Mt-CO_2-e) in 2010; projected 125 Mt-CO_2-e in 2020 (Belkhir & Elmeligi, 2018, p. 458)). The major environmental issue with this trend is that – calculated over an average lifespan of only two years – almost 85 – 95 % of the energy consumed over a smartphone's lifespan is used for its production (p. 458), and that – though technically easily recyclable – only 17% of the global electronic waste is properly recycled (Gill, 2022, para. 10).

There is also an increased demand for data centers. For industrial purposes alone, the demand for significantly increased (61% in 2010; projected 79% in 2020), resulting in a similar growth in the GHG equivalents of the global industry sector (33 % and projected 159 Mt-CO_2-e in 2010 to 45% and projected 495 Mt-CO_2-e in 2020) (Belkhir & Elmeligi, 2018, p. 458). This tendency may be fueled by the COVID-19 pandemic became fully noticeable in 2020. It led to cloud computing being the top organizational investment in 2020 as almost any organization quickly needed mobile, scalable, and on-demand IT services in order to keep operational (Park et al., 2021, p. 2).

On the other side, IT and IS can be a key tool to solving organizational sustainability issues and significantly contribute to corporate sustainability by enabling the reduction of the energy or resource consumption, waste and emissions released by an organization (Baggia et al., 2019, p. 8; Brezavšček et al., 2019, p. 1043; Murugesan & Gangadharan, 2012, p. 152), as well improving processes and company image, and a more sustainable corporate culture (Gürlek &

Tuna, 2018, p. 483; Lunardi et al., 2015, p. 11). They also offer the potential to address other global challenges such as improving access to education, healthcare, and agriculture (Dörr, 2020, p. 5).

The major difference between the impact of digital transformation on companies and the impact of sustainability may be that digital transformation is based on a technological development that is basically not stoppable. Sustainability, on the other side, can rather be seen as a desirable state which links and balances efficient usage of resources, high quality of life for the global population, as well as economic benefits (Dörr, 2020, pp. 2–3).

2.3 The Influence of Ecological Sustainability on Corporate Actions

It is undeniable that to address the global climate disruption the (current) ways of using the planet's resources need to change (Brundtland Commission, 1987, Chapter 1) and that especially, organizations and businesses need to act more *sustainable* (Ahmed & Sundaram, 2011, p. 1). To clear what we mean with that, in this section, we will shortly elaborate on the understanding if sustainability that we will use in this dissertation and also link this to corporate practices.

One of the most frequently used understandings of sustainability is not a direct definition of the concept and term but the related understanding of what *sustainable development* should be. This understanding, suggested by the frequently referred to Brundtland Commission, defines sustainable development as such a development "that it [sustainable development] meets the needs of the present without compromising the ability of future generations to meet their own needs" (1987, p. 24).

Due to its abstract nature, this understanding is easily transferrable to a multitude of contexts. In the business context – that this work is positioned in – it is it is primarily the economic and financial dimension. In this work, we, however, primarily refer to its ecological dimension. This is primarily due to the act that especially financials – in the traditional economic sense – seem to be ultimate, if not the only relevant dimension relevant to corporate decisions-makers. Seeing and investigating corporate developments from a primarily ecological sustainable perspective, is – especially in the IS research domain – relatively new and hence offers fundamental insights of academic and corporate relevance.

While easy to understand, the abstractness of the sustainability concept has the downside of making it difficult for organizations to use it. Though frequently stated as one corporate goal, a company's (ecologic) sustainability, as well as its sustainable growth, is hard to determine (Brockhaus et al., 2019, p. 1166; Slaper & Hall, 2011, p. 4). They are not faced with making decisions for future generations, which only first manifest in multiple decades of time. They

and their strategists are – at most – concerned with 'strategic' and strategic-exploratory-matters for the upcoming five to eight years (Unhelkar, 2012, p. 152), and it seems that the focus on today's margins blinds business makers to focus goals for a distant future (Baer, 2014, para. 12; Brockhaus et al., 2017, p. 934).

A common way to operationalize sustainability in the corporate context is by extending the traditional decisive criterion of financials by social and environmental aspects; to respect a *triple bottom line (TBL)* of "people, planet and profits" (Slaper & Hall, 2011, p. 4). First suggested by Elkington (Elkington, 2018, para. 3), it has found its way into corporate usage and practical applicability (Mohan et al., 2012, p. 27) and was, for instance, identified of great CEO relevance and importance (Deng & Ji, 2015a, p. 1).

While this is a promising approach, it is criticized – also by Elkington himself (2018) – for instance, for leaving out the question of how to operationalize the two non-financial dimensions (Slaper & Hall, 2011). Monetizing the social and environmental components of the TBL requires to put a 'price tag' on items that are not easily or objectively priced (Slaper & Hall, 2011, p. 4). What, for instance, would be the monetary equivalent of a cut-down forest, a dried-up wetland, or a melted glacier for a company? For a country? For the entire planet? While one solution would be to calculate the TBL as an index and eliminate the challenge to compare incompatible units, "it was never supposed to be just an accounting system" (Elkington, 2018, para. 13), but a call for systems changes.

The challenge of using the TBL, and if and how to operationalize and put it into organizational use nicely illustrates the organizational struggle of not only adhering to economic but also social and ecologic goals. It can thus be seen as an overarching challenge of this work in general and be especially relevant for paper 3, in which we propose and categorize Green IT/IS quick wins.

2.4 The Role of Innovation Adoption to Address Corporate Sustainability Challenges

As already illustrated before, adopting and using novel and innovative technologies are a cause, but also a potential solution for corporate challenges. This consequently also counts for sustainability challenges (Börjesson et al., 2014, p. 120; Molla, 2008, p. 659; Tomlinson, 2010, p. 26). To better understand this argument, we devote this section to a presentation of the innovation concept, as well as the basic concepts of how these can be adopted and used in a corporate setting.

The fundamental understanding that we refer to and build upon is that *innovations* are anything that is new to an adopting entity (e.g., people and organizations) (Rogers, 2003, p. xvii). They can be and come in practically any kind of form, like a thought, a capability, a physical object,

a computer program, etc. (Börjesson et al., 2014, p. 121; Hameed et al., 2012, p. 358), and are typically evaluated in a three-step process of i) getting initial knowledge about an innovation, ii) evaluating it, and ii) deciding to either adopt or reject it (Rogers, 2003, p. 168).

In the organizational context, innovations are often seen as a new type of *resource* that an organization possesses or aims to possess (Wang & Dass, 2017, p. 127) that can be acquired, adopted, developed, and used to establish a competitive advantage over competitors (Baggia et al., 2019, p. 13). These resources can have a physical form or just be financial assets, employee skills, or organizational processes and require *capabilities* to be used within an organization (Hart & Dowell, 2011, p. 1465).

Organizational innovation adoption is a highly discussed topic in academic literature. Many frameworks or models explain selected aspects of corporate innovation adoption, while others focus on the entire process providing a holistic picture. One of the most fundamental and also most widely used approach (Pervan et al., 2005, p. 6) is the diffusion of innovation (DOI) theory and its underlying innovation-decision process (Rogers, 2003, Chapter 5). While an overall abstract and systemic view and originally conceptualized to explain the individual innovation-decision process, it is ever more used and applied in the organizational context (Hameed et al., 2012, p. 363; Lai & Guynes, 1997, p. 147; MacVaugh & Schiavone, 2010, p. 198).

It is not without criticism, though. One point of criticism is its individualistic view (Hameed et al., 2012, p. 363) missing external context factors, like organizational and environmental factors (Lee & Cheung, 2004, p. 386). Without these, the view remains rather limited, as it excludes crucial aspects that are necessary to provide a detailed picture of the adoption, usage, and consequential diffusion of innovation in an organization. This also trickles down to the underlying innovation-decision process.

One approach to address the criticism to the DOI and limitations of other frequently used innovation adoption models and frameworks is the conceptual model of IT innovation adoption in organizations (Hameed et al., 2012). Seeing that most of them are very specific with focusing on selected aspects of the adoption process, they identified the need for a model that completely or holistically explains the corporate (IT) innovation adoption process (p. 359). Their response is a model that consists of three adoption phases (initiation, adoption decision, and implementation) (p. 367). This process is influenced by certain factors, like the characteristics of the innovation and environmental characteristics (p. 369).

Both, the DOI, its associated innovation-decision process, and the Hameed et al. (2012) model form core pillars for this work. They, for one, provide a conceptual terminological basis. For another, they also represent a structure for our understanding of how (IT) innovations are

evaluated, adopted, and used in an organization. They, thus, are frequently referred to in our papers, especially in papers 1, 5, and 6.

2.5 Green IT and Green IS as Core Concepts of Digitally Enabled Corporate Sustainability

IT and IS can be a solution to decarbonize and dematerialize businesses and economies in general (R. T. Watson & Kranz, 2021, p. vii). To clearly refer to technologies an concepts with this aim, they are often coined as *Green IT* and *Green IS* (Park et al., 2021, p. 3). In this section, we present the development and our understanding of these concepts and give a brief overview over the Green IT and Green IS discussion in IS research.

There is a plethora of concepts and terms that concern the same or a similar concepts to Green IT and Green IS, like *Greening through IT* (i.e., "focus on the use of IT across many different sectors, rather than concentrating just on its own impact" (Tomlinson, 2010, p. 4)), *greening IT* (i.e., "situations where IT enables structural changes that lead to changes in broader social patterns, which take us closer to the low-carbon society and leads to further emission reductions" (Sobotta et al., 2010, p. 26)), or *IT for Green* (i.e., "analyzing, designing, and implementing systems to deliver positive sustainability benefits beyond the direct footprint of IT" (Curry & Donnellan, 2014, p. 3)). Deng and Ji (2015b, tbl. 1) present a summary and overview of the numerous and seemingly similar understandings.

While not uncriticized, for instance, for its technology focus (Sobotta et al., 2010, pp. 25–26), or negligence of the social sustainability dimensions (El-Rayes et al., 2022, p. 9) – potentially also the media friendliness of the terms Green IT and Green IS held them afloat in the discussion they are still relatively frequently used and discussed in both academic literature (e.g., Harnischmacher et al., 2020; Loeser, 2013; Zaung Nau & Marinova, 2020), practitioner literature (e.g., McKinsey, 2022), as well as corporate (e.g., IONOS, 2022; Nischler, 2022), and governmental circles (e.g., BMUV, n.d.).

While we see and partially agree with this criticism, we decided to use and refer to Green IT and Green IS. Three central reasons for this are:

i) <u>There is a lot of literature published that uses the terms Green IT and Green IS and there is a rather broad discussion built around these two terms</u>.

   We, of course, see that – especially in the beginning – there has been hype around Green IT and what it can deliver (Pettey & Goasduff, 2008; Pütter, 2007). This is nothing special and has been observable in other concepts and technologies, of which artificial intelligence (AI) may be one of the most prominent (Schank, 1991, p. 41). Similarly, like AI, Green IT – and consequentially Green IS – have originally failed to meet their expectations. This may be the case for many

technologies as they are novel and immature, but also especially for those that have disruptive or revolutionary characteristics or tendencies (Bower & Christensen, 1995, p. 45). Also due to the recent developments and reasons (see section 2.2) the academic and practitioner interest in Green IT / IS as well as the associated technologies and practices is flourishing again – while keeping the initially used terms.

ii) Both, Green IT and Green IS, are relatively media-friendly terms and thus have the potential to bridge and link academic and practitioner discussions.

We see that the term Green IT was first used in a practitioner publication (Wang et al., 2015, p. 397) and, from there, found its way into the academic discourse. We, of course, see and agree that the terms hence may lack an 'academic' conceptual clarity. Their figurative nature, for instance, may be interpreted as a lack of scoping conditions or semantic relationship (Suddaby, 2010, p. 347). We nevertheless argue that this may be the case for a great many of concepts. The term AI, for instance, it is also a very broad concept that – for researchers and practitioners, but also novices and experts – requires further explanation as to, one, for instance, refers to the concept and its history in general, machine learning (ML), speech-to-text / text-to-speech, image recognition, or any other functionality.

iii) Both, the Green IT and Green IS term, are sufficiently specific that they are not misleading but illustrate and deliver their message.

We see that, in order to raise interest and also start and engage in a discussion, terms and concepts need to provoke and evoke an image that also catches the interest of yet uninvolved persons. This may be especially true for concepts that have high practical relevance. At some point, decision-makers need not only to be informed about but also interested and engaged in a discussion. This, ideally, results in their agreement to initialize corporate or organizational changes as well as to make the associated investments. This will lead – as we will also further elaborate on in paper 2 (see section 4.3) – to needing common terminology and a shared language. Starting the discussion and keeping it alive requires strong terms that deliver a message about their intention. Green IT and Green IS, in our view, greatly serve this purpose.

We also want to advocate the position that Green IT and Green IS are different but integrative to one another. We not only feel that it increases conceptual and terminological specificity, but it is also clearly requested for academic research in the IT and IS-enabled sustainability discussion (R. T. Watson & Kranz, 2021, p. vi). Furthermore, it also respects the view within the Green IT/IS discussion, which sees IT as an issue that can be solved by using Green IT

and respecting Green IT principles. Green IS, on the other hand, sees IS as the potential solution to the emergent issue. Dedrick (2010, pp. 174–175), for instance, argues that – as IT is estimated to be responsible for 2% of the global CO_2 emissions – Green IT can consequentially also only address 2% of the overall problem. Green IS, on the other side, focuses on the other 98% of the issue, and this can address the remaining 98% of the issue (Deng & Ji, 2015b, p. 16738).

2.6 Understanding of Green IT and Green IS

IT – as any produced, procured, and used technology – has a certain effect on an organization's sustainability, and it is therefore understandable that the academic discussion in this domain already started in the 1980s (Zaung Nau & Marinova, 2020, p. 240). The term Green IT, however, was first used in 2007 (Wang et al., 2015, p. 397) in the practitioner-oriented CIO magazine (Pütter, 2007, para. 1), in which it was coined one of the most important technology for 2008. Chief Information Officers (CIOs) – as the key decision-makers for an organizations (information) technology-related matters (McKinsey, 2022, para. 2) – were called to especially investigate data centers and their CO_2 emissions – thus further underlining the concepts focus on hardware.

As the article presented no specific definition, the first academic papers on Green IT were accessibly keen to conceptualize and clearly define the term. Given its origin, it is not surprising that also the first academic papers on Green IT – for instance Butler and Daly (2008, p. 2) – only focus on technical and operational aspects of the phenomenon. Others, like Murugesan (2007), have an integrated understanding that combines both hardware-related concerns of IT, as well as other aspects, like “improved system performance and utilization and highlights our social and ethical responsibilities” (Murugesan, 2007 para. 20). Some researchers (e.g., R. T. Watson et al., 2010, p. 24) early on criticized the selective on IT as too narrow and advocated to use the inclusive Green IS term, as it “incorporates a greater variety of possible initiatives to support sustainable business processes” (p. 24) An overview of selected early Green IT definitions is presented in Table 2.

To address this issue and present a relatively holistic overview of the discussion on Green IT understanding and definitions, Loeser (2013) collected and categorized the predominant Green IT definitions in the IS literature and suggested an incorporated understanding. He defined Green IT as “measures and initiatives which decrease the negative environmental impact of manufacturing, operations, and disposal of Information Technology (IT) equipment and infrastructure” (p. 6). We also follow his view and use the suggested definition, as it i) integrates most of the until then conceptualized Green IT understandings, ii) is sufficiently specific but also abstract to be used by both research and practice.

Table 2. Overview of selected Green IT definitions

Publication	Green IT definition/understanding
(Butler & Daly, 2008)	[…] the term Green IT was coined by practitioners to differentiate between IT artefacts that had been designed with environmental sustainability in mind—that is, to contain the minimum amount of hazardous materials, to be energy efficient during the use period of their lifecycle, and to be disposed or recycled with the minimum effect on the environment and human health […]
(Murugesan, 2007 para. 20, 2008, pp. 25–26)	Green IT refers to environmentally sound IT. It is the study and practice of designing, manufacturing, and using computers, servers, monitors, printers, storage devices, and networking and communications systems efficiently and effectively with no or minimal impact on the environment. It also focuses on achieving economic viability and improved system performance and utilization and highlights our social and ethical responsibilities.
(Molla et al., 2008, p. 671)	We define Green IT as a holistic and systematic approach to address the challenges surrounding the *IT infrastructure* such as data centre space and energy efficiency; *IT's contribution* to reducing the environmental impacts of business IT activities (such as through adopting green technologies), *IT's support* for environmentally sustainable business practices (such as in enabling green supply chain management through carbon foot print monitoring through building tools for energy management options) and *IT's role* (such as supplanting high CO_2 emitting business practices) in the low-carbon economy.
(Brooks et al., 2010, p. 3)	[…] we categorize Green IT in two ways: 1) the initiatives that utilize IT infrastructure to change organizational processes and/or practices to improve energy efficiency and reduce the environmental impacts, and 2) environmentally healthier IT products and/or services.
(Schmidt et al., 2010, p. 2)	Green IT comprises the management of all activities and measures of the IT department, which are aimed to reduce the resource consumption by IT, e.g., in terms of energy, material or paper. Furthermore, it includes instruments to control, steer, and communicate the success.
(Tomlinson, 2010, p. 3)	Green IT involves any IT that helps to make any aspect of society greener, including IT itself.
(Loeser, 2013, p. 6)	Green IT refers to measures and initiatives which decrease the negative environmental impact of manufacturing, operations, and disposal of Information Technology (IT) equipment and infrastructure.

The logical conclusion of the previous argumentation is to also present a separate understanding and definition for Green IS. Like the distinction between IT and IS (see section 2.5), we also regard Green IS to have a primarily non-technical focus (see Table 3). Literature also encompasses a variety of different understandings that – like Green IT – can also be traced back to the origins of the discussion. They also almost exclusively exceed the Green IT understandings and – partially relatively abstractly – refer to Green IS as "the inscription, enactment and/or realization of eco-sustainability values in the spirit, practice, and impact of

IS" (Ijab et al., 2010, p. 438), or also rather tangibly to "the design and implementation of IS" (Boudreau et al., 2008, p. 2).

Table 3. Overview of selected early Green IS definitions

Publication	Green IS definition/understanding
(Boudreau et al., 2008, p. 2)	Green IS […] refers to the design and implementation of information systems that contribute to sustainable business processes.
(Ijab et al., 2010, p. 438)	Green IS can be defined as the inscription, enactment and/or realisation of eco-sustainability values in the spirit, practice and impact of IS.
(Loeser, 2013, p. 6)	Green IS refers to practices which determine the investment in, deployment, use and management of information systems (IS) in order to minimize the negative environmental impacts of IS, business operations, and IS-enabled products and services.

Also, in this regard, we follow the suggestion by Loeser (2013) and use his integrative understanding of Green IS as "practices which determine the investment in, deployment, use and management of information systems (IS) in order to minimize the negative environmental impacts of IS, business operations, and IS-enabled products and services" (p. 6), and follow Watson and Kranz (2021), who argue that "organizations need to buy Green IT so they can make an environmentally sustainable difference with Green IS" (p. vii).

2.7 Problem Statement and Research Questions

IS research was initially rather concerned with solving technological questions, like the automation of corporate processes (Myers & Avison, 2002, p. 3). Since the late 1990s and early 2000s, researcher interest, however, has shifted towards managerial questions, as well as understanding how IT and IS can contribute to addressing global sustainability challenges (Elliot & Webster, 2017; Sedera et al., 2017). While addressing the grand challenge of environmental sustainability still only is a relatively novel stream of IS research (Wolff et al., 2022, p. 8). Especially the use of digital technologies, like Green IT and Green IS – as outlined before (see sections 2.2 – 2.4) – promise to be a technological and socio-technological way to simultaneously address intra- and inter-organizational challenges of the digital transformation (Elliot & Webster, 2017, pp. 375–376; Hu et al., 2016, p. 1169; Kiron & Unruh, 2018, para. 6) but also sustainability challenges (Loeser, 2013, p. 6). As there appear to still be certain fundamental problems, uncharted areas, as well as gaps in the Green IT/IS discussion (e.g., Harnischmacher et al., 2020, p. 11; Henkel & Kranz, 2018, pp. 11–12; Jenkin et al., 2011, pp. 28–34; Seidel et al., 2011, p. 5; Wang et al., 2015, pp. 403–407), this dissertation seeks to be a valuable contribution in the following ways:

First, we see that corporate understanding of and beliefs about Green IT/IS are still sparsely understood (Henkel & Kranz, 2018, p. 11). These are, nevertheless, crucial for motivating and

initializing corporate sustainability change (Seidel et al., 2013, p. 1288). Especially misleading or false assumptions can have severe consequences, as they may hinder the required changes from being initialized at all (Jenkin et al., 2011, p. 30; Patón-Romero et al., 2021, pp. 9–10). While the academic understanding of Green IT/IS is relatively established (see section 2.6), this appears not to have translated to a generally accepted or undisputed conceptual foundation – as illustrated by the different understandings that many recent articles are referring to. It also seems to not have sufficiently translated into i) a similar corporate understanding as well as ii) an understanding of the technologies and their multi-level benefits (Patón-Romero et al., 2021, pp. 9–10). It hence is necessary to integrate and align the academic with practical understandings and to also outline the various levels that corporate Green IT/IS motivations, adoption, and outcomes influence.

To see and realize the benefits Green IT/IS adoption and usage can have for an organization seems to be a further challenge. Still, only few companies adopt Green IT/IS and thus miss to realize the consequential benefits (Hanelt et al., 2017, p. 494; Mithas & Rust, 2016, p. 223; Patón-Romero et al., 2021, pp. 9–10; Sedera et al., 2017, p. 686). They thus can also not be further developed as Green IT/IS actions are not or only insufficiently aligned with the other corporate actions (Jenkin et al., 2011, p. 31), which hinders sustainability actions from becoming mainstream organizational practice (Brockhaus et al., 2017, p. 941).

We also see that IT/IS enabled sustainability initiatives – at least publications of the leading IS journals (Venkatesh et al., 2022) – have only received somewhat limited research attention (Zaung Nau & Marinova, 2020, p. 245). The primary focus was on other topics, like solving engineering issues with solar panels, wind turbines, etc. (R. T. Watson & Kranz, 2021, p. v). This is at least surprising, given the importance these technologies play in modern society.

We consequently summarize and propose that – due to a multi-layered mix of limitations of academic understandings and insights, as well as practitioner assumptions and goals – Green IT/IS – though academically relevant and practically promising – have not (yet) found the way into mainstream corporate adoption. We decided to investigate this problem and formulate the following overarching research problem (RP) for this dissertation:

RP: *Due to a flawed conceptual understanding of Green IT and Green IS as well as their benefits, company decision-makers refrain from their adoption; this results in low Green IT/IS adoption rates and consequentially unutilized potential.*

Green IT/IS can generally be considered as innovations (see sections 2.4 and 2.5) that adopting entities, like companies, initially get knowledge about, evaluate and form an opinion about to thus adopt or reject it (Rogers, 2003, p. 168).

As with any innovation, it is crucial to get a clear understanding of the dimensions that its adoption touches. Not only for reasons of determining and measuring its effective adoption as well as its benefits but also as these categories need to be carefully observed and managed during the innovation's initial adoption and further consequential maturation.

Recent research on the adoption of Green IT/IS seems to be rather narrow and frequently excludes or neglects internal and external motives that drive their corporate adoption (Deng & Ji, 2015b, p. 16750). Especially organizational contextual factors (Harnischmacher et al., 2020, p. 12), like the social contexts of IT organizations (i.e., regulatory and normative environments (Park et al., 2021, p. 2)), but also environmental benefits and impacts are disregarded (Elliot & Webster, 2017, p. 375).

This is also reflected in the available academic (Green IT/IS), but also practitioner-based and used adoption frameworks. They, thus, miss out on important societal factors, like governmental movements (e.g., the Paris Climate Agreement) that at some point will also affect business, but also the ever-worsening state of the global environment (IPCC, 2022), as a potentially similar driving force.

Frameworks like these are of significant importance for management to further develop adopted technologies and capabilities (Becker et al., 2009, p. 221). They, however, by nature are very focused on a specific issue, like how a single adopted innovation can be matured and further developed (Curley et al., 2016). This focus nevertheless leads to another issue that may be especially relevant in the Green IT/IS discussion. As organizations tend not to respect the differentiation between Green IT and Green IS (Curley et al., 2016, p. 104), they seem to be primarily focused on the technological aspect of the matter (Lunardi et al., 2015, p. 4). They thus do not – or not adequately – respect the fundamentally needed social and socio-technological factors (e.g., a shared vision and a fundamental sense for the purpose of the required changes (Hart, 1995, p. 992)) for initializing, adopting, and maturing an innovation.

The IT Capability Maturity Framework (IT-CMF), as one rather popular maturity framework, for instance, also describes how a company's Green IT capabilities can be assessed and developed (Curley et al., 2016, p. 103). It thus mixes technological maturity (Green IT) with the capability concept (Helfat & Peteraf, 2003, p. 999). This mix-up hence bares the risk of seeing a company's sustainability development as a purely technological matter. This might be regarded as a negligible issue, but especially in educational matters, conceptual and terminological clarity is especially important (Harnischmacher et al., 2020, p. 13).

The observations and problems within our Green IT/IS adoption understanding can thus be summarized by one central argument: Companies appear to treat Green IT and Green IS like regular technologies. They therefore not only fail to see the previously outlined ecological and

socio-technological dimensions and benefits, but also to the necessity of establishing an organizational commitment towards the novel sustainability changes that can overcome countering institutional forces (Mohan et al., 2012, pp. 26–27).

We seek to address this in two ways. First, by 'zooming out' and creating a more holistic perspective on the corporate process towards digitally enabled corporate sustainability (Henkel & Kranz, 2018, p. 11; Seidel et al., 2011, p. 5). Second, will 'zoom in' and align the academically identified Green IT/IS dimensions with the specific practitioner view of the IT-CMF (Henkel & Kranz, 2018, pp. 11–12).

We specifically ask the following research question (RQ):

RQ 1: *Which dimensions distinguish sustainability innovations, like Green IT and Green IS, from traditional innovations, and how does this influence their corporate adoption?*

It is sometimes hard to understand why companies – as the key driving forces of the global climate disruption (EDGAR/JRC, 2022) – make no fundamental change. Why they do not engage in sustainability actions (Patón-Romero et al., 2021, p. 1), as the continuous deterioration of the planet is increasingly well documented and ever more worsening prognoses about the future state of the planet are being published (see section 2.1). One of the key reasons may be that – as many organizations still seem to rely on a single bottom line (see section 2.2) – they fail to see the benefits of sustainability actions for their company.

To behave more ecologically sustainable, however, should generally be in the corporate interest, as sustainable actions can be a core competitive driving force (e.g., Baggia et al., 2019, p. 13; Hart, 1995; Hart & Dowell, 2011, pp. 1470–1471). Especially Green IT/IS have the potential to address digitalization as well as sustainability challenges simultaneously (Hu et al., 2016, p. 1169; Kiron & Unruh, 2018, para. 6; Unruh & Kiron, 2017, para. 1).

By failing to see the benefits of Green IT/IS adoption, they not only fail to create a promising business case around it (Butler & Daly, 2008, p. 2) but also to align the 'regular' corporate actions with the sustainability initiatives (Jenkin et al., 2011, p. 31), or convince their employees about the desired sustainability actions (p. 32). Sustainability, thus, faces the danger of remaining an unconventional corporate practice (Brockhaus et al., 2017, p. 941; Kiron et al., 2017, para. 2).

There are still several academic insights that outline potential Green IT/IS benefits. While they undoubtedly have environmental performance benefits (e.g., reduction of waste, emissions, and dangerous or toxic materials (Brezavšček et al., 2019, p. 1043; Lunardi et al., 2015, pp. 9–10), Green IS also have numerous competitive advantage benefits (Deng & Ji, 2015b, p. 16750) that can also be assessed in traditional dimensions. They, for instance, enable

organizational decision-makers to make better (sustainability) decisions (R. Watson et al., 2012, p. 12) and thus react more appropriately to external pressures and internal needs (Henkel & Kranz, 2018, p. 11) and – from an external perspective – can have benefits for the social performance, like an improved company image (Brezavšček et al., 2019, p. 1043).

A further observation not only adds but also seems to be core to this problem: It is to-date rather unclear how many companies use sustainability technologies, such as Green IT and Green IS. While many globally known companies of various industries, like BlackRock (2023), Google (2023), and the Boston Consulting Group (2023), but also locally operative and known companies (e.g., Materna (2023), Wirtschaftsbetriebe Duisburg (2023)) frequently stress that they are 'committed to sustainability' and that sustainability initiatives are of top strategic priority (Brockhaus et al., 2017, p. 933), it is unclear how many have turned these visions and missions' statements into corporate actions. There are some academic studies (e.g., Baggia et al., 2019; Brezavšček et al., 2019; Loeser et al., 2017) that report on corporate Green IT/IS usage. These, however, are isolated observations that remain inconclusive for a greater population (Cunha et al., 2018, p. 165), and still, many companies seem challenged to change towards increased sustainability (Engert et al., 2016, p. 2833).

Consequently, Green IT/IS benefits remain – from a practical point of view – unclear to companies, but – from a scientific point of view – also under-researched. We thus ask:

RQ 2: *Which are the benefits of Green IT/IS-enabled sustainability, and which Green IT/IS are suited for an initial successful adoption?*

For RQ 2, we took a positive view. We assumed that companies were not adopting Green IT/IS as they were unaware of the benefits and potential the technologies have for their business. There is, however, also another view to this, as sustainable technologies can – compared to 'traditional technologies' – be and also are regarded as disruptive technologies (Mohan et al., 2012, p. 27). These are oftentimes not as cheap as mainstream technologies (Brockhaus et al., 2017, p. 935) and/or perform worse in established performance criteria (see section 2.5). Hence, companies that adopt and use sustainable technologies seem not purely driven by economic interests (e.g., lower costs, improved systems performance) but also by the idea of the TBL (see section 2.2) and that also societal and environmental need to play a role in corporate decision making (Koo et al., 2015, p. 70; Murugesan, 2008, p. 24).

While there have been calls to further investigate factors that focus on how sustainability and sustainable technologies can be integrated into traditional corporate strategy (Deng & Ji, 2015a, p. 7; Engert et al., 2016, pp. 2834–2835), we also argue that the opposite – investigating factors and reasons of why sustainability and sustainable technologies are *not* integrated – is

similarly promising. Recent works also make this point and find that the influence corporate decision-makers have on why Green IT/IS are (not) adopted remains under-researched (Harnischmacher et al., 2020, p. 12).

We thus see that – also from a practical point of view – there might be certain aspects that make sustainability and sustainable products unattractive for adoption. From a scientific point of view, we also see that this area is also rather under-researched. There is no study that seeks to collect and explain aspects of why sustainable technologies are not adopted by companies.

We consequentially ask:

RQ3: *Which managerial assumptions, attitudes, and assertions about sustainability and sustainable technologies negatively influence corporate Green IT/IS adoption decisions?*

3 Research Design

3.1 Meta-Theoretical Assumptions

To better understand the research project, its context as well as its proceeding, we will first outline our meta-theoretical assumptions. It seems important to do this, as these philosophical baselines guide and inflict the research done by a researcher (Guba et al., 1994, pp. 106–107) and – especially due to the imperfect nature of theories in the social sciences (Bhattacherjee, 2012, p. 4) – consequently also affect the validity, reliability, quality, and rigor of the undertaken research (Becker & Niehaves, 2007, p. 198; Lincoln & Guba, 1985, Chapter 11).

Furthermore – as this dissertation follows the cumulative tradition of the IS research domain – it consists of multiple conceptual, methodological, as well as interpretative parts (Hirschheim & Klein, 2012, p. 218; Recker, 2013, p. 65). We follow, build up, or generally relate to work done by other researchers and therefore also want and need to philosophically position ourselves to the work of others by shedding light on our ontological, epistemological position, as well as our theoretical perspective (Becker & Niehaves, 2007, p. 198; Crotty, 1998, p. 2).

Ontological Position – We elaborate on our ontological position by distinguishing whether we regard the world as being constructed of subjects that incumbent or subscribe to certain qualities (Democritus' subject-cum-quality ontology) or whether the world is made up of processes, in which entities are mere manifestations of ongoing processes (Heraclitus' process ontology) (Langley et al., 2013, p. 5).

We consider our position, our research, and especially the reality and world – of which we are a part – to be relatively stable but nevertheless also in a constant state of flux. This flux – in our view – is only recognizable over longer periods of time. It may, to give an illustrative example, be compared to observing the sun. When looking at it, it is a physical entity that does not imminently visibly change. Only when monitoring it over time (e.g., over the course of twelve hours) or against another (seemingly and relatively) stable entity (e.g., the Earth's horizon) do we perceive that the sun altered its position and thus has changed in a perceivable way. We, of course, also know – or at least need to assume – that during the time of our observation, the sun will also have altered. As the fusion processes within the sun, for instance, are constantly happening. Hence, it will at any given moment necessarily and undoubtedly be different from any other moment. These alterations – though undoubtedly present – however, are so small that we can see them as negligible and can assume the object of interest as constant. This simplification makes it possible to study objects and their change in the time and space continuum. Consequently, we see that it is the entities like organizations or persons, but also us as researchers that change over the course of time (*Democritus substance-cum-*

quality view of reality) and that it is not the change that manifests in relatively stable events and experiences (*Heraclitus process view of reality*).

Epistemological Position – Our outlined ontological position is also closely linked to our epistemological stance of how we, as researchers, study certain phenomena (Becker & Niehaves, 2007, p. 198). Many positions were conceptualized over time, and three general positions are objectivism, constructivism, and subjectivism (Crotty, 1998, pp. 8–9).

We consider ourselves as *constructivist* and, for instance, in comparison to an objectivist, doubt that the reality around us can objectively be perceived or discovered. For instance: We know that there is a bright object in the sky; that it moves across the sky, and that it brings light and warmth to Earth. There is, however, no way for us to know or to make absolutely sure that other persons and we would have captured the exact same aspects of the reality of this object without being taught, primed, or influenced in any other way.

Similarly, there is also no absolute way for us to know whether we got the same meaning and understanding of the sun as any other human being. These attributes of it (e.g., that the sun shines in bright, white, yellow, or reddish colors, and that it emits – at least – light and heat) and the consecutive meaning are – in our view – constructed by people, so that even sometimes the meaning about a certain phenomenon may vary from person to person (Crotty, 1998, p. 8; Gephart, 2004, p. 457).

We, however, also believe that – compared to *subjectivism* – the object itself is part of how the reality about it is perceived and constructed (Blagoev & Costas, 2021, p. 13). Imposing meaning to an object without the object contributing to it, in our view, would be like trying to grasp all facets and characteristics of a given object in a pitch-black room in which the person is not allowed to interact with the object in any way. As the object does not provide any feedback, the person would have no possible way to get any information about the object, despite knowing that it is there in the first place.

Theoretical Perspective – As the last aspect, we also want to outline and comment on our general theoretical perspective, as our dissertation is strongly influenced by *epistemological realism*. As already implicitly stated in our ontological and epistemological position, we believe that we, as researchers, can partially and indirectly get to know the world, the reality, or the phenomenon of interest by acquiring data about it (Reihlen et al., 2021, p. 8). We thus cannot create a definite and universal understanding of a phenomenon but only describe it as best as possible. We need to debate and falsify other competing views in order to come to a certain agreement with other researchers about our views. This means that data is not only a documented manifestation of a being but an intermediate between the researcher and the object of interest (Bhattacherjee, 2012, p. 10). This counts not only for (physical) objects that people

usually describe as non-living beings but also for living beings (subjects), such as animals, plants, or people, as well as their (social) interactions. We, as researchers, can only study objects, subjects, and their interactive relationships, by acquiring data. May it be by studying the physical behavior of an object under certain circumstances or by monitoring or directly questioning a subject.

As the levels of reality are interwoven and not clearly separate (Reihlen et al., 2021, p. 14), we need to strive for a high *descriptive validity*, and this acquires and collect as much data and in as many different forms as possible about it (Maxwell, 2009, p. 236). This, however, does not mean that we limit ourselves to research that follows the same or similar philosophical positions as ours as it would – in our view – not only leave out a substantial amount of research but also significantly increase the risk for systematically biased, or one-sided observations and results (Bhattacherjee, 2012, p. 35; Maxwell, 2009, p. 236). This plethora of insights and views thus helps us to achieve our goal of creating not only a rich understanding and deep insights about the phenomenon of interest (Schultze & Avital, 2011, pp. 2–3) but also frame or model the perceived reality that – in the end – it may be captured in an abstract and logical description and explanation of these observations (theory) (Bhattacherjee, 2012, pp. 28–29; Oates, 2006, p. 146).

The bottom line of these meta-philosophical assumptions, which embed the proposed research project into a grand scheme of the entire research endeavor, is not only a natural but a logical consequence. It may be described by relating it to the image used by Blagoev and Costas (2021): A better understanding of the process of Green IT/IS adoption in organizations is not achieved as with reaching a fixed point, or line, but rather a horizon that – though clearly existing – is inaccessible and its reality consequently also (socially) constructed.

3.2 Research Process and Applied Methods

This dissertation is based on a multi-method research design that consists of literature reviews and both quantitative and qualitative approaches (see Figure 1).

Based on an initial literature-heavy phase, we then linked quantitative and qualitative research methods. This proceeding was also chosen as it i) promised a richer and deeper understanding of the phenomenon at hand (Miles & Huberman, 1994, p. 41; Schultze & Avital, 2011, pp. 2–3), but ii) was also a reaction to unforeseen developments during the research process (Edmondson & McManus, 2007, p. 1155). As it was also clear from the beginning that this dissertation would consist of and rely on multiple methods that investigate the field of organizational adoption and usage of Green IT/IS, we ensured a methodological fit along the four criteria of aligning:

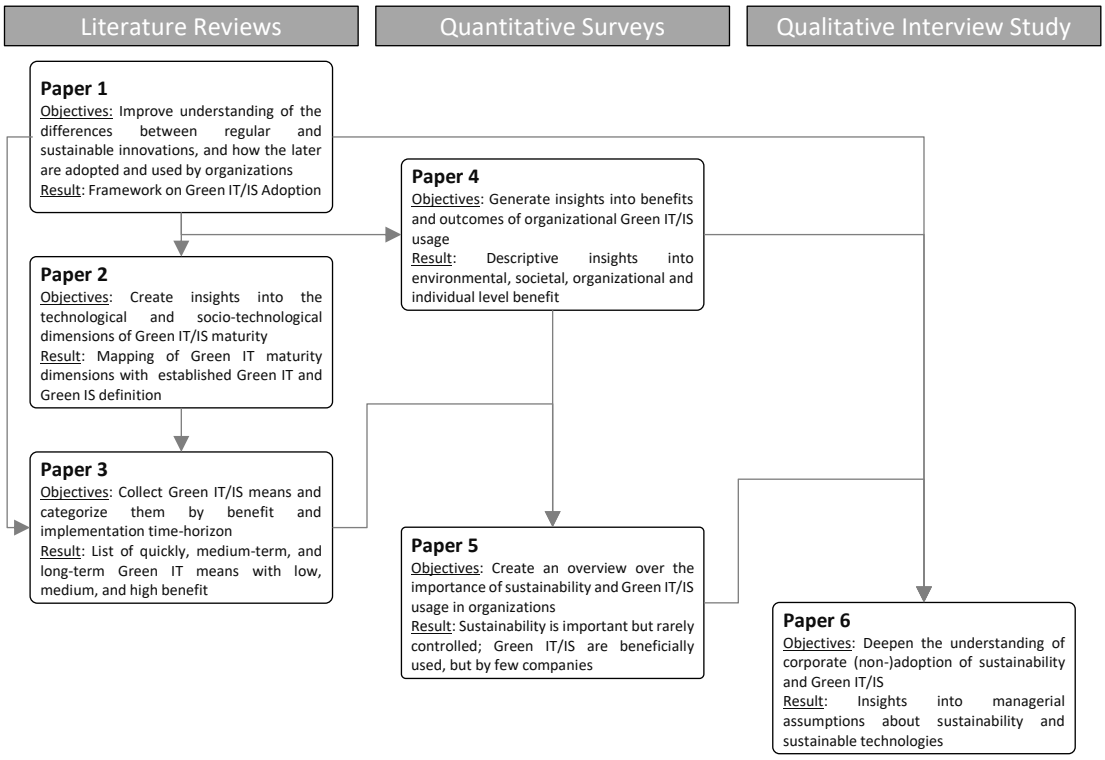

Figure 1. Research process overview

i) *research questions* (i.e., focus on a relatively narrow issue of the general topic to create meaningful theoretically and practically significant insights),

ii) *prior work* (i.e., highlight the theoretical and empirical literature basis of the study to outline the yet unanswered research problem),

iii) *research design* (i.e., alignment of where and which data is collected and how it is analyzed), and

iv) *contribution to literature* (i.e., integration of the findings to advance or challenge present theoretical findings and derivation of practical insights) (Edmondson & McManus, 2007, p. 1156).

The first criterion was addressed by ensuring that all works concerned the topic of adoption and usage of Green IT/IS in an organizational context. We, for instance, excluded individual adoption and usage topics, like the use of green applications (Brauer et al., 2016), environmental sensemaking (Degirmenci & Recker, 2018), or nudging of users (Henkel et al., 2019). The second criterion was ensured by i) using a similar literature basis of our conceptual understanding of Green IT/IS (i.e., Loeser, 2013), the diffusion of innovations in organizations (i.e., Rogers, 2003), as well as the notion that resources and capabilities can be used to create a sustainable (sustainability-based) competitive advantage (i.e., Hart, 1995; Hart & Dowell, 2011), as well as ii) our successively published work. The research design criterion was ensured by i) using literature that is of high relevance to the IS research community, ii)

collecting data from organizations of the DACH region, and iii) ensuring that the collected data (e.g., for paper 2, and 3) was at least reviewed by the doctorate candidate. For the last criterion, we made sure that our results were not only of relevance to the academic community but that explicit contributions were also outlined.

3.2.1 Literature Reviews

Like most research projects, also we commenced work on this dissertation with literature work, as it is likely the most suitable approach to get an overview of a phenomenon of interest (Dyllick & Muff, 2016, p. 157). We started to familiarize ourselves with fundamental concepts, recent insights, developments, and trends in the Green IT and Green IS domain and also identified key works as well as researchers. We followed the structured Webster and Watson (2002, p. xvi) approach and not only got a fundamental understanding of the current state of the Green IT/IS discussion but spotted certain gaps that seemed promising for further research. We also identified certain larger and more fundamental problems and issues within the body of Green IT/IS literature (Alvesson, 2011, pp. 266–267).

We specifically found that Green IT/IS were almost exclusively treated like a regular innovation despite their core aim to not only address a digitalization issue but to address an organization's sustainability issue(s) with the help of digital technologies (Tomlinson, 2010, pp. 26–27). Consequently, also the predominant adoption models and frameworks were only partially suitable to explain Green IT/IS adoption, usage, and its outcomes. The Green IT Adoption Model (GITAM), for instance, respects only economical, regulatory, and ethical drivers (Molla, 2008, p. 662), thus neglecting the direct influences of the natural environment. The framework of predictors for Green IT adoption (Schmidt et al., 2010) respects the environmental engagement of a company (p. 3) but only sees it from a managerial view. We find this problematic, as it is not only an intra-organizational view but it also neglects other important aspects of processes and culture (Loeser et al., 2017, p. 533). The same counts for the environmental awareness construct in the model on factors that influence a firm’s green IT Practices (Hu et al., 2016). We consequently specified our literature analysis and identified 18 papers on Green IT/IS adoption models and frameworks, as well as their determinants and outcomes, and used them for the creation of an integrative Green IT/IS adoption framework (see paper 1).

Based on this work, we continued work in two ways. First, we continued with additional literature work to improve our understanding of Green IT/IS and how they could be adopted and used by organizations. Second, we undertook an initial quantitative study (see paper 4). For the literature work, we cooperated with other researchers from the Green IT/IS domain and jointly carved out two additional gaps in the Green IT/IS domain, for which we thought it was promising to provide the first literature-based insights.

The first one was that Green IT/IS adoption – like many other technological innovations – their adoption is primarily seen from the technological side. Green IT/IS are just another form of technology that needs to be integrated and made compatible with the technologies that are already in use. This view almost exclusively neglects the social and socio-technological components of Green IT/IS (Lunardi et al., 2015, p. 4). We, therefore, decided to map our general Green IT/IS understanding with the IT-CMF; a prominent and – especially in the practical domain – frequently used framework for assessing and improving the maturity of a (to-be) adopted innovation. We found that especially the adoption of Green IT/IS is primarily a matter of developing capabilities and not technologies (see paper 2).

The second insight – that also partially overlaps with the first one – was that companies seem to struggle with initializing their sustainability uptake and Green IT/IS adoption (Brockhaus et al., 2017, p. 933; Engert et al., 2016, p. 2833). They struggle with selecting the first steps that, on the one side, are quickly and ideally cost-neutral to realize but also, on the other side, also have a measurable effect on an organization's sustainability. As with almost any adopted innovation, they seek to underline its value and contribution. This is hardly achievable by developing capabilities. As they are conceptualized as "valuable, rare, and costly to imitate" (Ray et al., 2005, p. 626) and thus require a substantial amount of time to be developed, and also for their effects to manifest. Hence, making first technology-based green IT/IS steps seems a viable option. We therefore undertook a literature review to search for technological matters that organizations can relatively quickly adopt. We overall collected 47 papers and identified five relevant ones with which we suggested corporate Green IT/IS quick wins means, with which companies can achieve initial benefits and that also serve as a basis for further development of an organizational Green IT/IS strategy (see paper 3).

3.2.2 Quantitative Survey Studies

After the initial literature review, we wanted to shed further light on corporate Green IT/IS adoption and designed a study that aimed at two goals: First, to document outcomes and benefits that organizations achieved from adopting sustainability and Green IT/IS. Second, to find out about the interplay and relationships of the conceptualized Green IT/IS adoption determinants and factors. We selected a quantitative approach for a multitude of reasons: i) It seemed promising to contact and question a wide variety of companies in order to create recent insights on the topic in practice (Bhattacherjee, 2012, p. 73). ii) Especially survey research is highly cost and time efficient, which also falsifies the planning and further development of the overall research project (Oates, 2006, p. 104). iii) It allowed to establish a mechanism so that respondents could volunteer to be contacted for further questioning and thus engage in theory building (Bhattacherjee, 2012, p. 4).

We designed a questionnaire that consisted of six groups of questions: i) use and administration of sustainability, ii) use and administrative support of Green IS, iii) non-adoption of Green IS, iv) status of the Green IS initiative, and vi) outcomes of the general sustainability and Green IS initiatives. To achieve a qualified sample, we contacted companies that were either linked to any kind of sustainability initiative or to Green IS usage (sampling frame (Bhattacherjee, 2012, p. 66)) and were therefore listed on websites that offer an overview of sustainability-engaged companies. All 850 identified companies were contacted.

During the conduction of the study, we realized that both a sufficient number of companies and also those that used Green IT/IS could not be reached. We only managed to generate 55 validly filled-out questionnaires and directly realized that most companies had only initialized general sustainability initiatives. We were able to document certain benefits, but due to the limited number of study participants and consequential responses, we could use the responses as descriptive data. We, therefore – though providing valuable and interesting insights – only partially achieved our first goal. Our second goal, however, could not sufficiently be reached (see paper 4).

From this point on, we decided to proceed in two ways: First, we designed another quantitative study (see paper 5) that set out to document the relevance of corporate sustainability as well as digitally enabled sustainability in organizations. This was done out of the observation that it first seemed relatively unclear how relevant sustainability is for companies and second how many companies really engaged in corporate sustainability as well as Green IT/IS actions. An overview seemed tremendously promising and beneficial; not only to put this dissertation into context but also for the research community. This proceeding also offered the possibility of finding representatives for our upcoming study (Miles & Huberman, 1994, p. 41).

Second, we decided to proceed qualitatively, and document context factors as well as reasons and motives for companies to not engage in Green IT/IS adoption and usage. This was also done as a reply to the often brought forward critique towards quantitative research that is solely numerical and does not incorporate any context information that would have, for instance, been interesting in order to better understand the investigated actions and outcomes (Oates, 2006, p. 105).

3.2.3 Qualitative Expert Interview Study

After getting a literature and empirically based understanding of the concepts of Green IT, Green IS, their organizational adoption, as well as the challenges and prejudices corporate decision-makers have about them, we felt it necessary to go into detail. Merely relying on already published, literature-based insights and relatively context-less data (Guba et al., 1994, p. 106) seemed to miss out on crucial details about our topic of interest. We hence decided to

contact, and question people that are responsible for their organization's (non) adoption and (non) usage of Green IT and Green IS. We seemed it not only promising – as there are only a few insights into the matter (e.g., Molla et al., 2009, p. 21) – but also necessary to document detailed information about the often complex managerial situations and explicitly interview corporate decision-makers about their explicit motives, intentions, and rationales in context of Green IT/IS (non) adoption, and thus to consequentially also challenge established Green IT/IS views (Alvesson, 2003, p. 13; Bansal et al., 2018, p. 1189; Oates, 2006, p. 187).

We selected a semi-structured interview approach – one of the most frequently used types of qualitative research (Myers & Newman, 2007, p. 4). It allows researchers – for one – to pre-define topics and questions of interest, structure the discussions, and to also compare, triangulate, and interlink the insights acquired in multiple interviews (Oates, 2006, p. 188; Recker, 2013, p. 31). For another, the format also allows for deviating from the pre-defined paths, improvising questions, or following related and potentially interesting and valuable streams in the discussion (Myers & Newman, 2007, p. 4).

We, of course, also see the potential downside and criticism to our choice of also selecting a qualitative path. IS research and its publications are still dominated by positivist and quantitative research (Avison & Malaurent, 2014, p. 82; Monteiro et al., 2022, p. iv), and qualitative research is often criticized for being ‘unscientific’ and only ‘pre-research’ (Sarker et al., 2012, p. 2) non-transparent (Oates, 2006, p. 267), and low generalizable (Recker, 2013, p. 37). Also, interviews and interview data are often challenged as to only documenting an interviewee's political agenda, which leads to the question if the generated data can be seen as genuine and if and how it should be interpreted (Schultze & Avital, 2011, p. 3).

During the design and conduction of our interviews, we had clear quality criteria in mind. We especially took care to proceed in such a way that the four established quality criteria for qualitative research of *credibility* (i.e., ensuring that the results and interpretations become more trustworthy (Lincoln & Guba, 1985, p. 301)), *transferability* (i.e., ensuring that the sample has a high internal validity to that it is a good representation of it applied-to population (p. 297)), *dependability* (i.e., taking factors of instability about the phenomenon and the data gathering process into account (p. 299)), and also *confirmability* (i.e., seeking similarity between the documented cases (p.307)) were met (see paper 6).

4 Thesis Structure and Included Research Papers

This dissertation is of cumulative format and includes six papers (see Figure 2) that were successfully published in either a highly respected IS conference or in a highly accepted academic or practitioner journal (see List of Publications). This proceeding was chosen for multiple reasons.

First, we wanted to ensure that our research efforts could be successfully published in relevant IS conferences to get in touch with the general research as well as the topic-specific community. Without these early successes (i.e., Schmermbeck, 2019; Schmermbeck et al., 2020), further research projects would probably not have been realized, as the scholars we met were willing to undertake a joint research project that was also successfully published (i.e., Alsdorf et al., 2022).

Second, conference submissions have the clear benefit of getting quick feedback on research efforts as they are usually reviewed within two to three months, while journal submissions can take considerable months longer and sometimes even years (Recker, 2013, pp. 116–117). The review is nevertheless not of lesser quality. Also, conferences usually – at least the ones we selected for publication – use a double-blind peer review process which aims for an objective, high-quality review of the work submitted (Recker, 2013, p. 117). Like the initially presented reason, we saw this as an opportunity to get a high qualitative review of experts from our field of research, which contributed to our understanding of the field, but also our methodological understanding.

Third, conferences, as well as practitioner publications, tend to have rather strict lengths and limitations. We consequently saw both outlets as opportunities to improve not only our writing but also our argumentative style and to focus on the necessary aspects. This also counts especially for practitioner publications, as they – accessibly – require a somewhat different style of writing and argumentation. We also chose to publish in them as we experienced the IS domain as a very fast-moving community. We, therefore, did not want to wait for our results to trickle down to corporate decision-makers but pro-actively make use of channels on the borderline between purely academic and practitioner channels.

In the following, we will first give an overview over the Green IT/IS discourse as it has certain implications of where we chose to publish the papers included in this dissertation. Then, we will shortly present and summarize the main content of each research paper. After this, the papers are presented. Then, we present and summarize the key findings and give an answer to the research problem as well as the research questions. The dissertation concludes with a brief discussion in which theoretical and practical contributions and limitations are outlined, as well as an outlook. An overview is illustrated in Figure 2.

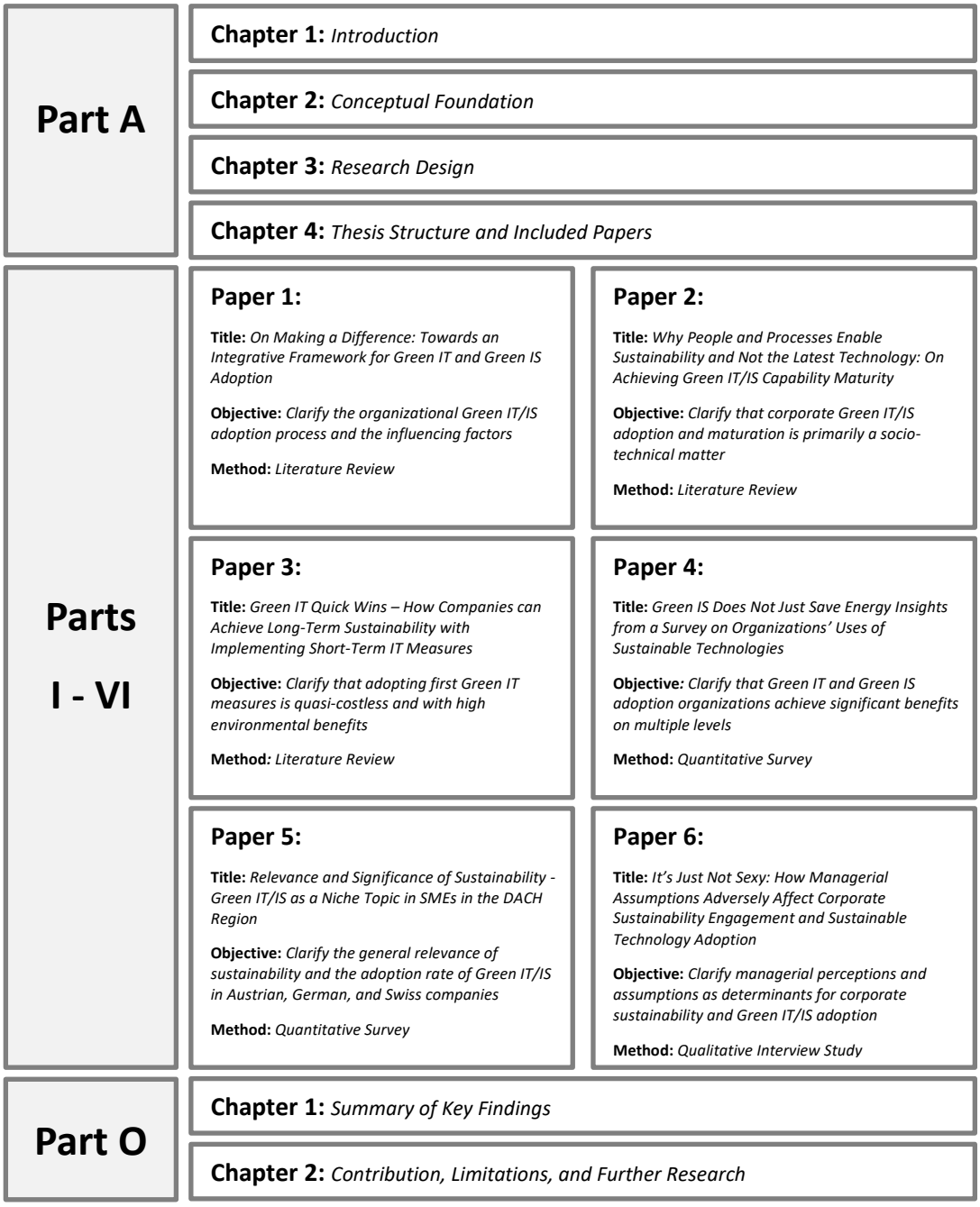

Figure 2. Structure of this dissertation

4.1 Placement of Research Papers in the Green IT/IS Discussion

Like any research topic, the discussion on Green IT and Green IS has had its first ups and downs, and also certain countries and researchers that lead the discussion. While the Green IT/IS has brought forth some well-respected literature reviews on the topic (e.g., Harnischmacher et al., 2020; Loeser, 2013; Wang et al., 2015), only recently a bibliometric

literature review on Green IT/IS was published that creates a rather holistic overview over the first thirteen years of Green IT/IS research.

Zaung Nau and Marinova (2020) replicated and continued or confirmed the works of Loeser (2013) and Harnischmacher et al. (2020), as they identified an initial high interest – and consequently relatively high number of publications – on Green IT/IS that decreased in 2015, as well as in 2018 and 2019 (Zaung Nau & Marinova, 2020, p. 243).

They overall collected 909 published articles on Green IT and Green IS and found that more than half of the literature (55%) was published in academic journals, followed by conference proceedings 39% (p. 242). The top journals are Sustainability[4] (26; 2.86% of all Green IT and Green IS publications), the Journal of Cleaner Production[5] (16; 1.76%), and the Australasian Journal of Information Systems[6] (12; 1.32%). With the Communications of the Association for Information Systems[7], there are also publications from the Association for Information Systems (AIS) among the identified top journals (10; 1.1%), and with the Proceedings of the Annual Hawaii International Conference on Systems Sciences (HICSS Proceedings)[8] a relatively AIS relevant conference.

This insight has certain implications for this work and where we chose to publish our research papers: i) Two fundamental papers were published in HICSS (top 9 publication), and ii) the opus magnum was published in Sustainability (top 1 publication).

Admittedly, both, the HICSS Proceedings and the Sustainability journal do not have the highest h-indices of 72 (HICSS Proceedings) and 53 (Sustainability) (Zaung Nau & Marinova, 2020, p. 245) or VHB JOURQUAL rankings (both C ranked)[9]. We nevertheless defend against criticism that both outlets – as well as the other outlets the other publications were published in – are to be seen as inferior or sub-qualitative. First, as the academic rigor was nevertheless respected, all publications went through a double-blind (for HICSS, PACIS, and HMD – Praxis der Wirtschaftsinformatik) or single-blind peer review (for Sustainability). Certain journals – though not receiving a high ranking – nevertheless have a high topic-related specific relevance – as shown by Zaung Nau & Marinova (2020, p. 245) and thus relevance for publication.

It is furthermore interesting to inspect the countries that are highly engaged in the Green IT/IS discussion. The United States of America take the leading position (139 articles; 15.3%), which is not surprising, as they have a particularly active IS community and are also home to

[4] https://www.mdpi.com/journal/sustainability
[5] https://www.sciencedirect.com/journal/journal-of-cleaner-production
[6] https://journal.acs.org.au/index.php/ajis
[7] https://aisel.aisnet.org/cais/
[8] https://shidler.hawaii.edu/itm/hicss
[9] https://vhbonline.org/vhb4you/vhb-jourqual/vhb-jourqual-3/gesamtliste

the AIS. Germany takes the second place (50; 8.8%), but also India (60 articles, 6.6%), Australia (57 articles, 15.3%), and England (57 articles, 15.3%) take top positions (Zaung Nau & Marinova, 2020, p. 247). As a region, the Asia-Pacific countries (Australia, China, Malaysia, South Korea, Japan, Taiwan, and Indonesia) also account for 27.83% (253 articles) of all Green IT/IS articles and were thus regarded as an important target group for our papers (Zaung Nau & Marinova, 2020, pp. 247–248).

This insight has certain implications for where the individual publications of this dissertation were placed and how they contribute to the overall Green IT/IS discussion: i) Two papers were published in a German Journal HMD – Praxis der Wirtschaftsinformatik, and ii) one paper was published in the Proceedings of the Pacific Asia Conference on Information Systems (PACIS). Consequentially, though also these outlets have relatively modest rankings (D for HMD; C for PACIS)[6,] we similarly argue that here, the publications are placed at outlets in highly active communities which underlines their relevance and contribution to the discussion. Furthermore – as we will outline in section 2.7 – we also seek to address relatively fundamental problems in the corporate understanding of Green IT/IS and thus regarded HMD as a fitting outlet to share our insights with the practitioner community.

4.2 Paper 1 – On Making a Difference: Towards an Integrative Framework for Green IT and Green IS Adoption

The first paper collects and analyzes literature on Green IT and Green IS adoption. Its goal is to show that both, Green IT and Green IS, need to be evaluated along more than the traditionally relevant dimensions of organizational (e.g., economic drivers (Lunardi et al., 2015, p. 5; Molla, 2008, p. 662; Radu, 2016, p. 10), ethical drivers (Molla, 2008, p. 663), competitor actions (Hu et al., 2016, pp. 1159–1160), equity holder interests (Hu et al., 2016, pp. 1158–1159)) and individual factors (e.g., champion support (Bose & Luo, 2011, p. 48), intrinsic user motivation (Koo & Chung, 2014, p. 146), employee skills (Radu, 2016, p. 10)) that are usually respected and regarded in an organizations' innovation adoption process. It argues that also societal factors (e.g., non-governmental organization initiatives (Radu, 2016, p. 10), legislator requirements (Kurnia et al., 2014, p. 9)) and natural environment factors (e.g., conditions of the natural environment (Radu, 2016, p. 10), care for the natural environment (Karanasios et al., 2010, p. 4)) need to be regarded. The paper shows that the factors of the respective four levels influence not only the decision process of pre-adoption, adoption, and post-adoption but also how the innovations are evaluated before they are even considered for adoption (outset phase) and consequently on how they are evaluated (outcome phase). Next to these summaries, the paper contributes to the discussion by framing a process that links the influences of the four levels and the five identified adoption phases. It thus is a contribution to

research and practice at it improves not only the conceptual understanding of Green IT and Green IS, but also on how to adopt and use them in organization.

4.3 Paper 2 – Why People and Processes Enable Sustainability and Not the Latest Technology: On Achieving Green IT/IS Capability Maturity

The second paper continues the work of the first one. It specifically seeks to respond to the problem (Alvesson, 2011, p. 252) of academia specifically differentiating between Green IT and Green IS (e.g., Loeser, 2013, p. 6), while practice does not (Curley et al., 2016, pp. 103–104; Henkel & Kranz, 2018, p. 11). This problem becomes especially visible during the transfer and alignment of academic insight into practice, as potentially crucial information or constraints – like the non-technological components of the respective innovation (Lunardi et al., 2015, p. 4) – are not respected or simply ignored. For instance: Many companies rely on and use frameworks and models to better steer, direct, and develop their (to-be) adopted technological innovations, but also capabilities (Becker et al., 2009, p. 221). One very popular framework that – to the best of our knowledge, the single one – encompasses Green IT is the IT-CMF (Curley et al., 2016, 2016). Especially the terminology of naming the capability a Green IT capability seems highly misleading as it seems to indicate that adopting and developing Green IT (and Green IS) is primarily, if not exclusively, a technological matter. Building on this flaw, we thus analyzed and segregated both i) the Green and Green IS understandings, as well as ii) the Green IT capability, as suggested by the IT-CMF. We showed that – contrary to the title – adopting and developing Green IT/IS, is primarily a non-technical, but socio-technological matter.

This distinction and conceptual clarity is an especially relevant contribution to practice, as it underlines that initializing sustainability change is not primarily a matter of adopting costly and potentially immature technologies. Especially altering and re-defining the underlying corporate language and culture (Allen, 2012, para. 1; Curley et al., 2016, p. 108; Curry et al., 2012, p. 72), corporate governance (Curley et al., 2016, p. 109; Weill, 2004, p. 2), and aligning the IT strategy with the overall corporate strategy towards a shared sustainability goal (Curley et al., 2016, p. 106; Murugesan, 2008, p. 31) are almost exclusively managerial, and thus Green IS concerns. Only the aspects of setting IT objectives and goals is a nearly fully Green IT matter, as it seeks to address aspects that are closely linked to sustainability matters along the IT lifecycle. It also contributes to theory, as it fosters the capability and (natural) resource perspective (Hart, 1995; Helfat & Peteraf, 2003) to the concepts of Green IT/IS.

4.4 Paper 3 – Green IT Quick Wins – How Companies can Achieve Long-Term Sustainability with Implementing Short-Term IT Measures

The third paper also underlines the strong ties between academic contribution and the practical relevance of this dissertation. Many companies are inexperienced or struggle when it comes to adopting sustainability and Green IT/IS means (Brockhaus et al., 2017, p. 933; Engert et al., 2016, p. 2833; Luftman et al., 2013, p. 356). As sustainability laws and regulations seem to become increasingly binding, and non-environmental behaviors prosecuted and taxed (e.g., Bray, 2022; Citizens' Climate Lobby, 2021; Lichtenthaler, 2022, p. 87), they are challenged and driven to actively engage in sustainability (Leidner et al., 2022, p. 591). We wanted to assist corporate decision-makers by documenting and cataloging effective measures that – for one – can quickly and cheaply be implemented and – for another – also serve as first steps towards a long-term sustainability engagement.

To do so, we turned to literature and analyzed publications on Green IT and Green IS that list explicit actionable measures. Surprised by the sparse results, we could only analyze five publications (i.e., Bose & Luo, 2012; Curry & Donnellan, 2014; Erek et al., 2010; Loeser, 2013; Murugesan & Gangadharan, 2012) that met our criteria. We worked them up and categorized them along two dimensions: i) required time for adoption and implementation and ii) sustainability effect. Each dimension consisted of three steps: Short-term, mid-term, and long-term for the first category and high, medium, and low for the second one. To support companies in their first Green IT/IS actions, our key aim was to specifically identify measures that can be quickly implemented and have a relatively high sustainability benefit that we coined *quick wins*.

We found both Green IT, as well as Green IS actions that fall into the quick win category. The Green IS actions seemed particularly simple and effective, as they consisted, for instance, of activating and actively managing the energy setting of the computers used in a company (e.g., so that monitors are automatically deactivated after a short period or that the computer switches into a dormant state after a pre-defined time) (Bose & Luo, 2012, p. 68; Curry & Donnellan, 2014, p. 3; Erek et al., 2010, p. 24; Loeser, 2013, p. 7; Pon Kumar & Kannegala, 2012, pp. 29–30), as well as to increase the use of groupware (e.g., to actively use video-conferencing tools in order to avoid business trips) (Bose & Luo, 2012, p. 73; Curry & Donnellan, 2014, p. 14; Erek et al., 2010, p. 22). The Green IT quick wins are, for instance, to alter hardware procurement requirements (e.g., that primarily or exclusively eco-labeled hardware is purchased) (Bose & Luo, 2012, p. 68; Erek et al., 2010, p. 24; Loeser, 2013, p. 7). We also stress that the outlined list of measures is not to be seen as a complete list and that their implementation is not the end of a company's sustainability but the beginning.

The paper, thus, contributes to both research and practice, as it – for the academic part – summarizes and extends existing insights and – for the practical part – suggests specific corporate actions that managers can directly put into practice.

4.5 Paper 4 – Green IS Does Not Just Save Energy Insights from a Survey on Organizations' Uses of Sustainable Technologies

In the fourth paper, we shed light on the outcomes of Green IT and Green IS adoption and usage. We thus set forth and build up on our own initial literature work (see section 4.1). We first want to address that there seem to be only very few empirical studies on Green IT and Green IS actions and their outcomes of corporate sustainability (Bohas & Poussing, 2016, p. 1; Malhotra et al., 2013, p. 1266) or environmental benefits and impacts (Elliot & Webster, 2017, p. 375). While the literature on the topic was primarily concerned with conceptual or literature work (e.g., Dedrick, 2010; El-Rayes et al., 2022; Lei & Ngai, 2013; Loeser, 2013), suggesting research agendas (e.g., Harnischmacher et al., 2020; Henkel & Kranz, 2018; Jenkin et al., 2011; Lei & Ngai, 2014), developing models and frameworks (e.g., Lunardi et al., 2013; Molla, 2008; Molla et al., 2008; Yoon, 2018), only a few studies find and report on general, and Green IT/IS enabled environmental, social, and economic benefits of a company (e.g., Baggia et al., 2019; Brezavšček et al., 2019; Loeser et al., 2017; Lunardi et al., 2015; Simmonds & Bhattacherjee, 2017).

Consequently, we designed and undertook a quantitative study that conceptually relied on the (competitive) value of sustainability innovations for a company (Dedrick, 2010; Hart, 1995; Loeser et al., 2017), as well as our own research (i.e., the Green IT/IS adoption framework (Schmermbeck, 2019)). It consisted of five constructs: i) use and administration of sustainability, ii) use and administration of Green IS, iii) non-adoption of Green IS, iv) status of Green IS initiative and v) outcomes of general sustainability and Green IS initiatives. It was sent to 850 top-managers from German companies that were listed on publicly accessible official eco-standard websites (e.g., Blauer Engel). We thus aimed for a confirmative, purposive sampling technique to identify companies that are linked to a sustainability initiative and producing or highly visibly using eco-sustainability products. With 55 valid responses (6.47% response rate), we received only relatively few responses that we worked up for interesting insights.

We, for instance, found that 67.3% of most surveyed companies subscribed to an official sustainability standard that ties their efforts together but that these do not necessarily need to be translated into sustainability actions. 87.3% of all companies, for instance, performed actions that lowered their energy consumption in both technical (60%) and non-technical ways (58.2%).

While only eleven companies reported using Green IT/IS, some of the non-adopters gave reasons for why they decided against Green IT/IS adoption. Some, for instance, reported that Green IT/IS had too little relevance for their IT department or that they see no clear benefit for their company. These insights are specifically relevant to paper 6 (see section 4.7).

The insights from the remaining Green IT/IS-adopting companies are also relevant and interesting, as almost all of them reported actively using Green IT practices. 100%, for instance, reported recycling their unused equipment, 81.8% consolidated their IT (i.e., servers, desktops, etc.), and 63.6% actively switched to more energy-saving hardware (e.g., monitors). For Green IS means, also 63.6% reported actively using hardware energy management, and 90.9% used teleworking means.

Regarding the outcomes, we found that all companies achieved benefits on all four conceptualized levels (see paper 1 in sections 4.1) and that especially the recycling and reuse of materials (natural environment level), their ecological transparency (societal level), energy and resource consumption (organizational level), and compliant behaviors of employees (individual level) benefited from the sustainability engagement.

4.6 Paper 5 – Relevance and Significance of Sustainability - Green IT/IS as a Niche Topic in SMEs in the DACH Region

The fifth paper was also conceptualized as a response to the learnings from paper 4 (see section 4.5). We learned that further quantitative studies needed to be addressed towards a more specific target group and that – for generating additionally interesting and contributing results – a greater number of sample companies needed to be contacted and questioned. We also wanted to address the shortcoming in academic insights that studies on Green IT/IS seem to have rather narrow study settings, only investigating a specific region or limiting them to specific aspects. Brezavšček et al. (2019), for instance, studied 156 Slovenian companies and concluded that adopting Green IS can lead to improved environmental and social performance (p. 1043). Bohas and Poussing (2016) studied 815 Luxembourgian companies. They identified different types of Green IT adoption whose drivers are economic (e.g., cost reductions) and social factors (e.g., green corporate image) (p. 5). The findings of these studies are interesting and relevant to Green IT/IS research but limited by their focus on a single country. We thus wanted to create an overview of how relevant sustainability was for companies of a larger region and also investigate if we could detect a larger population of companies that used Green IT/IS and thus could also report on their usage and management.

We consequentially designed a descriptive survey (Leidner et al., 2018, p. 5064) that – for one – was sufficiently short and of practical relevance so that a large number of top-managers were

willing to participate, and – for another – also generated sufficiently relevant scientific insights. We took care to specifically ask questions on i) the explicit goals that companies aim for with their sustainability strategy, ii) if and how Green IT/IS are part of that strategy, and iii) which Green IT/IS practices companies actually use. The created survey was based on parts of our own research (i.e., the Green IT/IS adoption framework (see section 4.1)) as well as literature on Green IT/IS (e.g., Harnischmacher et al., 2020; Loeser, 2013) and their usage in companies (i.e., Larrán Jorge et al., 2016; Lunardi et al., 2013; Molla et al., 2009; Sayeed & Gill, 2009). The final questionnaire consisted of only 16 questions along four thematically grouped blocks: i) demographic information, ii) sustainability orientation of the company, iii) corporate sustainability measurement and reporting, and iv) Green IT/IS practices.

As we aimed for a sufficiently large population, we chose to contact small and medium-sized enterprises (SMEs) from industries whose business models or operations significantly relied on IT/IS usage. To not limit ourselves to one country but also keep the boundary conditions of cultural, legislative, and language settings relatively comparable, we selected companies of the DACH region (i.e., Austria, Germany, and Switzerland). This selection left a sampling frame with SMEs that are – taken together – not only a significant contributor to the respective country's welfare but also to its environmental impact.

By using the AMADEUS company database, we were able to achieve a sample population of 126,961 companies (Austria: 9.9%; Germany: 78.7%; Switzerland: 11.4%). All were contacted via e-mail that contained a description of the research endeavor, as well as a link to the online survey. We received 1,684 responses (1.3% return rate), of which 1,535 were valid and used for further investigation (Austria: 8.0%; Germany: 82.4%; Switzerland: 9.6%). The respondents were primarily top (60.7%) or middle managers (26%).

The most relevant findings are that i) though 70.8% of all companies state that sustainability is relevant for them, only 60% also anchored sustainability in their company strategy, and even only 23.7% control and measure their selected sustainability efforts with specific performance indicators; ii) only 51% of all sampled companies reported that IT/IS are relevant for their sustainability efforts, and also only 12.1% use Green IT/IS. Of the companies that use Green IT and Green IS, we found that – along the three dimensions of Green IT and Green IS (Loeser, 2013, pp. 7–8) – 69.17% used Green IT (IT sourcing: 66.1%, IT operations: 72%, IT disposal: 69.4%), and 42.3% used Green IS (IT department: 35%, organization: 65.1%, external market: 26.9%).

These findings are relevant to both research and practice as they especially underline three aspects: First, many companies still need to make first experiences with Green IT/IS usage (the premise of paper three (see section 4.4)). Second, most companies seem to rely on technological means (Green IT) and either ignore or not using process and socio-technological

means (Green IS) (the premise of paper two (see section 4.3)). Third, our study also underlined that companies from different countries and regions have different motivations and starting points for their sustainability endeavors. While the primary aim for Swiss SMEs was to increase the amount of recycled or reused materials. Austrian companies aimed for reduction of energy used as well as compliance with environmental laws and regulations, and German SMEs reported to especially aim to sensibilize their workforce. This also translates to the multitude of outset factors for sustainability and Green IT/IS initiatives (see paper one and section 4.1).

4.7 Paper 6 – It's Just Not Sexy: How Managerial Assumptions Adversely Affect Corporate Sustainability Engagement and Sustainable Technology Adoption

The sixth and final paper builds up all previous papers and also brings their insights together but seeks to add another view to the ongoing discussion. It takes the previously outlined observations of i) conceptual misunderstandings of Green IT and Green IS, ii) low corporate sustainability and Green IT/IS adoption rates, iii) unclear benefits of Green IT/IS adoption and usage and looks at them from another point of view. It does not so much seek to propose answers or shed light on the stated issues but seeks to find reasons for why the issues exist in the first place.

The study sets off by the fact that corporate (adoption) decisions are not only made by (top-) managers but that they are especially influenced by their attitudes, aspirations, and assumptions. It uses data from three separate (yet unpublished) research projects on corporate Green IT/IS adoption that focuses on i) the reasons for and measurement of corporate Green IT/IS adoption, ii) the acquisition and development of Green IT/IS capabilities, and iii) the influence of internal and external factors that influence Green IT/IS adoption. All three are qualitative interview studies that stand in the context of the research project of this dissertation. They have the same conceptual and terminological fundament as this dissertation (see chapter 2), and we took special care to respect the alignment criteria of i) research question, ii) prior work, iii) research design, and iv) contribution to literature (Edmondson & McManus, 2007, p. 1156) (see section 3.2).

Overall, 21 interviews were conducted for the first three projects (six for study I, five for study II, and ten for study III). Study I focused on two large German companies and investigated corporate adoption intentions and pre-adoption drivers. It found that both companies saw the potential of adopting sustainability and Green IT/IS for simplifying and rationalizing corporate processes and also improving their carbon tracking. They, however, argued that these innovations need to be fully integrated into a company's strategic goals. Study II focused on SMEs in Germany and investigated why they adopt Green IT/IS. It found that – potentially

driven by the then ongoing COVID-19 pandemic – primarily societal drivers (i.e., legislative pressures) influenced corporate Green IT/IS adoption (e.g., video conferencing and remote working technologies). It also documented several adoption hurdles, like technological and infrastructural hindrances (i.e., being inexperienced with these technologies). Study III focused on how required Green IT/IS capabilities can be gained and managed during the adoption and post-adoption phase. It found that companies seem to not develop any special capabilities and that this was primarily justified by them still being inexperienced with using Green IT/IS.

We saw that primarily the large companies had a profound experience with using and adopting Green IT/IS and hence selected the interviewees of study I for further investigation. Four of them agreed to be interviewed a second time. We created a semi-structured interview guide based on the results of both the other papers, as well as the three initial studies. It overall consisted of six blocks, of which three concerned i) the companies' general sustainability, ii) the adoption of sustainable technologies, and iii) the adoption of Green IT/IS. We asked questions to the respective topic blocks but also developed propositions out of the data analyzed from the initial interviews (e.g., "Sustainability is considered unattractive and not innovative" (block i), "Many Green IT/IS initiatives only focus on end-of-the-pipe measures" (block iii)). We read these statements to the interviewees and asked them to commend and think aloud about them. This was done to provoke more emotional but also honest comments on the topic at hand and thus also create more meaningful insights.

Our main observations are that i) adopted sustainability measures that are highly visible and visibly promoted often only have a rather limited contribution to an organization's sustainability, ii) companies tend not to initialize sustainability changes as they are unsure about how to measure the initialized change, and that iii) many corporate Green IT/IS actions focus only on end-of-the-pipe measures without initializing fundamental process changes.

The paper added to the discussion of why companies refrain from sustainability and Green IT/IS adoption. It underlined that especially individual and subjective managerial assumptions about sustainability are often critical or negative. They assume and see that sustainability innovations are non-confirmative of traditional and established quality criteria (Mohan et al., 2012, p. 27). This non-conformity hence leads to negative adoption decisions, although the not to be neglected benefits can either manifest at a later point in time when companies can make use of a first mover or beyond compliance leadership position (Orsato, 2009, pp. 133–134). They also can achieve certain non-financial benefits (Corbett, 2010, p. 14) that can have an indirect effect on the business value (e.g., enhanced brand or company image (Brockhaus et al., 2017, p. 942), more sustainability-aware corporate culture (Gürlek & Tuna, 2018, p. 483)). Especially the latter – as they take time to build and develop, and to also be noticed by

stakeholders – are also hard to imitate and duplicate and hence can be seen as prime RBV-relevant resources (Dehning & Stratopoulos, 2003, tbl. 1; Wade & Hulland, 2004, p. 121). Practitioners, hence, should not see sustainability and business making as opposites or as positions between which they need to choose. They should rather see them as convergent as both offer the possibility to achieve corporate benefits with altered marked and organizational settings and circumstances (Dörr, 2020, p. 2).

From an academic perspective, it seems advisable to shed further light on the difference between sustainability and traditional innovations. A better understanding of the 'non-traditional' and 'non-established' aspects and benefits of sustainable technologies can consequentially lead to better ways of how these can be measured, managed, and also matured. We, therefore, suggest to i) undertake a thorough review of criteria that can ii) be exploratively discussed with corporate decision-makers. Especially focusing on those that take in leading sustainability positions in the respective markets seems promising, as they are not only capable of providing rich insights that can be used to further develop the assessed criteria. They are potentially also able to challenge traditional criteria and give insights into why and how their company parted from purely relying on them. It might also, therefore, be one step to making sustainable evaluation criteria the new normal.

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I

ON MAKING A DIFFERENCE: TOWARDS AN INTEGRATIVE FRAMEWORK FOR GREEN IT AND GREEN IS ADOPTION

Abstract

Organizations and society nowadays face significant challenges. Organizations are required to fundamentally digital transform by assimilating information technology (IT) and information system (IS) assets. Humanity faces an increasingly severe global climate disruption and needs to become more environmentally friendly. Green IT and Green IS – as technologies and initiatives that seek to reduce the negative impacts of IT/IS on the environment – are a response to this. They can help organizations gain a competitive advantage while addressing broad-scale environmental issues. We undertake a literature review to frame the general Green IT/IS adoption process. We provide an overarching understanding by modeling a sequence of five cognitive adoption phases (outset, pre-adoption, adoption, post-adoption, and outcome) on four levels (environmental, societal, organizational, and individual). By recognizing that Green IT/IS adoption has multiple drivers and outcomes, we provide an extensive perspective on Green IT/IS adoption.

Keywords: *Green IT, Green IS, innovation adoption, adoption factors, adoption outcomes*

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1 Introduction

Green denotes artifacts that "positively impact the environment" (Nishant et al., 2017, p. 545) and, in the information systems (IS) domain, are primarily linked to green information technologies (Green ITs). Although there are various many Green IT understandings and definitions (Loeser, 2013, p. 4), it originally described "technologies and initiatives to reduce the power, cooling and real estate costs associated with data centre operations" (Molla, 2008, p. 660). This understanding served as the foundation of the Green IS concept, which refers to utilizing IT and IS to make organizations more sustainable and green (Ijab et al., 2011, p. 1). Overall, Green IS is extensive to Green IT since it also focuses on business processes and the sociotechnical interplays of persons and IT (Erek et al., 2012, p. 3).

Concerning the different capitalizations of Green IT and Green IS (Sedera et al., 2017, pp. 679–681) and in the ongoing discourse about using them distinctively (Brooks et al., 2010, p. 3), interchangeability (Lunardi et al., 2015, p. 2), and integratively (Loeser, 2013, p. 6), we agree with the latter. We view Green IT as "measures and initiatives which decrease the negative environmental impact of manufacturing, operations, and disposal of Information Technology (IT) equipment and infrastructure" (Loeser, 2013, p. 6) and Green IS as "practices which determine the investment in, deployment, use, and management of Information Systems (IS) in order to minimize the negative environmental impact of IS, business operations, and IS-enabled products and services" (Loeser, 2013, p. 6). To simultaneously address Green IT and Green IS, we use Green IT/IS.

While an organization's adoption of a novelty is traditionally seen as a quest for more significant economic benefit, we acknowledge that adopting green technologies differs (Lunardi et al., 2013, p. 2). Fundamentally, Green IT/IS are innovations that any adopting entity (AE) (e.g., organizations, individuals) evaluates in a cognitive innovation-decision process (gain initial knowledge of, form an attitude towards, and make a decision to adopt or reject the innovation (Rogers, 1983, p. 169). It thus includes a decision to adopt or not adopt it (Hameed et al., 2012, p. 360). Adopting Green IT/IS seems only secondarily driven by economic intentions (e.g., lower costs, improved systems performance). Its primary driver appears to be ethical and sustainable considerations (e.g., reducing power consumption, lower carbon emissions, environmental impacts) – a concern for the natural environment (Koo et al., 2015, p. 70; Murugesan, 2008, p. 24).

We acknowledge that Green IT/IS initiatives and acting in environmentally friendly ways is already – or will very soon be – recognized by customers and society, resulting in a competitive advantage for organizations, i.e., by lowering costs and enabling a differentiation advantage (Henkel et al., 2017, p. 13). Customers increasingly differentiate between companies that "effectively contribute to sustainability and those that do not" (Dyllick & Muff, 2016, p. 157).

Thus, Green IT/IS can be a crucial trigger for both: An enabler for a sustainable business transformation (Seidel et al., 2013, p. 14) and a further argument that a company's success is not only evaluated by its finances but also societal and environmental value (Dyllick & Muff, 2016, p. 171).

We argue that, in recent times, in which digital transformation is seen as key for the well-being of global welfare (OECD, 2017, p. 136), novel and resource-conserving Green IT/IS has the potential to both (reactively) address modern digitalization and environmental challenges, and to proactively create sustainable benefits (Hu et al., 2016, p. 1169; Kiron & Unruh, 2018; Unruh & Kiron, 2017).

However, we also see that society has yet to realize the full potential of Green IT/IS to embrace and promote research into it (Seidel et al., 2017, p. 41). This may be because it is generally believed that interest in Green IT/IS is dwindling. While we agree that the initial hype around the topic has passed, overcoming this critical point may be particularly valuable for a technology or business application since it is expected to be further processed with realistic expectations about outcomes (Gartner, 2022, sec. 3).

Taking this as a starting point, we seek to better understand Green IT/IS adoption drivers, outcomes, and the forces that influence the implementation of green technologies in organizations (Cooper & Molla, 2012, p. 3; Lunardi et al., 2013, p. 6, 2015, pp. 4–6; Tushi et al., 2014, pp. 693–694), contributing to both research and practice. From a theoretical perspective, we agree with other researchers (e.g., Unruh & Kiron, 2017) that, to fully pursue beneficial Green IT/IS initiatives and make use of it as a contribution to both digitalization and societal changes, the topic needs to be put into a broader perspective.

We also intend to answer calls for a theoretical framework to structure Green IT/IS research (Lunardi et al., 2013, p. 11; Tushi et al., 2014, p. 678). Traditional adoption frameworks are only partially suitable to frame Green IT/IS adoption since they traditionally only focus on the individual and organizational levels. Thus, they neglect societal and governmental movements (e.g., the Paris Climate Agreement) that, at some point, will also affect business but also altered environmental conditions (e.g., human-driven climate disruption (Tomlinson, 2012, p. 43)) as a driving force of sustainable technology adoption.

Concerning practice, we acknowledge that a great many organizations are undertaking environmental efforts (Hu et al., 2016, p. 1166; Kiron & Unruh, 2018; Lunardi et al., 2013, p. 9), but that only a few (e.g., Patagonia, Tesla Motors) are committed to fully embracing and using green technology endeavors (Brockhaus et al., 2017, p. 938). Thus, we seek to support initial but also deepening organizational Green IT/IS endeavors by providing them with a full spectrum of relevant factors for Green IT/IS adoption.

A literature review approach has proven suitable for providing an overview and structuring insights into contemporary phenomena, such as Green IT/IS (e.g., Deng & Ji, 2015; Loeser, 2013; Lunardi et al., 2013; Molla et al., 2008). We summarize models and frameworks on Green IT/IS adoption and integrate them into a cognitive adoption framework. We include perspectives of the natural environment, society, and individuals since organizations "are not the only relevant actors in the global sustainability area" (Dyllick & Muff, 2016, p. 157).

We will first present our framework of analysis before elaborating on our research method. We then present our literature review results by outlining the individual building blocks, which we then integrate into an integrative Green IT/IS adoption framework. We discuss the framework by highlighting further research implications and close by pointing out limitations as well as theoretical and practical implications

2 Analysis Framework

We will now specify our framework of analysis as a basis for our to-be-developed Green IT/IS adoption framework, which is built on three assumptions: First, we regard organizational innovation adoption as a desirable process. It is initiated by reactive or pro-active strategic decisions concerning internal or external drivers that activate and energize organizations with the potential for increased performance (Rahim & Rahman, 2013, p. 2; Subramanian & Nilakanta, 1996, p. 644). Although it may simplify the complex underlying processes, we decided to use the term *driver* to reflect proactive implications and practical links of the term. Second, we regard Green IT/IS as a desirable capability with which to establish a competitive advantage to, for instance, pursue a differentiation strategy (Henkel et al., 2017, p. 13). Third, and separating it from other innovations, Green IT/IS may be used to address ongoing global climate disruption, as one of society's severe challenges, by supporting the preservation of the natural environment (Tomlinson, 2012, p. 52). Thus, Green IT/IS needs to be set in relation to an AE, the natural environment, and society (Dyllick & Muff, 2016, pp. 161–162).

We distinguish between two complementary dimensions: i) adoption phases and ii) adoption levels. In the first dimension, we conceptualize innovation diffusion as an iterative, three-stage process (pre-adoption, adoption, and post-adoption) that bridges an initial as-is state (outset) and a future to-be state (outcome). This is based on the conceptualization of innovation adoption as a sequential process through which an AE passes from getting knowledge about an innovation, forming a positive or negative attitude towards it, to making an adoption decision that is then reinforced by consecutive behaviors (Rogers, 1983, p. 169).

This process bridges an entity's current and future state, which we further regard as two district states of, for instance, organizational resources, capabilities, and employee skills (RCS). We term the beginning or starting point the outset phase. It defines the initial RCS combination and is taken as a baseline to be compared to the outcome phase, as the projected or documented RCS state after adopting and implementing Green IT/IS.

In the second dimension, we model the natural environment, the societal level, the organizational level, and the individual level for multiple reasons. First, integrating various ecological, economic, and social dimensions has become a practice. It is, for instance, termed the triple-bottom-line principle and reflects that organizations need to adhere not only to economic goals (single bottom line) but should also emphasize social and ecological goals (Elkington & Rowlands, 1999, p. 42; Seidel et al., 2017, p. 42). This reflects the claim that IS research should change its primarily inward orientation to become more inclusive by incorporating social and environmental challenges (Brocke et al., 2012, p. 2; Watson et al., 2010, p. 34).

Second, AE Green IT/IS innovation actions may be caused by one or multiple factors, for instance, an altered organizational culture (Deng & Ji, 2015, p. 7), societal drivers (e.g., social

and cultural influences (Murugesan, 2008, p. 16)), or legislative pressures (Koo et al., 2015, p. 72). Also, governments, media, and other institutions (e.g., NGOs) may influence an AE's actions, creating both opportunities and challenges (Dyllick & Muff, 2016, p. 163).

Third, organizations are central but "not the only relevant actors in the sustainability arena" (Dyllick & Muff, 2016, p. 157). For instance, individual persons also determine organizational actions and activities. The management lays out strategic and tactical courses of action (e.g., to adopt Green IT) that are then operationalized and put into practice by staff. Thus, not only their actionable outcomes should be integrated, but also external factors (e.g., the perceived state of the natural environment) that determine these outcomes.

Fourth, and in contrast to traditional innovations, Green IT/IS adoption can have implications and outcomes for individuals, society, and especially the natural environment that first manifest in the long-term and medium-term (Henkel et al., 2017, p. 13; Simmonds & Bhattacherjee, 2015, p. 7).

3 Research Method

Our research is a literature review that has synthesized and integrated literature from IS journals and conferences. To get a comprehensive picture, we first only used only ‘Green IT’ and ‘Green IS’ as search terms for literature searches in AISeL and Business Source Premier Database in EBSCOhost. We chose these since they cover almost the entire spectrum of conference and journal publications most relevant to the academic IS community.

We then did additional searches that combined these terms with ‘adoption’, ‘innovation adoption’, ‘adoption model’, ‘adoption framework’, ‘determinants’, ‘adoption outcome’, and ‘outcome’. To cover all the studies published since the origin year of the term Green IT (Brooks et al., 2010, p. 3; Sedera et al., 2017, p. 676), we set 2007 as the only search date limit.

The initial sample contained 203 papers. Similar to other research (e.g., Sedera et al., 2017), and as an indication of the position of Green IT/IS on the Gartner Hype Cycle (Gartner, 2022), we also identified 2010 to 2014 as the years with the most publications about Green IT/IS. After eliminating duplicates and papers that, according to the abstract, did not fit our scope, the final sample contained 129 publications (98 conferences, 24 journals, and seven others). From these, we used 18 articles that concerned Green IT/IS adoption models, frameworks, determinants, and outcomes. Nine concerned organizational or individual readiness, 15 addressed environmental, societal, organizational, or individual drivers, and five addressed adoption intentions. Twelve handled adoption, use, or continued use, while nine concerned ecological, societal, organizational, or personal outcomes. Table 1 presents an overview.

Table 1. Sample and construct overview

Source \ Consnstruct	Environmental conditions	Individual preset	Organizational preset	Societal driver	Organizational driver	Individual driver	Adoption intention	Adoption	Use	Continued use	Environmental outcome	Societal outcome	Organizational outcome	Individual outcome
(Molla, 2008)		X	X	X	X	X	X	X						
(Lunardi et al., 2015)			X		X	X			X	X	X	X	X	X
(Murugesan, 2008)				X	X									
(Koo et al., 2015)				X	X	X	X	X	X	X				
(Hu et al., 2016)		X	X	X	X	X			X					
(Deng & Ji, 2015)				X	X	X		X			X		X	
(Simmonds & Bhattacherjee, 2015)					X						X	X	X	X
(Molla et al., 2008)			X	X	X									
(Bose & Luo, 2011)			X	X		X		X		X	X			
(Karanasios et al., 2010)			X	X	X			X			X	X	X	
(Molla et al., 2014)			X		X	X			X					X
(Koo & Chung, 2014)		X				X	X			X				X
(Wang et al., 2015)		X	X				X	X	X			X	X	X
(Radu, 2016)	X			X	X	X								
(Kurnia et al., 2014)				X	X	X								
(Schmidt et al., 2010)					X	X	X	X	X					
(Rahim & Rahman, 2013)					X	X		X					X	

4 A Green IT/IS Adoption Framework

As presented above, the identified Green IT/IS adoption models, and frameworks have two dimensions: adoption phase (outset, pre-adoption, adoption, post-adoption, and outcome) and level (environmental, societal, organizational, and individual). During our literature review, we realized that the initial five-phase view must be specified by a distinction between the intention to adopt Green IT/IS as part of the pre-adoption phase and Green IT/IS use and continued use as part of the post-adoption phase. We integrated the identified Green IT/IS adoption criteria and outcomes on the outlined levels into a Green IT/IS adoption framework (as illustrated in Figure 1). However, it is to be understood as an illustration of an overall cognitive process rather than a specific innovation adoption process.

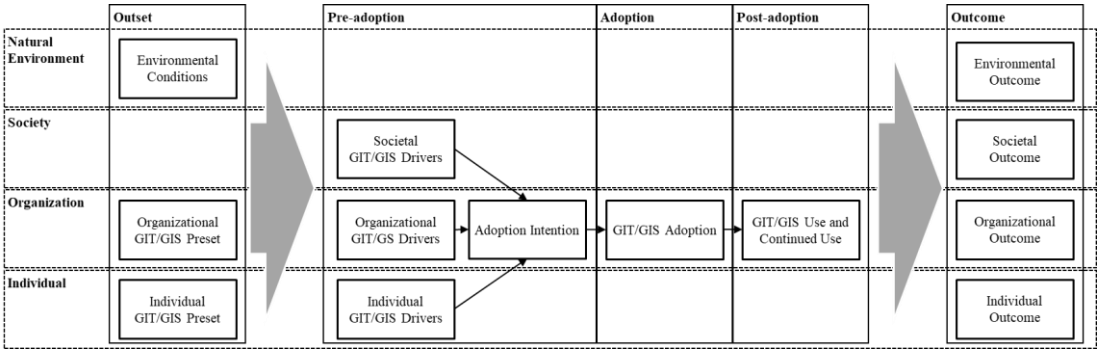

Figure 1. Integrative Green IT/IS Adoption Framework

4.1 Adoption Phase: Outset

Before turning to the core influencing factors of the explicit corporate adoption as, we must look at the context for Green IT/IS adoption. These characteristics are linked to the adoption phase (Molla, 2008, p. 663) in that way, that they preceed and determine all futher actions. We found that the outset phase reflects factors of the natural environment as well as organizational ones and those of individual readiness (see Table 2).

4.1.1 Environmental Conditions

We recognized that only selected publications in the identified literature directly address and incorporate the natural environment. This may seem accessible since they don't enact upon themselves but are acted upon and passed through other drivers. The specified paradigmatic conditions we identified stem from the changing environmental conditions (e.g., global climate disruption), as well as pollution and the diminishing of rare and valuable resources (Radu, 2016, p. 6).

Table 2. Outset phase factors

Environmental conditions - Environmental conditions
Organizational preset Technology factors - Available and installed (information) technologies Organizational factors - Hard factors (e.g., corporate citizenship, company size, policies, governance) - Soft factors (e.g., work standards, practices, normatively acceptable behavior, organizational culture, and attitude) Environmental factors - National and international regulations - Market structures and characteristics - Stakeholder pressures
Individual preset - Attitude (e.g., intrinsic motivation, mindset, experience) - Actions (e.g., manager leadership)

4.1.2 Organizational Preset

Organizational factors are closely linked to two theoretical constructs: i) the Technology-Organization-Environment (TOE) framework (Bose & Luo, 2011; Molla, 2008, p. 660) and the Green IT readiness (Karanasios et al., 2010, p. 4; Molla, 2008, pp. 664–665; Molla et al., 2008, p. 671). TOE is an organizational-level theory that considers the technological, organizational, and environmental contexts to be essential for an organization's innovation adoption decision (Baker, 2012). In this theory, technical context refers to the already available technology, IT, and their characteristics in the company (Bose & Luo, 2011, p. 45; Molla, 2008, p. 663). We regard it as a critical determinant of organizational Green IT/IS adoption since Green IT/IS will primarily be adopted in organizations that have significant IT assets or are undertaking green technology initiatives (Molla, 2008, p. 663) since these technologies provide an ideal basis and platform for initial or further Green IT/IS initiatives. The organizational context describes various hard factors, such as structural aspects of branch, corporate citizenship, and company size, or other formalized structures that may enable internal innovation processes, such as communication structures (Bose & Luo, 2011, pp. 47–48; Molla, 2008, pp. 663–664). They also describe soft factors such as work standards, normatively acceptable behaviors, and organizational culture. Especially soft factors make a substantial difference in which of the four Green IT/IS adoption approaches (e.g., green-washing or the deep green approach) an organization intends to pursue (Molla et al., 2014, p. 135). Environmental context is the third pillar of the TOE framework and contains external influences, such as legislative and governmental regulations, as well as market structures and characteristics (Bose & Luo, 2011, pp. 48–49; Molla, 2008, p. 664).

Green IT readiness captures internal factors of perceived i) organizational readiness, ii) institutional readiness, and external factors of iii) value network readiness. Organizational and institutional readiness describes five factors: attitude, policy, practice, technology, and

governance (Molla et al., 2008, p. 672) as well as the ability (Karanasios et al., 2010, pp. 4–5), as a unique combination of adoption determinants. Further, the value network captures the readiness of a company's external stakeholders (e.g., suppliers or customers). If determinants along the internal dimensions are perceived to be excessive, or if stakeholders regard Green IT/IS adoption negatively, these initiatives are unlikely to be initiated at all (Molla, 2008, p. 659). Since TOE is well accepted and theoretically founded, we take it as a basis for merging its components with Green IT readiness.

4.1.3 Individual Preset

At the individual level, we identified personal attitudes and actions (e.g., intrinsic motivation, green mindset, managers' leadership, and past experience (Koo & Chung, 2014, p. 151; Wang et al., 2015, pp. 678–679)). Concerning the first two factors, users and managers engage more in Green IT/IS adoption if their green ambitions derive from pleasure and self-determination to the cause. Concerning the last two factors, leaders not only serve as role models to other employees but their actions and initiatives also influence further actions.

4.2 Adaption Phase: Pre-Adoption

We found that both internal and external drivers influence organizational Green IT/IS adoption. While recognizing that the literature contains many specific categorizations of these drivers (e.g., cost reduction; demands from legal and regulatory requirements; sociocultural and political pressures; enlightened self-interest; a collaborative business ecosystem; new market opportunities (Murugesan, 2008, p. 31)), we decided to categorize these drivers into three abstract categories: regulatory, economic, and ethical drivers (Molla, 2008, p. 662). We understand regulatory drivers as actions initiated to meet voluntary or mandatory demands. Economic drivers refer to actions with efficiency improvement or cost reduction intentions, while ethical drivers refer to sustainable and normatively good behaviors that seek social, global, and local recognition. Depending on the perspective, these may be internal, external, or both to an organization.

4.2.1 Societal Drivers

Regulatory, societal drivers initiated by national, international, and professional institutions can start, set up, and enforce coercive Green IT/IS pressures. These may deal with energy efficiency, waste and recycling policies, or other environmental protection principles (Deng & Ji, 2015, p. 4; Karanasios et al., 2010, p. 3; Molla et al., 2008, p. 672).

We identified economic societal drivers as primary tax or fine-driven influences since governments raise fees or compensation for environmental pollution or environmentally related incidents and accidents (Hu et al., 2016, p. 1169).

Table 3. Drivers of adoption intentions

Societal drivers Regulatory, societal drivers • National and international legislative, regulatory, and compliance requirements • Public or social demand for adherence to green practices Economic, societal drivers • Financial incentives (e.g., avoid liability risks) Ethical, societal drivers • Responsible business practices and corporate citizenship • Normative pressures and cultural expectations
Organizational drivers External organizational, regulatory drivers • Social, cultural, and political regulations • Professional network, customer, and vendor requirements • Equity holder norms and competitors Internal organizational, regulatory drivers • Corporate citizenship; strategy practices and processes • IT, Green IT, and Green IS governance and policies • Knowledge and technological capabilities • Internal stakeholder regulations (e.g., top management) External organizational, economic drivers • National and international pro-environmental grants • Industry, competitor, and vendor pressures • Equity holder pressures and customer expectations • Internal organizational, economic drivers • Green strategy (e.g., use of renewable energies) • Efficiency incentives (e.g., hardware consolidation, virtualization, complexity reduction) • Investment incentives (e.g., reduce lifecycle cost) • Investment concerns (e.g., budget or capacity concerns) External organizational ethical drivers • Global and local community incentives • NGO incentives Internal organizational ethical drivers • Corporate culture (e.g., shared vision) • Business ethics (e.g., responsible business practices) • Managerial attitudes (e.g., towards green practices)
Individual drivers Individual regulatory drivers • International and national policies • Management policies and leadership Individual economic drivers • Intrinsic motivation (e.g., improve sustainability) • Extrinsic motivation (e.g., financial incentives or fines) • Attitudes and perceptions (e.g., perceived benefits) Individual ethical drivers • Attitude (e.g., identification with green practices) • Actions and skills (e.g., top-down or bottom-up influence)

Ethical, societal drivers are usually initiated by environmental NGOs (e.g., Greenpeace) or institutions that seek to influence businesses and whose actions generally receive much attention. Organizations, for instance, may shift towards more sustainable activities if other companies, customers, or equity holders respond positively to these drivers (Hu et al., 2016, p. 1169; Karanasios et al., 2010, pp. 3–4).

4.2.2 Organizational Drivers

Green IT/IS adoption owing to coercive pressures, such as external organizational, regulatory drivers, may arise from external stakeholders (e.g., investors, customers) who influence the organization's public image or can result in legal consequences concerning disobeying government laws (Karanasios et al., 2010, p. 3; Kurnia et al., 2014, p. 5; Molla, 2008, p. 664; Radu, 2016, p. 6). Excellent reception of environmental actions by members of the own or a competing organization may lead an organization to take up or increase its Green IT/IS adoption initiatives (Deng & Ji, 2015, p. 8). Such initiatives can also be driven by the industry since it can be in an organization's interest to establish and meet specific industrywide legal or de facto standards, to reduce corporate, financial, or customer risks (Hu et al., 2016, p. 1170).

Normative pressures associated with internal organizational, regulatory drivers are also linked to the TOE framework. Institutionalized as actions that professionalize, standardize, or refocus an organization's environmental performance or control, they target internal and external stakeholder requirements (Deng & Ji, 2015, pp. 5–7; Lunardi et al., 2015, pp. 4–6; Radu, 2016, p. 8; Schmidt et al., 2010, p. 9). Some of these factors, for instance, top management or strategic influences, may also inhibit or prevent Green IT/IS adoption.

External organizational, economic drivers are primarily initiated by external stakeholders (e.g., investors or customers) since non-adherence to meeting demands may lead to significant financial losses (Kurnia et al., 2014, p. 9; Radu, 2016, p. 10). They may be driven by an organization's intention to mimic its competitors, promote its business model, reduce uncertainty for customers, or limit exposure to similar external pressures (Hu et al., 2016, p. 1159). It may create an (initial) technical superiority, which can then lead to a relative advantage (Deng & Ji, 2015, p. 8; Karanasios et al., 2010, p. 5; Radu, 2016, p. 8).

Often, internal organizational, economic drivers stem from the desire to reduce costs (e.g., power, cooling, or real estate), to increase IT efficiency, or to use IT to reduce costs (e.g., fleet management, dynamic vehicle routing (Molla, 2008, p. 658; Radu, 2016, pp. 10–11; Simmonds & Bhattacherjee, 2015, p. 7)). However, they may also be characteristic of an organization or its IT strategy (Rahim & Rahman, 2013, p. 2). We identified that technical compatibility determines initial and further Green IT/IS adoption since significant technological or organizational changes may lead to staff resistance and, thus, unprofitable investments (Deng & Ji, 2015, p. 6).

We found that external organizational ethical drivers can be caused by NGOs that consider the natural environment as normatively worth protecting (Karanasios et al., 2010, p. 4) and thus seek to initiate organizational behaviors towards environmentally friendly practices (Hu et al., 2016, p. 1170).

Internal organizational ethical drivers urge organizations to link their "business to socially accepted norms of going green such as reducing emission, recycling, reuse and electronic waste management" (Molla, 2008, p. 663). They may institutionalize a supportive (e.g., sustainability-driven) or an opposing corporate culture (e.g., purely profit-driven (Karanasios et al., 2010, p. 5; Radu, 2016, pp. 10–11)).

4.2.3 Individual Drivers

Individual regulatory drivers can be understood as initiatives started by internal stakeholders (e.g., top-management) that have the regulatory force to alter an organization (Deng & Ji, 2015, p. 7; Hu et al., 2016, p. 1170; Kurnia et al., 2014, p. 5). They set formal or informal norms, practices, and standards for behaviors that can drive an organization towards green readiness or improvement (Bose & Luo, 2011, pp. 47–49; Molla et al., 2014, p. 149).

Individual economic drivers may originate from corporate managers and their promotive or depressive motivation for green technologies' benefits. Although efficiency incentives are often only beneficial in the short term, they may also lead to Green IT/IS capabilities and improved long-term competitiveness (Kurnia et al., 2014, p. 5; Rahim & Rahman, 2013, p. 4; Schmidt et al., 2010, p. 9). Individual stakeholders (e.g., employees, investors) may also be motivated by their economic incentives (e.g., financial bonuses or fines) or may transfer personal experiences to their employing organization to translate individual benefits into corporate ones (Hu et al., 2016, p. 1161; Koo & Chung, 2014, p. 151).

Individual ethical drivers stem from stakeholders (e.g., consumers, employees, managers) with an environmental mindset, sentiments, values, and norms (Deng & Ji, 2015, p. 10; Molla et al., 2014, pp. 133–134)). These external and internal stakeholders may influence employees, who may then stimulate sustainability values within an organization (Deng & Ji, 2015, p. 7) to initiate or extend its Green IT/IS endeavors (Lunardi et al., 2015, pp. 4–5) to improve its image (Kurnia et al., 2014, p. 10). However, opposing individual attitudes on, for instance, green technologies' usefulness may have a negative influence.

4.2.4 Adoption Intentions

We identified only a few sample studies that stress the gap between awareness of the environment and environmental actions. Of these, one makes an argumentation distinction (Molla, 2008). Another finds empirical evidence for differences between organizations that have i) not yet planned or implemented, ii) planned, iii) implemented, or iv) implemented and further plan to implement Green IT (Schmidt et al., 2010, p. 8). A third study highlights the difference and stresses that intention to adopt Green IT/IS – not adoption – is influenced by technological attributes, the organization, and environmental factors (Wang et al., 2015, p. 679).

At the *individual level*, attitude to Green IT/IS adoption may be positively or negatively influenced by external regulations (Koo & Chung, 2014, pp. 142–143).

4.3 Adoption Phase: Adoption

Compared to the intention to adopt Green IT/IS, Green IT/IS adoption deals with de facto implementation. Some, like Molla (2008) or Schmidt et al. (2010), view this stage as the outcome of a Green IT/IS adoption or the start of a Green IT/IS maturation process (Bose & Luo, 2011, p. 45). Others link it to resource adoption and capability, and skill building, stressing it as a vehicle toward a competitive advantage (e.g., Deng & Ji, 2015, p. 8; Rahim & Rahman, 2013, p. 4). Further, some, like Wang et al. (2015, p. 676), take a more diverse approach regarding Green IT/IS adoption and implementation as a process with individual, organizational, and social outcomes. We follow this view and add environmental outcomes.

4.4 Adoption Phase: Post-adoption

We realized a necessity to distinguish between the adoption, use, and continued use of Green IT/IS. Adopting a specific technology is not enough, but they need to be applied since it is "not technologies per se, nor how they may be used in general that matter, but the specific technologies in practice" (Lunardi et al., 2015, p. 4). Also, ensuring that Green IT/IS is not initially but continuously used provides positive long-term outcomes. We came to realize that the terminology of use and continued use of Green IT/IS varies between the sample authors, like "pro-environmental IT practices" (Molla et al., 2014, p. 129), "green IT practices" (Hu et al., 2016, p. 1150), "Green IT in practice" (Lunardi et al., 2015, p. 4), or "Green IT Maturation" (Bose & Luo, 2011, p. 46). However, most refer to a Green IT adoption understanding of incorporating "ecological principles and energy-efficient operations into its technology life cycle" (Hu et al., 2016, p. 1150) in terms of design, production, purchase, utilization, and disposal.

Furthermore, only a few sample studies have included additional Green IS aspects of extensive success management (Schmidt et al., 2010, p. 7) or individual moral and social beliefs (Koo et al., 2015, p. 76). Some researchers theorize that after initial Green IT/IS adoption, organizations will adopt additional measures to further reduce their environmental impacts, which may exceed Green IT/IS initiatives (e.g., by planting trees (Bose & Luo, 2011, p. 45)). Thus, we emphasize that use and continued use of Green IT/IS in organizations (i.e., usage duration, frequency, and intensity (Koo et al., 2015, p. 71)), but also demonstrate the Green IT/IS benefits (e.g., cost savings through improved material utilization (Lunardi et al., 2015, p. 5)), may cause a continuous use of Green IT/IS (Koo & Chung, 2014, p. 144).

Table 4. Green IT/IS adoption outcomes

Environmental outcomes Environmentally friendly activities and behaviors - Minimize waste, greenhouse gas, hazardous /toxic material emissions - Reduce energy and natural resource consumption - Fewer environmentally related accidents
Societal outcomes Address global social imperatives - Less resource consumption; reduce costs Address local social imperatives - Less road traffic; fewer road accidents; Address individual social imperatives - Increased employee safety Governmental impacts - Fewer regulatory taxes
Organizational outcomes Reduced costs - Decrease operational costs, avoid regulatory taxes - Optimize energy efficiency - Increase the sustainability of activities Reduced resource consumption - Digitalization of processes - Increase the efficiency of activities via IS New business opportunities - Novel environmentally friendly products and services - Proactive corporate strategy - Enabled IT innovation capabilities Increased safety - Reduced likelihood of environmental accidents
Individual outcomes Altered individual behaviors - Increased Green IT/IS use (e.g., video-conferencing software) - Manifest the positive effects of Green IT Altered individual capabilities - Build Green IS capabilities (e.g., green expertise) Altered individual attitudes - Employee psyche and satisfaction (e.g., pleasure from environmentally friendly behaviors)

4.5 Adoption phase: Outcome

Green IT/IS adoption outcomes differ from those of other technologies. Besides organizational-level and individual-level outcomes, they incorporate societal and environmental consequences (Simmonds & Bhattacherjee, 2015, p. 7; Wang et al., 2015, p. 676) (see Table 4).

4.5.1 Environmental Outcomes

We understand these as “benefits to the natural environment” (Simmonds & Bhattacherjee, 2015, p. 4). Green IT primarily affects the environment at the end of the pipe by reducing the impacts along a product’s lifecycle that do not necessarily alter production processes (Molla et al., 2014, p. 133). Environmental Green IS also focus on capability building, modifying (e.g., updating), optimizing (e.g., function enrichment), consolidating (e.g., server shutdown), or increased use (e.g., video-conferencing) of tangible and intangible IS (Simmonds & Bhattacherjee, 2015, p. 11). Producing environmentally friendly (IT) products as a Green IS outcome in the long term also affects the natural environment (Lunardi et al., 2015, p. 9).

Organizations may exceed green technological endeavors, for instance, by planting trees for further neutralization of emissions.

4.5.2 Societal Outcomes

Society can benefit from Green IT/IS adoption from the production and use of environmentally sound products that meet predefined environmental regulations (Lunardi et al., 2015, p. 2). Also, IS usage can have societal crosslinked impacts since automatic optimization of delivery routes can reduce traffic jams, road accidents, and vehicles' fuel consumption (Simmonds & Bhattacherjee, 2015, p. 4), yet reduce the amount of taxes and environmental fees (Lunardi et al., 2015, p. 5).

4.5.3 Organizational Outcomes

At the organizational level, Green IT/IS adoption outcomes are primarily measured concerning their ability to create a (sustainable) competitive advantage. We found that Green IT and Green IS may also be differentiated by their outcomes. Green ITs primarily focus on technology. Thus, Green IT in practice (as sustainable and efficient computer resource uses) can, for instance, reduce costs and emissions and can minimize risks by avoiding penalties. Thus, Green IT can create an initial and limited competitive advantage (Lunardi et al., 2015, p. 1). Since Green IS also incorporates sustainable management activities and capability building (Loeser, 2013, p. 8), they focus on long-term ecological behaviors and may thus create sustainable economic activities (Deng & Ji, 2015, p. 8).

4.5.4 Individual Outcomes

The individual level may be the most crucial level for both Green IT/IS adoption and use and for its continued use since the decision to (not) adopt and use Green IT/IS is made by top management and the user level (Deng & Ji, 2015, p. 7; Lunardi et al., 2015, p. 4). It may, for instance, be evaluated concerning its criteria of technological complexity, ease-of-use, relative advantage (Deng & Ji, 2015, p. 8), and learning, understanding, and incorporating Green IT/IS advantages for individual strategic value (Simmonds & Bhattacherjee, 2015, p. 5).

5 Discussion and Research Implications

The result of our literature review is an integrative framework that links individual, organizational, societal, and environmental Green IT/IS adoption drivers and outcomes. It integrates multiple studies that highlight selected perspectives on Green IT and Green IS that, for instance, either selectively present Green IT adoption factors (e.g., Kurnia et al., 2014, p. 5; Radu, 2016, p. 5), practices (Molla et al., 2014, p. 133), or a high-level overview of the Green IT adoption process (e.g., Molla, 2008, fig. 1).

Our framework proposes an initial configuration of environmental conditions and an organizational and individual preset. These factors determine societal, organizational, and individual factors that initiate an organization's intention to adopt, use, and continuously use Green IT/IS, which further leads to environmental, societal, organizational, and individual outcomes.

Based on these findings, we want to discuss some apparent perspectives and their implications for further research: First, our framework documents environmental conditions, as well as organizational and individual factors, as outset factors of Green IT/IS adoption. Nonetheless, we theorize that certain societal conditions also influence Green IT/IS adoption. These may, for instance, be relatively stable cultural paradigms that manifest in a variety of cultural concerns and actions (e.g., environmentalism) but also fundamental economic and political assumptions (e.g., capitalism). Researching the interactions of these stable societal determinants with Green IT/IS may prove valuable for the further development of Green IT/IS adoption mechanisms, but also on how they may determine societal structures.

Second, our investigation revealed that incorporating the societal and environmental levels distinguish Green IT/IS innovations from traditional innovations. Accessibly, since Green IT has been around for only a decade (Sedera et al., 2017, p. 676), considerably more emphasis has been put on researching it at the organizational and individual levels. We propose that uncovering societal and environmental impacts may be fruitful in establishing novel categories for evaluating technologies and broadening the perspective. Technological effects on these dimensions take longer to manifest and are, therefore, also harder to measure. However, in our view, these efforts are beneficial for long-term outcomes of Green IT/IS use since these may underline Green IT and Green IS superiority over traditional IT and IS.

Third, we see that there are not only interactions but strong, interdependent ties between outcomes on the four levels. Digitalization of processes (organizational outcome), for instance, translates to altered employee work procedures (individual outcome). Building Green IS capabilities and behaviors (individual outcome) may also lower costs since more sustainable resources, and less energy consumption (organizational outcome) translate into the generation of fewer taxes on resources and energy bills (societal outcome). These interactions should be

further addressed since they may enable policymakers to enforce policies that trigger the desired environmentally friendly results and assess these policies' long-term implications.

This study has limitations. First, not all models and frameworks we used were empirically tested. While some have been tested in case of studies (e.g., Karanasios et al., 2010; Kurnia et al., 2014; Simmonds & Bhattacherjee, 2015) or surveys (e.g., Hu et al., 2016; Lunardi et al., 2015), some are only conceptual (e.g., Molla, 2008; Molla et al., 2008; Rahim & Rahman, 2013). Thus, the presented framework should be understood as a high-level overview that describes the overall context of Green IT/IS adoption between these two streams: the need for digital transformation and sustainable business. Further research may address this shortcoming by empirically validating our work while addressing the general lack of empirical work on sustainability and Green IT/IS (Hu et al., 2016, p. 1171; Rahim & Rahman, 2013, p. 2). Also, although we identified a multitude of both positive and negative factors, our work is not extensive, a constraint that further qualitative research may address.

Nonetheless, our work is beneficial for practice. Practitioners may take this work as a prompt to initialize first or advance Green IT/IS endeavors in their organizations. As a starting point, an organization may choose to document employee attitudes and ideas (of the individual preset factors) to mobilize the employee base and initialize a transformation from within. It may decide to take the identified outcome factors to add to the elements a company reports on to address its sustainability reputation. It may, for instance, choose to also report on the extent of reduced greenhouse gas emissions owing to the increased use of video-conferencing instead of employees taking business trips) or increased employee satisfaction (e.g., owing to home office work instead of commuting to work).

6 Conclusion

Organizations and society, in general, now face substantial challenges. On the one hand, digitalization requires businesses to further incorporate IT/IS assets to digitally transform their structures and processes. On the other hand, society – as customers, competitors, and vendors – is forced to behave increasingly in environmentally friendly ways to address the challenges of global climate disruption (Tomlinson, 2012, p. 43). As assets that "minimize the negative environmental impacts of IS, business operations, and IS-enabled products and services" (Loeser, 2013, p. 6), Green IT/IS can help us to simultaneously pursue both goals.

We addressed the call for a framework to structure Green IT/IS research (Lunardi et al., 2013, p. 10; Tushi et al., 2014, p. 678), providing an overview that is detached from an organization's specific strategy and processes (Henkel et al., 2017, p. 7), and the shortcoming of present Green IT/IS research, which has focused on the organizational and the individual levels, by incorporating societal and environmental perspectives (Lunardi et al., 2013, p. 10).

Based on the developed framework, we propose avenues for further research. In our view, especially the missing societal conditions of the outset phase, as well as the implications of the societal and environmental determinants and outcomes, should be addressed.

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II

WHY PEOPLE AND PROCESSES ENABLE SUSTAINABILITY AND NOT THE LATEST TECHNOLOGY: ON ACHIEVING GREEN IT/IS CAPABILITY MATURITY

Abstract

Green information technologies (Green ITs) and green information systems (Green IS) are innovation types that organizations adopt to digitally and sustainably transform themselves. Since it is not the innovation adoption itself that leads to the desired outcomes, organizations need to build the necessary Green IT/IS capabilities. To do so, they may adhere to the IT-Capability Maturity Framework, which incorporates an explicit Green IT capability. We improve this framework and provide a better understanding of the Green IT/IS concept as well as of how to achieve Green IT/IS maturity. We map and integrate the Green IT capability to well-known understandings of Green IT/IS and find that, despite the technology-related label, most Green IT capability building blocks relate to socio-technological and management processes. Thus, organizations need not first invest in new Green IT before building Green IT/IS capabilities; altering processes and sensitizing employees may be equally effective.

Keywords: *Green IT, Green IS, Capabilities, Capability Maturity, Maturity Framework*

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1 Introduction

In the current era of digital transformation, information technologies (ITs) and information systems (ISs) are regarded as essential organizational resources (Carr, 2004, p. 5; Molla et al., 2009, p. 10). They generally improve the overall business performance (Weill, 2004, p. 3) and are typically seen in a very positive way (Belkhir & Elmeligi, 2018, p. 448).

IT and IS usage nevertheless also comes with certain significant downsides. Their increased construction and use, for instance, leads to higher consumption of electrical energy (Murugesan, 2008, p. 26) as well as higher CO_2 (Karanasios et al., 2010, p. 1). As environmental awareness is constantly increasing (Gürlek and Tuna 2018), organizations need to also become more environmentally friendly and reduce their overall negative ecological impacts (Molla et al., 2009, p. 11). To simultaneously address both challenges, organizations may decide to use ecologically sustainable IT and IS (Deng & Ji, 2015, p. 2) and to build sustainability capabilities that foster ecological awareness and actions (Olson, 2008, p. 27).

The term sustainability is often ambiguously used. In this work, we almost exclusively refer to sustainability in its ecological connotation with its three goals of i) reducing the ecological impacts of a product throughout its lifecycle (eco-efficiency), ii) establishing a fair distribution of resources between current and future generations (eco-equity), and to iii) not making products and services less ecologically harmful, but to create them new from scratch (eco-effectiveness) (Watson et al., 2010, p. 28).

One set of technologies that reflects this view is Green ITs (Arnfalk et al., 2016, p. 3). Some view IT as a central part of the ecological issue that needs to be addressed, mitigated, and designed in a way that it does less harm to the environment (Belkhir & Elmeligi, 2018, p. 449). As this primarily addresses only the eco-efficiency aspect – and it is not the adoption of technologies per se that leads to organizational benefits (Lunardi et al., 2015, p. 4) – Green ITs need to be successfully adopted, assimilated (Molla & Cooper, 2014, p. 11), and effectively managed (Helfat & Peteraf, 2003, p. 998). Some, for instance, state that while it is IT that causes approximately 2% – 4% of the global CO_2 emissions (Belkhir & Elmeligi, 2018, p. 449), it is IS that can be used to address the remaining share. This view is essential to the Green IS concept (Brooks et al., 2010, p. 2), which – from an inter and intra-organizational perspective – describes an organization's ability to use IT, redesign its IS, and restructure its business process in more eco-sustainable ways (Loeser, 2013, p. 6); thus also including eco-equity and eco-effectiveness.

Sustainability transformations hence are strongly tied to developing the required sustainability capabilities (Cooper & Molla, 2012, p. 3); not just within the IT department but across the entire organization (Cooper & Molla, 2012, p. 675; Loeser, 2013, p. 6). Various frameworks and models address how this can be done. We chose to rely on the practitioner-originated IT-

Capability Maturity Framework (IT-CMF) (Curley et al., 2016) for three core reasons: First, it is – potentially due to its practitioner-orientation – one of the most frequently used frameworks (Grant, 2010), that, second, also incorporates a Green IT capability and thus extends other well-known frameworks, like the Capability Maturity Model (Nishant et al., 2020, p. 5504). Third, it addresses not only adoption and assimilation but the advancement of Green IT/IS technologies and capabilities and thus also exceeds specific sustainability frameworks, like the G-readiness framework (Molla et al., 2009).

Within this discussion, we see an underlying problem (Alvesson, 2011, p. 247): While the research community increasingly tends to differentiate between the technology-centric Green IT and the process and capability-centric Green IS concept (Loeser, 2013, p. 6), this does not seem to be the case for practice (Curley et al., 2016, p. 104). We thus aim to support theory building in Green IT/IS research (Wang et al., 2015, p. 671): We first seek to specify terminology and add to the required conceptual clarity in Green IT/IS. It may be beneficial for education on Green IT/IS (Harnischmacher et al., 2020, p. 13), where precise terminology is essential to avoid unspecific and misleading communication (Suddaby, 2010, p. 347). This clarity may also be beneficial for current organizational practices. The IT-CMF, for instance, uses the term Green IT capability (Curley et al., 2016, p. 103). It links a technological connotation (Green IT) with the capability concept (Helfat & Peteraf, 2003, p. 999) and hence – at least terminologically – may be understood as that it is only technological advancement that increases an organization's sustainability. This conclusion strongly contradicts the multi-dimensionality of Green IT and Green IS (Molla et al., 2008, pp. 664–665), but also current findings (e.g., Nishant et al., 2020, p. 5508), which underline that organizational sustainability is not primarily achieved through technological maturity (Lunardi et al., 2015, p. 4).

Second, we seek answer calls (Loeser et al., 2017, p. 535) to advance theoretical understanding of how to adopt and assimilate Green IT/IS in organizations (Deng & Ji, 2015, p. 10; Molla & Cooper, 2014, p. 11). We seek to show how this technological evolution overlaps with building and advancing necessary Green IT/IS capabilities (Lei & Ngai, 2013, p. 6; Loeser, 2013, p. 9). Third, we seek to create a better understanding for practitioners of how to use Green IT/IS as tools to achieve and monitor sustainability goals (Arnfalk et al., 2016, p. 4; Molla et al., 2008, pp. 661–662) and thus consequently also help to address the global climate disruption (Malhotra et al. 2013). We thus ask:

RQ: *How can Green IT/IS capabilities be integrated into specific Green IT and Green IS technology dimensions?*

To answer this question, we analyze the IT-CMF's Green IT capability (Curley et al., 2016, p. 104), unpack its individual maturity levels, and map and integrate its building blocks to the specific definitions of Green IT and Green IS (Loeser, 2013, p. 6). We aim to provide insights

that are useful in i) capturing the to-be-developed capabilities of an organization (Curry et al., 2012, p. 72) through ii) advancing the Green IT/IS definition-related discussion (e.g., Dedrick, 2010, p. 180; Loeser, 2013, p. 8), and also iii) providing further advancements in building and explaining Green IT/IS theory (Molla & Cooper, 2014, p. 11). We capture our findings in propositions that, for one, can be used by practitioners to advance their current practices and, for another, can be tested by fellow researchers to advance Green IT/IS theorization.

This paper is structured as follows: After providing the conceptual foundation – distinguishing between Green IT and Green IS, introducing the capabilities concept, capability, and the IT-CMF – we outline our literature work as our method. We then map and integrate the identified Green IT capability building blocks into separate Green IT and Green IS elements. We then present our results, followed by a discussion, an outline of theoretical and practical implications, and a conclusion.

2 Conceptual Foundation

2.1 Green IT and Green IS

The manufacturing and use of IT hardware are accompanied by the increased use of limited physical resources (Murugesan, 2008, p. 25), pollution of a substantial amount of greenhouse gasses (Haughton, 2021, sec. 3), and the subsequent generation of physical waste (Deng & Ji, 2015, p. 2). Thus, both researchers and practitioners are seeking ways to reduce and limit the environmental impacts of increased IT manufacturing and use. Green IT – as a picturing connotation of making IT more sustainable and ecologically friendly – was a conceptual result. It describes "measures and initiatives which decrease the negative environmental impact of manufacturing, operations, and disposal of Information Technology (IT) equipment and infrastructure" (Loeser, 2013, p. 6). It is frequently regarded as a hardware-focused concept (Murugesan, 2008, pp. 25–26), which is often criticized (e.g., Watson et al., 2010, p. 24), as people (i.e., users, employees), processes, software, and other organizational assets must also be considered (Boudreau et al., 2008). This criticism seems to be a significant factor in why the current discussion seems to shift focus from focusing initially solely on Green IT to primarily concentrating on Green IS (Loeser, 2013, p. 13); a further motivating argument for our investigation. Green IS a concept and practice that "determines the investment in, deployment, use, and management of information system (IS) to minimize the negative environmental impacts of IS, business operations and IS enabled products and services" (Loeser, 2013, p. 6) can be regarded as a Green IT-encompassing, and enriching concept (Erek et al., 2012, p. 3) (see Figure 1).

Green IT and Green IS can generally be regarded as i) separate, ii) overlapping, or iii) integrative. Concerning the first view, Brooks et al. (2010, p. 3) suggest to clearly distinguish between Green IT and Green IS, with Green IT being part of the problem, while Green IS is part of the solution (Dedrick, 2010, p. 174). The second overlapping perspective draws no boundaries between Green IT and Green IS. It assumes that the two concepts are similar, resulting in their being used interchangeably (Tushi et al., 2014, p. 2). The third integrative perspective conceptualizes Green IT as a fundamental component of Green IS (Watson et al., 2010, p. 24). It is based on a similar view that IS also conceptually incorporates IT (Erek et al., 2012, p. 3). We subscribe to the third view. To regard Green IT as a subset of Green IS (Loeser, 2013, p. 6), for one, the required encompasses terminological clarity (Suddaby, 2010, p. 347) but also reflects an influential and central aspect of the mainstream Green IT/IS discussion (Harnischmacher et al., 2020, pp. 2–3) as it is "not technologies per se, nor how they may be used in general that matter, but the specific technologies in practice" (Lunardi et al., 2015, p. 4).

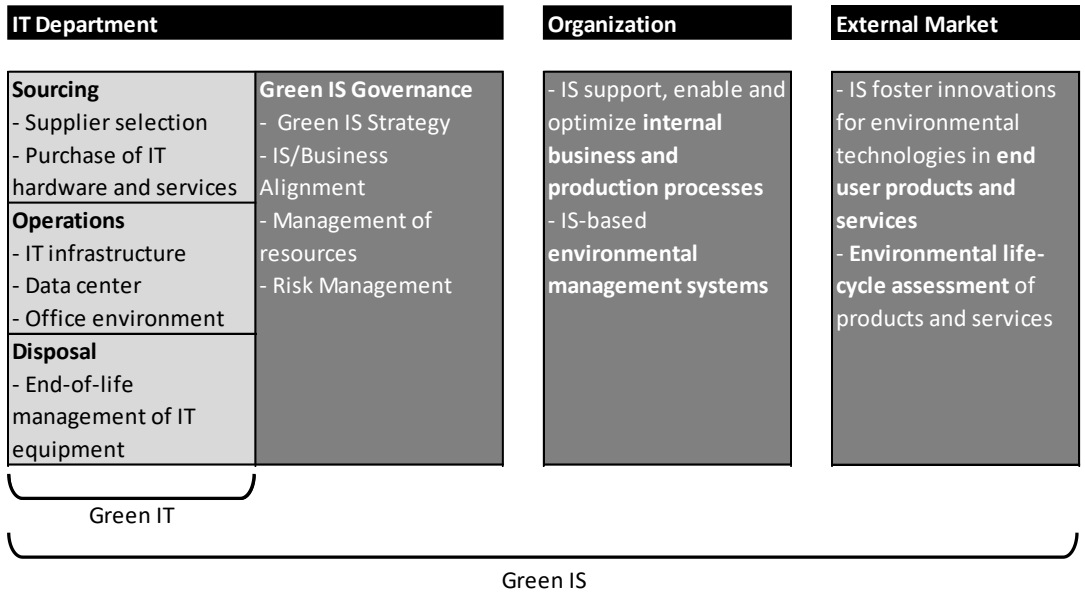

Figure 1. Green IT/IS scope (reduced version from Loeser (2013))

2.2 Resources and Capabilities as Innovations

Green IT/IS – like anything new to an organization (Hameed et al., 2012, p. 358) – can be considered as material and immaterial innovations. According to the resource-based view (RBV) (Wade & Hulland, 2004; Wernerfelt, 1984), organizations can use both material resources (e.g., employees, computer assets) and immaterial capabilities (e.g., knowledge, experience) to build and maintain a competitive advantage over their competitors (Eisenhardt & Martin, 2000, p. 1110). This view was also transferred to the organizational sustainability context, called the Natural-Resource-Based View of a Firm (NRBV) (Hart & Dowell, 2011, pp. 1465–1466). It states that organizations acquire, use, and develop resources and/or capabilities which add factors to their products and services that focus on the natural environment (e.g., through sustainable development of products or extended product stewardship). Bearing this in mind, it becomes clear why developing capabilities that aim to increase an organization's sustainability is crucial for an organization (Curry et al., 2012, p. 72).

2.3 Capability Maturity Management and the IT-CMF

There are specific models, frameworks, and theories that seek not only to explain conceptually how this can be done but also to provide guidance to managers. All of them share the premise that capabilities – similar to technologies (e.g., Nishant et al., 2020, pp. 5505–5506) – must be further developed and matured and that "organizations pass through a number of identifiable growth phases […] [which] identify the organization's level of [capability] maturity" (Bose & Luo, 2011, p. 43). These levels can then be distinctively separated and enable the categorization of organizations relative to their identified maturity, as well as also to identify critical options for their further individual development (Bose & Luo, 2011, p. 50).

Certain types of models can be used for our research endeavor. We could first opt for a framework that directly assesses a capability relevant to building sustainability relevant capabilities, like the Green IT Adoption Model (GITAM) (Molla, 2008) and the G-readiness model (Molla et al., 2008). Their specific nature, however, limits them in their usability for our endeavor. Both models, for instance, only focus on organizational aspects and thus exclude particular factors on the level of the individual (i.e., users) that will need to alter their behaviors and put Green IT/IS into practice.

Table 1. IT-CMF maturity levels of Green IT capability

Level	Relevance of environmental sustainability	IT-related environmental actions
1	No or little awareness of issues	Ad hoc
2	Emerging awareness of issues	Partial application
3	Sustainability impact criteria are agreed upon between business units	Design and operation of IT activities across the IT function respect environmental sustainability guidelines
4	Principles and impact criteria are adopted across the organization	The IT function is a key technological enabler of the organization's sustainability goals
5	Environmental sustainability is considered a key success factor	The IT function is a key technological enabler of the ecosystem's sustainability goals

We could also opt for a relatively general type of model, like the Capability Maturity Model (CMM) (Paulk et al., 1993). It has been used and adapted to assess and progress the maturity of various capabilities and thus is one of the most frequently used and cited maturity models in IS (Poeppelbuß et al., 2011, p. 505), but shows no direct linkage to sustainability or sustainability innovations.

We thus chose to rely on a model that connects both the specificness of the sustainability frameworks, as well as the holistic ness of a general framework, and thus chose the IT-Capability Maturity Framework. The framework was directly inspired by the CMM and identified a large number of capabilities of overall IT functions. It emerged from practitioners' need for a holistic framework that supports IT decision-makers (e.g., CIOs) in evaluating, enhancing, and assessing the value gained from all organizational capabilities (Curley, 2007, p. 63) and has successfully been used in a great many organizations (Agerbak & Deutscher, 2010, para. 5; Grant, 2010, para. 4). It is – to our best knowledge – the only IT capability maturity framework that also incorporates a Green IT capability (Curley et al., 2016, p. 103). It thus seemed ideal for our project for three reasons:

First, the IT-CMF contains a Green IT capability, which it defines as "the ability to minimize the environmental impact of IT, and to make the best use of technology to minimize environmental impact across the organization" (Curley et al., 2016, p. 104). Thus, the IT-CMF seems to regard this capability – per definition – as purely tech-centric. We challenge this view since

it remains unclear or at least questionable whether the term Green IT was only chosen as a media-friendly label (Erek et al., 2012, p. 3) or whether it genuinely addresses Green IT – and not also Green IS – capabilities. We thus see a chance to create conceptual clarity and improve both the IT-CMF and our Green IT/IS understanding.

Second, the IT-CMF is a practice-oriented framework. It was developed by the Innovation Value Institute (IVI) and is based on design science and an open innovation approach (Vaziri et al., 2015). It considers a broad spectrum of an organization's capabilities as well as its creation, management, and expansion. As a tool that primarily assists IT decision-makers, it has underlined its value for organizations that have used it by improving IT effectiveness, which has led to significant operational budget savings (Agerbak & Deutscher, 2010, para. 7). We thus see the opportunity to add conceptual clarity (Suddaby, 2010, p. 347) and scientific rigor.

Third, the IT-CMF covers all IT functions, encompassing a set of 36 interrelated capabilities, which are further categorized into four macro-capabilities: i) *managing IT like a business* – capabilities that create value for the entire organization as they shift from a purely tech-centric to a business-centric perspective (which also includes the Green IT capability); ii) *managing the IT budget* – capabilities that help to assess the value gained by investments in IT (Curley et al., 2016, p. 103). Similar to other frameworks (i.e., CMM), each is assessed in five successive maturity levels (see Table 1), which range from no or ad hoc structures (Level 1) to structures that regard the specific capability as a critical success factor (Level 5). We thus see the opportunity to transfer this approved view to our theoretical view of Green IT/IS.

2.4 IT-CMF Green IT Capability Domains

The IT-CMF's Green IT capability differentiates nine capability building blocks (see Table 2) along four domains (see Figure 2). We now list the IT-CMF definitions of these domains and their building blocks and place them in an academic perspective by relating them to well-known theoretical concepts.

	Green IT Capability			
Domains	Strategy & Planning	Process Management	People & Culture	Governance
Capability Building Blocks	Objectives	Operation & Life Cycle	Language	Regulatory Compliance
	Alignment	Technology-Enhanced Business Processes	Adoption	Corporate Policies
		Performance and Reporting		

Figure 2. Green IT capability structure (based on Curley et al. 2016)

2.4.1 Strategy and Planning

These IT-CMF building blocks refer to the strategy and objectives of the Green IT capability (Curley et al., 2016, p. 106) with two building blocks. The *objectives* building block captures

"the green information technology objectives for the IT function" (Curley et al., 2016, p. 106) and thus defines the IT department's overall strategy and goals. Reich and Benbasat (1996) refer to it as "the degree to which the IT mission, objectives, and plans support and are supported by the business mission, objectives, and plans" (p. 56). Thus, developing and maturing this capability seems crucial as it transforms short-term objectives and goals into a long-term vision. It seems particularly important for Green IT/IS as sustainability initiatives – compared to traditional ones – take much longer to pay off (Olson, 2008, p. 28).

Table 2. Capability building block (CBB) and definitions (based on Curley et al. 2016)

CBB	Definition
Objectives	Define the Green IT objectives for the IT function.
Alignment	Align Green IT objectives between the IT function and the rest of the business.
Operations and Life Cycle	Source/design, operate, and dispose of IT systems in an environmentally sensitive manner.
Technology Enhanced Business Processes	Identify IT solutions that enable environmentally sensitive business operations.
Performance and Reporting	Demonstrate progress against objectives for Green IT concerning the IT function or technology-enabled solutions across business operations.
Language	Define, communicate, and use language and vocabulary for Green IT that are understood by all stakeholders.
Adoption	Promote principles and behaviors that support Green IT.
Regulatory Compliance	Enable and demonstrate compliance with external standards and regulations concerning the environmental impact of computing and business operation activities.
Corporate Policies	Establish corporate policies to support a Green IT strategy.

The *objectives* are closely connected to the *Green IT alignment* block, as the alignment of "green information technology objectives between the IT function and the rest of the business" (Curley et al., 2016, p. 106). IS literature refers to it as business-IT alignment, a further development of the IT objectives. It captures the appropriate use of IT "in harmony with business strategies, goals and needs" (Luftman, 2000, p. 3). An increasing number of studies underline that IT and Green IT/IS use can have substantial benefits for organizations (Schmermbeck, 2019, p. 2046). Thus, the better business and IT strategies are aligned, the better both can create organizational (sustainability) value.

2.4.2 Process Management

These building blocks refer to approaches that enable Green IT across the IT lifecycle and the business value chain (Curley et al., 2016, p. 106). *Operations and lifecycle* capture how organizations "source/design, operate, and dispose of IT systems in an environmentally sensitive manner" (Curley et al., 2016, p. 106). IS literature also refers to it as a cradle-to-cradle approach, which can be extremely valuable for IT since its core components (e.g., CPUs, RAM,

hard drives) primarily consist of metals that are very easy to recycle and reuse (Murugesan, 2008, p. 30).

This view links to the *technology-enhanced business processes* building block of "IT solutions that enable environmentally sensitive business operations" (Curley et al., 2016, p. 107). It reflects (Green) IT usage to improve an organization's overall sustainability (Murugesan, 2008, p. 31). Reducing or avoiding printer use in organizations with digitally enabled processes seems the most frequently cited example of this capability since it can have significant environmental effects on wood harvesting, the generation of solid waste, and CO_2 emissions (e.g., Degirmenci & Recker, 2018, p. 1).

The *performance and reporting* building block measures "progress against objectives for green information technology concerning the IT function or technology-enabled solutions across business operations" (Curley et al., 2016, p. 107). It is connected to the disclosing of standards and principles of the Global Reporting Initiative (2013), which suggests disclosing economic, ecological, and social performance to an organization's stakeholders (Hilpert et al., 2014, p. 2), since they can also increase organizational (Nishant, 2012, p. 13) and market performance (Nishant et al., 2017, p. 559).

2.4.3 People and Culture

These building blocks refer to the management of an organization's people and the organizational culture among them. According to the *language* building block, an organization must "define, communicate, and use language and vocabulary for green information technology that are understood by all stakeholders" (Curley et al., 2016, p. 108). Shared terminology, phrases, and tone strongly shape an organization's culture (Allen, 2012, para. 1), but also the employees' mindset (Curry et al., 2012, p. 66). It is thus also essential for building its Green IT capability, which was shown to benefit business efficiency, resource consumption, and waste production (Curry et al., 2012, p. 66).

The *adoption* block addresses the promotion of "principles and behaviours that support green information technology" (Curley et al., 2016, p. 108). The IS literature contains many frameworks and models that address novelty adoption (e.g., Davis, 1989; Hameed et al., 2012). For Green IT/IS, the adoption process is not yet fully addressed. Though they share similarities with traditional innovations (e.g., Molla et al., 2008, p. 659), some non-negligible differences indicate that established models are only partially usable to promote Green IT/IS adoption in organizations (Schmermbeck, 2019, p. 2046).

2.4.4 Governance

The *governance* building blocks refer to compliance with policies and reporting protocols (Curley et al., 2016, p. 105). IT governance is a well-researched concept in the IS literature

and has mainly been referred to as specifying "decision rights and accountabilities to encourage desirable behavior in the use of IT" (Weill, 2004, p. 2). The IT-CMF splits it into two blocks: *Regulatory compliance* captures how organizations "enable and demonstrate compliance with external standards and regulations concerning the environmental impact of computing and business operations activities" (Curley et al., 2016, p. 109), while *corporate policies* captures how organizations "establish corporate policies to support a green information strategy" (p. 109). For Green IT/IS use, this may mean adopting a sustainability standard (e.g., ISO 14000) or at least setting up policies for purchasing and use of IT – e.g., only purchasing from certified vendors or purchasing certified hardware (e.g., Energy Star, der Blaue Engel).

3 Method

We aim to categorize and integrate the IT-CMF's Green IT capability into the Green IT/IS concepts as well as to create a better understanding of how organizations can acquire and manage the various capability building blocks. For this, we took the IT-CMF – as presented by Curley et al. (2016, pp. 103–117) – and the definitions of Green IT and Green – as presented by Loeser (2013, p. 6) – and integrated the two concepts as explained in the literature, making the method of our work purely literature based.

Combining and integrating terms, concepts, theories, models, and frameworks is a relatively intuitive and accessible approach and are, therefore, also often used in scientific disciplines. It was, for instance, used by Barrales-Molina et al. (2014), who combined the dynamic capabilities view with the absorptive capability and knowledge management perspective to suggest integrative dynamic marketing capabilities. Hameed et al. (2012) used an integrative approach to "theoretically construct an integrated model for IT adoption process in an organization" (p. 359). In the Green IT discussion, the approach was used for an integrative understanding of Green IT/IS adoption (Schmermbeck, 2019).

We proceeded by first critically analyzing the IT-CMF's Green IT capability (Curley et al., 2016, p. 105). We then used the individual building blocks to confront them with Green IT/IS concepts as analyzed and defined by Loeser (2013, p. 6) – another example of the use of a combinatory approach in the IS literature. Although, as outlined in the conceptual foundation, there are a variety of different understandings and definitions of Green IT/IS (e.g., Harnischmacher et al., 2020, pp. 2–3), we chose this view, as it i) connected the research steam of the tech-centric Green IT, and the business process-centric Green IS (Malhotra et al., 2013, p. 1266); ii) created improved definitions by integrating dominant Green IT and Green IS definitions; and iii) established a modular overview over Green IT/IS building blocks which we can ideally use.

4 Results

As specified by the IT-CMF, the Green IT capability can be categorized into four domains: i) strategy and planning, ii) process management, iii) people and culture, and iv) governance. These domains are further segmented into specific capability building blocks (see Figure 2). We mapped each building block as well as the specific five maturity levels to the Green IT and Green IS building blocks (see Figure 1), creating an overall map (see Figure 3). We realized that no capability building block only addresses Green IT aspects and that five blocks (alignment, performance and reporting, language, regulatory compliance, corporate policies) address Green IS. The remaining four blocks share Green IT and Green IS aspects. We now outline the results for each capability building block.

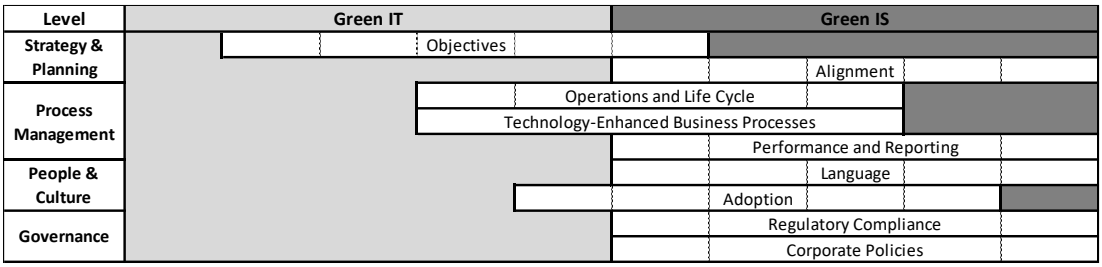

Figure 3. Mapping IT-CMF capability building blocks and definitions of Green IT/IS

We mapped *objectives* to both Green IT and Green IS. Although the IT-CMF describes this block as the ability to set goals for Green IT, higher levels of this block significantly exceed a pure technology focus. Curley et al. (2016) state that for operations to be categorized as level 3, sustainability "criteria and policies […] are implanted for most IT assets within the IT function, and there is emerging evidence for this happening in some of the wider business operations" (p. 106). This exceeds the Loeser (2013) Green IT scope, as it also addresses a more refined "management of resources" (p. 6) and thus addresses Green IS concerns.

This is different for the *alignment* block, which links the IT department's objectives to the other business objectives. It addresses the strategic issue of building and establishing a sustainable IT strategy. We regard this as an entirely managerial task that exceeds the operational management of technologies (Loeser, 2013, p. 6) and is, therefore, wholly categorized as Green IS. This perspective spans all five levels, ranging from an inconsistent and informal alignment of sustainability objectives (Level 1) to agreed, integrated, and reviewed sustainability objectives that cover end-to-end activities in the entire organization as well as relevant business partners (Level 5).

Although primarily concerned with hardware-related aspects – such as sustainable design, operation, and disposition of IT – *operations and lifecycle* covers Green IT and Green IS. Like the objectives block, in Level 5, an organization reviews its operations and seeks input from

relevant business partners (Curley et al., 2016, p. 106). As a managerial, not an operational, task, we regard it as Green IS.

The *technology-enhanced business processes* block – on Level 1 – incorporates the "application of IT to reduce the environmental impact of operations" (Curley et al., 2016, p. 107), which overlaps with our definition of Green IT (Loeser, 2013, p. 6). On level 3, this shifts toward Green IS, which also requires IT and other business departments to develop, identify, and use technologies that reduce the impacts of operations. Thus, the capability block addresses both Green IT and Green IS.

The *performance and reporting* building block is first and foremost based on and linked to the IT equipment an organization uses. It measures the maturity of how the IT equipment's performance is measured and reported on. While on Level 1, there are no Green IT metrics in place, on Level 5, the reports aggregate the organization's IT and that of relevant stakeholders (Curley et al., 2016, p. 107). Hence, it can be regarded as a governance practice that determines the management and use of IT (Weill, 2004, p. 3). All five levels, thus, subscribe to Green IS.

The *language* building block refers to building a specific sustainability mindset and understanding between employees. It is based on the use of a shared language with a particular terminology (Curry et al., 2012, p. 67), which allows for intentions and strategies to be turned into specific actions. On Level 1, there is no or little consistency in the language and terms used to discuss Green IT matters (Curley et al., 2016, p. 108). On Level 5, a shared Green IT language is an essential part of an organization's mindset, which defines and reinforces both the employees' and the customers' values and missions. Consequently, all levels defined by the IT-CMF refer to linguistic practices that determine IS use and management. This building block is therefore regarded as a Green IS capability.

Concerning *adoption*, it is ambiguous whether the block's first maturity levels incorporate aspects of using, disposing, or managing IT or whether it only focuses on addressing these assets. In Level 1 maturity of this block, principles and behaviors relating to Green IT are only adopted ad hoc and are limited to individual initiatives (Curley et al., 2016, p. 108). Since the IT-CMF does not provide a specific definition of Green IT – but only of the Green IT capability – we assume that these building blocks refer to initiatives that lower IT's negative environmental impacts and not just to the management of the Green IT capability. We connect Level 1 maturity to our understanding of Green IT (Loeser, 2013, p. 6). This is different for Level 2, which refers to sharing principles and behaviors as well as establishing training and communication channels. From this level on, we consider this to be a Green IS capability building block.

Level 1 organizations in the *regulatory compliance* building block do not comply with external standards and regulations (Curley et al., 2016, p. 109). As these links – although incomplete

or non-existent – can be regarded as links to IT governance, which specifies decision rights and accountability to enable desirable IT use (Weill, 2004, p. 3), we still view it to address managerial and, thus, Green IS concerns.

A similar argumentation holds for the *corporate policies* block. Although organizations on this level 1 only establish ad hoc policies, this can – identical to establishing other governance mechanisms (Weill, 2004, p. 3) – be regarded as a managerial concern and hence fully subscribes to Green IS.

5 Discussion and Further Research Propositions

Nowadays, organizations are challenged to simultaneously digitally transform themselves and to behave economically friendly. However, it is not the mere adoption of (Green IT) technologies that enable them to address these challenges (Lunardi et al., 2015, p. 4). Organizations must also develop the necessary (Green IS) skills to achieve the desired benefits (Eisenhardt & Martin, 2000, p. 1116). The development and management of capabilities thus becomes increasingly important.

The IT-CMF, which also encompasses a Green IT capability (Curley et al., 2016, p. 103), can be used to address both topics but requires further conceptual clarity. We see the problem (Alvesson, 2011, p. 247) that its Green IT terminology leads to unjustifiably setting a transformation focus on only technologies. Also, its non-academic origin opens the opportunity to add scientific rigor to underline its value for businesses. To address these issues, we mapped the IT-CMF's Green IT capability with a well-known understanding of Green IT/IS.

We found that the capability primarily addresses Green IS aspects (see Figure 3) and that Green IT/IS need to be simultaneously adopted and developed. The IT-CMF's Green IT capability hence needs to be re-labeled as a *Green IT/IS capability*. We propose and, in the following, will also use this terminology. It also provides a terminological answer to our set-out research question and aims to i) add conceptual clarity, and underline that achieving a digitally enabled sustainability transformation as well as technological Green IT/IS maturity is not a purely hardware-related issue. Based on this core insight, we will now highlight three propositions on how organizations may shape their sustainability transformation that is driven by Green IT/IS. They may assist decision-makers but also serve as implications for further research:

Proposition 1: *Organizations that seek a successful Green IT/IS-driven sustainability transformation need to primarily adopt Green IT/IS capabilities*.

Our analysis shows that 34 out of 45 Green IT/IS capability building blocks subscribe to the Green IS domain and that it is primarily non-equipment-related aspects that drive a digitally enabled sustainability transformation. This insight allows for a variety of options for organizations to adopt and use Green IS without no or little upfront investments. They may, for instance, start to build Green IT/IS *language* capabilities which creates awareness and lowers employee resistance, and can generate a (cultural) foundation for subsequent technological changes (Olson, 2008, p. 23). This could then be followed by building the *alignment* capability and by aligning IT and business objectives (Murugesan, 2008, p. 31). This adds (tangible) seriousness to the previously (intangible) verbal changes. Thus, the IT-CMF allows organizations to flexibly and parallelly build Green IT/IS capabilities. Further research may test this proposition in an action-oriented research endeavor. It may select an organization that is not

yet using Green IT/IS and assist and actively contribute to them by creating a roadmap for a successful transformation and putting it into practice.

Proposition 2: *Organizations that seek a successful Green IT/IS-driven sustainability transformation can achieve significant benefits without (large) monetary investments*.

Shifting aspects that fall into the people and culture capability block are i) quasi-costless, ii) underlie the intention to become more sustainable, and iii) can initiate measurable outcomes (energy savings). They can ideally function as a multiplicator and control mechanism among employees. Though only a first step, they nevertheless subscribe to partial eco-efficiency as well as eco-effectiveness aspects (Watson et al., 2010, p. 28) and make these changes more believable and sincere throughout the entire organization. Arnfalk et al. (2016), for instance, support this view. They show that sustainability changes heavily rely on how employees see and use current technologies (p. 9). Education and training of not just individual people and work groups but interactive training of multi-disciplinary teams seems to be vital to increasing the adoption and usage of sustainable technologies within an organization. Further research may shed light on this by investigating working routines, social aspects as well as the overall corporate culture of sustainability leaders. A thorough documentation of how monetary investments are supported and supplemented by (quasi) non-monetary changes may help particularly sustainability-wise immature or struggling companies as it may uncover their blind or weak spots.

Proposition 3: *Organizations that seek a successful Green IT/IS-driven sustainability transformation need to sync technological with socio-technological changes*.

As IT and IS are the backbone of nearly all modern enterprises, it may lead to the fallacy that even the increased usage of these technologies brings organizations onto the winning straight. This is not the case; neither in achieving a competitive advantage (Eisenhardt & Martin, 2000, p. 1118) nor to (also) becoming more sustainable (Lunardi et al., 2015, p. 4). Careful selection, purposeful use, and continuous maintenance of IT and IS is yet crucial (Loeser, 2013, p. 7) for achieving IT/IS-enabled sustainability advantages (Curry et al., 2012, p. 72). Organizations can indeed address currently used technology deficits by replacing them (e.g., replacing desktop computers with laptops or thin clients (Murugesan, 2008, p. 28). It is nevertheless essential to create a long-term vision that contains replacement plans for technologies, which also includes the redesign of the surrounding processes (Loeser, 2013, p. 8), addressing user's views, terminology, and language (Olson, 2008, p. 23), as well as their actual usage of these technologies (Gonserkewitz et al., 2021, p. 178).

6 Conclusion

Acquiring Green IT/IS innovations is an opportunity for an organization to increase digitality and sustainability. But, a sole focus on adopting technologies does not suffice. To beneficially use these innovations, organizations must also develop the related capabilities. To underline this argumentation and refine the concepts of Green IT capabilities, Green IT, and Green IS, we have mapped the IT-CMF's Green IT capability to well-known understandings of Green IT and Green IS. We found that i) the scopes of Green IT capabilities are primarily on Green IS, ii) organizations don't necessarily need to first adopt Green IT before developing Green IS, and iii) the individual capability building blocks can and should be developed in parallel. Thus, we have refined the IT-CMF's Green IT capability as well as the conceptual understanding of Green IT/IS by explicitly adding a capability perspective.

Our findings contribute to the theory in two primary ways: First, our argumentation indicates that the practitioner-originated and practitioner-oriented IT-CMF also has theoretical relevance, as we backed up and linked all IT-CMF Green IT capabilities to well-researched concepts and theories. Second, we refined the understanding of Green IT and Green IS by adding a capability perspective, providing an additional theoretical foundation. For practitioners, our mapping underlines that Green IT capability maturity is achieved primarily by developing Green IS and is necessarily linked to specific Green IT. Second, Green IT/IS maturity is not achieved unidirectionally. Organizations may develop Green IS practices before adopting Green IT. This seems especially the case for language capability.

Our research has limitations. First, our mapping is purely literature-based. Thus, further research may question organizations that are adopting Green IT/IS about their past, current, and intended future Green IT/IS maturity states. Second, we relied on the IT-CMF as one IT capability maturity framework. Further research may want to address this limited scope by creating a meta-map of both multiple-capability maturity frameworks that also incorporate Green IT/IS capabilities to respect that IT capabilities and capability maturity may be achieved in more than one selected way. Third, we acknowledge that our research focuses on breadth, and its argumentative depth is limited. For further research, it may thus be an option to select and focus on an individual capability block and investigate specific ways of how Green IT/IS maturity may be achieved in this limited scope.

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III

GREEN IT QUICK WINS – HOW COMPANIES CAN ACHIEVE GREATER SUSTAINABILITY IN THE LONG TERM THROUGH IT MEASURES THAT CAN BE IMPLEMENTED IN THE SHORT TERM

Abstract

Companies must meet increasingly stringent environmental requirements. Relying on information technologies (ITs) and information systems (IS) usage and especially their inclusion in and for sustainability initiatives, can make a significant contribution to this. To support managers in these efforts, we analyzed literature, identified Green IT and Green IS measures and categorized them by feasibility and ecological benefits. We mainly highlight quickly implementable actions with high environmental benefits (quick wins), many of which relate to the use and management of hardware and hence can be categorized as Green IT. We show that all identified measures can and need to be seen as the first steps of a long-term sustainability strategy that consequentially exceeds company boundaries. Due to the diversity of companies, the presented results nevertheless are not universal, but their adoption and usage are determined by enterprise characteristics.

Keywords: *Green IT; corporate sustainability; quick wins; digital transformation*

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1 Motivation and Introduction

An ever-increasing number of companies seem to take up sustainability initiatives and start addressing organizational ecological issues (Opitz et al., 2014, p. 2). For one, this appears to be caused by increasingly stringent environmental regulations. A growing number of countries, for instance, have started to either tax corporate carbon (CO_2) emissions or significantly increase the fees charged (Bray, 2022, tbl. 1). For another, companies themselves are also increasingly recognizing that behaving more ecologically sustainable is not only good for business (Brockhaus et al., 2017, tbl. 2) but that they can use innovative sustainability technologies to simultaneously address other pressing challenges, like the ones of the digital transformation (Hu et al., 2016, p. 1169; Kiron & Unruh, 2018, para. 7).

One category of these innovations is Green information technologies (Green ITs) and Green information systems (Green IS). They are understood as technologies and management practices that seek to "decrease the negative environmental impact of manufacturing, operations, and disposal" (Green IT) (Loeser, 2013, p. 6), as well as those that "determine the investment in, deployment, use and management of information systems (IS) to minimize the negative environmental impacts of IS, business operations, and IS-enabled products and services" (Green IS) (p. 6).

While – as their connotation indicates – both can be used to increase ecological sustainability (Deng & Ji, 2015, p. 16738), they are far from being single-purpose innovations. They can also serve as options with which companies can establish or widen their innovative products and service portfolio (Loeser, 2013, p. 8), make use of a different set of sustainability-related product strategies and strategic capabilities (Hart, 1995, fig. 1), to consequently open novel markets (Dörr, 2020, p. 2). They, however, can also serve to achieve soft goals of improving the corporate or brand image (Brockhaus et al., 2017, p. 942), improving the corporate climate (Gürlek & Tuna, 2018, p. 483), and overall employee environmental awareness (Lunardi et al., 2015, app. A).

Nevertheless, many companies are criticized for not taking sufficient responsibility for climate protection (Hanelt et al., 2017, p. 494). For example, while they seem to be aware that environmental sustainability is an important issue, it rarely manifests in strategic actions (Engert et al., 2016, p. 2834). Also, sustainable innovations need to compete with traditional, 'non-sustainable' technologies. In these, decision-makers very often decide on the established, 'non-sustainable' technology (van Helmond & Kok, 2022, p. 13) – simply because these are better understood or are a preferred short-time solution (Palčič et al., 2013, p. 409).

Turning to IS research – a domain that traditionally has a strong practitioner focus that leads to many practice-relevant insights (Hirschheim & Klein, 2012, p. 197) – could be one way for companies to address these challenges. The Green IT/IS discussion, however, seems to not

(yet) be very helpful. While there are many studies that, for instance, concern fundamental questions of the Green IT/IS understanding or conceptualization (e.g., Dedrick, 2010; Deng & Ji, 2015) or adoption determining factors (e.g., Asadi et al., 2017; Deng & Ji, 2015), there are only few that outline general and specific benefits (e.g., Loeser et al., 2017; Murugesan, 2013).

Only a few studies, however, suggest overarching sustainability measures that companies can take (Engert et al., 2016, pp. 2834–2835). For Green IT and Green IS, there are – to the best of our knowledge – no such studies that suggest and catalog specific means and measures that companies can take up, experiment with, and achieve the first benefits of Green IT/IS adoption and usage. Studies like these, thereby, seem highly beneficial. They would – from a practical point of view – serve as a relative collection of 'low hanging fruits' that can quickly and – ideally – cost neutrally be adopted or implemented. From an academic point of view, such a collection would also be beneficial, as it could be the basis for further fundamental data-driven research as their corporate adoption could, for instance, be academically monitored, documented, and analyzed.

We, therefore, want to show how companies can achieve (increased levels of) environmental sustainability through IT and IS. Especially the fact that many companies seem relatively inexperienced with Green IT/IS offers the great potential to collect and harvest the 'low-hanging fruits' (Hart, 1995, p. 993). In addition, we show how a long-term strategy can develop from individual measures (Searcy, 2012, p. 240).

This paper is organized as follows: In chapter two, we clarify the core terminology of Green IT and Green IS and outline how their environmental impacts may be assessed. In chapter three, we describe the literature review and analysis we undertook to create the collection of Green IT/IS means. We discuss these results in chapter five and draw a conclusion in chapter six.

2 Corporate Sustainability

The term sustainability stems from the German word ‘Nachhaltigkeit’ and was conceptualized by forest management as the objective only to cut as many trees as can grow back to achieve a long-term steady state (Klumpp, 2018, p. 2). The modern and frequently referred to understanding of the Brundtland Commission exceeds this purely agricultural understanding and widens it to a more global and societal issue. It states that sustainable development – of society, corporate actions, or any other action – is a development that fulfills the needs of the present without limiting the possibilities of future generations (Brundtland Commission, 1987, p. 24).

Sustainability consequently also increasingly affects companies. Environmental protection organizations not only raise awareness for the deterioration of the natural environment (IPCC, 2022, p. 12) but also – like AKEPA (2021) – uncover companies’ environmental misdoings or expose their greenwashing (i.e., “misleading customers regarding the environmental practices of a company or the environmental benefits of a product or service” (TerraChoice Group Inc., 2009, p. 1)). Governments around the globe, as well as multi-national institutions like the European Union, pass increasingly strict environmental protection laws (Plucinska, 2023, para. 4), increase carbon taxing (Bray, 2022, para. 1), and also customers increasingly demand sustainable products (Erek et al., 2010, p. 20).

The IT sector is not spared from this either as the digital transformation of society and industries continues (McLellan, 2021, para. 6). As the demand for digital technologies and services is continuously rising (Belkhir & Elmeligi, 2018, tbl. 10), it evermore becomes a sustainability burden. Not only because the consequential energy demand – as well as the associated carbon emissions – for using these devices will similarly grow (Belkhir & Elmeligi, 2018, fig. 7), but also as the lifespan of the equipment used is becoming shorter and shorter, thus contributing to a more significant environmental impact (Murugesan & Gangadharan, 2008, p. 34).

2.1 Green IT and Green IS

Many terms describe ecologically sustainable IT and IS, like ‘energy informatics’, ‘Sustainable Information Systems’ (El-Rayes et al., 2022, tbl. 1), or ‘IT for Green’ (Curry & Donnellan, 2014, p. 3). In particular, *Green IT* and *Green IS*, which we also use, are widely used as quite striking terms (Bose & Luo, 2012, pp. 63–64). Green IT is closely related to hardware and its life cycle and refers to “measures and initiatives that reduce the negative environmental impacts of manufacturing, operating, and disposing of IT equipment and infrastructure” (Loeser, 2013, p. 6). Green IS, on the other hand, is an overarching concept that encompasses practices “that guide information systems (IS) investment, deployment, use, and management to minimize the negative environmental impacts of IS, business processes, and IS-supported products

and services" (Loeser, 2013, p. 6). Green IS thus not only includes Green IT but also encompasses the overarching governance and management of the corresponding devices and technologies (Opitz et al., 2014, p. 3).

However, companies often lack the expertise and experience to deal with sustainability technologies such as Green IT and Green IS (Curry & Donnellan, 2014, p. 3). Consequently, the long-term impacts, as well as financial and environmental profits and losses, may be poorly balanced (Holland, 2003, p. 229; Searcy, 2012, p. 240). As a result, the sustainability measures are not (or cannot be) consistently observed or effectively pursued by the acting persons so that the set sustainability goals are not realized or are missed in the long term.

2.2 CO_2 Emission and Energy Consumption-Based Sustainability Measurement

The economic performance of a company is probably the most important indicator for all companies, which is determined using a limited number of comparable indicators (e.g., return on investment; profit before income tax). The sustainability of a company is not easy to determine for various reasons. For example, multiple indicators need to be recorded to measure it, which require their own measurement methods (e.g., greenhouse gases like H_2O (water), CO_2 (carbon dioxide), CH_4 (methane), N_2O (nitrous oxide) (EPA, 2022)). Thus, although their characteristics can be quantified (e.g., tons of CO_2; kWh of energy), they cannot be set off against each other or converted into each other, unlike financial indicators.

Also, while models have been developed that measure an organization's environmental performance (e.g., the ecological footprint (Holland, 2003)), none of these are universally accepted or used (Matuštík & Kočí, 2021, p. 124833). Governmental guidance is relatively low (Searcy, 2012, p. 240), which – in regard to the increasingly strict environmental protection rules and legislations (see above) – seems at least surprising. Despite these points, energy consumption and CO_2 emissions appear to emerge as key indicators of corporate sustainability (Hu et al., 2016, tbl. 1) since i) energy consumption is both an environmental and economic indicator, the reduction of which covers two interests, and ii) CO_2 is seen as the essential greenhouse gas, the emission of which many governments seek to reduce and therefore tax.

3 Literature Analysis

To categorize an overview of Green IT/IS measures and i) implementation horizon and ii) their environmental sustainability, we collected and categorized literature.

3.1 Literature Search and Analysis

Based on the Webster and Watson (2002) approach, we searched for scientific publications that listed overarching Green IT/IS practices and excluded publications that only identified measures for selected areas (e.g., data centers). The focus was on English-language literature, as most of the Green IT/IS literature is published in English journals and conference proceedings (Zaung Nau & Marinova, 2020, tbl. 1). We used “green IT”, “green IS”, “measures”, “best practices” in IEEE Xplore, AISeL, and Google Scholar as search terms. Since Green IT first appeared in the scientific discourse in 2008, we used that year as a baseline (Loeser, 2013, p. 2).

After screening the articles, we initially came up with 47 publications. We examined them for identified Green IT/IS measures and arrived at a final sample of 5 publications (Bose & Luo, 2012; Curry & Donnellan, 2014; Erek et al., 2010; Loeser, 2013; Murugesan & Gangadharan, 2008); one of which represents an edited volume whose articles were used individually.

3.2 Organizational Quick Wins

We categorized the identified measures according to the relative ease of implementation and the size of the expected positive ecological effect. This allows us to identify both quick wins and a strategic vision. We defined *quick wins* as measures that can be implemented immediately or in the short term, with no or relatively negligible cost, and lead to immediate positive environmental results (Erek et al., 2010, p. 24). We overall modified a time-based framework (Unhelkar, 2012, p. 152) to categorize the baselines for the implementation of the sustainability measures.

For the time horizon, we set that the implementation of a quick win should take a maximum of one-quarter year – regardless of whether the implementation can be fully completed. It felt that this would be a manageable timespan for most organizations to conceptualize the measure, get managerial approval, and initialize, if not conclude, the change. The time needed to pass a decision is, of course, highly dependable on multiple factors, like the size of the organization (i.e., number of employees), as well as its organizational structure. For a change request to pass through a highly formalized and hierarchically organized organization will accessible require a significantly longer time than to pass through one that has a flat, agile, and less formalized hierarchical structure. For measures that can be implemented in the medium term, we accordingly defined a period of three to twelve months, and for long-term actions, more than twelve months.

While the implementation horizon was – like the previously outlined outcome measurement – relatively easy to set, we faced the challenge of estimating and setting apart the environmental benefits. There is no universal measure that allows us to set clear boundaries for categorizing large, medium, or small benefits (Engert et al., 2016, p. 2842). We, therefore, needed to assess and compare the demonstrable explicit and implicit benefits. A direct and (relatively) immediate reduction of material or energy consumption – like reducing the amount of printer paper used or the reduction of energy consumed – was consequentially regarded as a relatively high benefit. The effects on customers and suppliers (e.g., establishing a sustainability dialogue) or corporate marketing (i.e., publication of a sustainability report), and corporate cultural measures were considered as (relatively) low.

3.3 Content Analysis and Evaluation

We thoroughly analyzed the identified publications and identified a total of 230 measures across all publications. To assess the feasibility and benefit of each action, the two key researchers separately evaluated the identified measures. They then compared their results and critically discussed them with the third researcher – an expert in the IS field – which led to a settling of the remaining disagreements and alternating evaluations.

The measures were then grouped thematically and combined into 36 clusters. In this way, duplications were identified, and the sporadic deviating evaluations between them were also discussed and eliminated if necessary. This also reduced the number of clusters to 27. In total, we identified 19 measures that could be implemented quickly, 32 in the medium term and 32 in the long term. For benefits, we identified 29 measures with an assumed high impact, 42 with a medium impact, and 12 with a low impact.

4 Green IT and Green IS Means

In the following, we present the results of our literature analysis and list the nine categories we identified. We outline them and present selected representative measures for each type.

4.1 Quick Wins

All quick wins – quickly implementable means with high ecological benefit – are categorized as Green IT and, therefore, hardware-related measures. *Hardware procurement* can be seen as one representative initiative and includes the procurement of devices and accessories. It may be relatively easy to change their selection also to include ecological criteria (e.g., low energy consumption or eco-certified device), which, consequentially, also leads to a high benefit for companies and the environment (Bose & Luo, 2012, pp. 70–71; Erek et al., 2010, p. 19; Loeser, 2013, p. 7). We categorized this as a measure with high benefits, as especially producing computer hardware has a very high environmental impact. Manufacturing one laptop, for instance, causes 75 – 85% of all carbon emissions during its lifetime (Haughton, 2021, sec. 3)

This also applies to printers and *printer management* and includes reducing the number of devices, using multifunction devices and environmentally friendly accessories (cartridges, paper, etc.) as well, as adjusting print settings (e.g., double-sided printing, black-and-white printing) (Bose & Luo, 2012, p. 73; Loeser, 2013, p. 7). Using recycled paper, for example, consumes 60% less energy and saves up to 70% water (Blauer Engel, 2013, sec. 1).

By using *groupware*, employees can collaborate virtually (Curry & Donnellan, 2014, p. 6). With the help of video conferencing tools, travel to customers, clients, or suppliers can be reduced or avoided altogether, among other things (Curry & Donnellan, 2014, p. 14; Erek et al., 2010, p. 22; Loeser, 2013, p. 8). This reduces the associated CO_2 emissions and also costs. An Australian telecommunications company used only virtual meetings for three months and saved about AU$60,000, as well as about 100 tons of CO_2 emissions (Guerin, 2017, p. 78).

Automated energy hardware management means using software-based functions that actively regulate the power consumption of electronic devices. These usually only need to be activated to bring significant benefits (Loeser, 2013, p. 7; Murugesan & Gangadharan, 2008, p. 99). We categorized this as an easily implementable measure, as in most companies, computer and laptop settings are centrally managed and controlled. In the case of computers, for example, hard disk usage and memory used can be adjusted, resulting in energy savings of up to 35% (Teeluck et al., 2013, p. 44).

Table 1. Overview of the identified Green IT Quick Wins

Benefit	Category	Measure	Reference
High	Hardware Procurement	Purchasing environmentally friendly and energy-saving hardware and accessories Purchasing hardware certified with eco-labels	(Bose & Luo, 2012; Erek et al., 2010; Loeser, 2013)
	Printer Management	Setting double-sided and black-and-white printing as standard Reduction of printers Development of a printer policy	(Bose & Luo, 2012; Erek et al., 2010; Loeser, 2013)
	Groupware	Switch to virtual meetings and teleworking Video conferencing tools to avoid travel	(Bose & Luo, 2012; Curry & Donnellan, 2014; Erek et al., 2010)
	Hardware Energy Management	Activation and use of energy management features Development of an energy management policy Use of Wake-on-LAN	(Bose & Luo, 2012; Curry & Donnellan, 2014; Erek et al., 2010; Loeser, 2013; Pon Kumar & Kannegala, 2012)
Medium	Hardware Refurbishment	Reuse of hardware Extending the lifecycle of hardware Refurbishment of hardware	(Curry & Donnellan, 2014; Loeser, 2013; Pon Kumar & Kannegala, 2012)
	Hardware End-of-life Management	Environmentally friendly disposal and recycling of hardware Development of disposal guidelines	(Bose & Luo, 2012; Curry & Donnellan, 2014; Loeser, 2013; Pon Kumar & Kannegala, 2012)
	Software Energy Efficiency	Use of energy-efficient software	(Curry & Donnellan, 2014; Loeser, 2013)
	Sustainability and Green IS Strategy	Regular meetings between IT and top management	(Loeser, 2013)
Low	Hardware Energy Management	Manual energy management of devices	(Pon Kumar & Kannegala, 2012)
	Asset Consolidation	Creation of a hardware inventory list	(Loeser, 2013)

4.2 Short-Term Means with Medium Benefits

Hardware refurbishment and the procurement of devices that can be easily repaired (e.g., Fairphone) enables devices to be used for longer than the often usual two to three years (Pon Kumar & Kannegala, 2012, p. 5). This means that less hardware is purchased, which in turn does not need to be produced (Loeser, 2013, p. 7; Murugesan & Gangadharan, 2008, p. 9). For example, a computer that has already been purchased consumes only about 30% of the energy in four years that would be required to produce and operate a new computer in the same period (Moshnyaga, 2008, p. 5).

Hardware end-of-life management includes disposal but also possible resale, donation, and trade-in of hardware. Many for-profit but also non-profit organizations professionalized in refurbishing and selling (e.g., AFB-group[1]) or reusing old computers and laptops for educational purposes in developing countries (e.g., Lapdoo e.V.[2]). If none of these options are possible, devices should at least be adequately recycled (Murugesan & Gangadharan, 2008, p. 35), as computers are made of rare and valuable metals that can be easily reused (Bose & Luo, 2012,

[1] https://www.afb-group.de/en/about-us/
[2] https://www.labdoo.org/deu/en/

p. 65). In addition, they also contain toxic or hazardous materials that should not be released into the environment (Loeser, 2013, p. 7; Unhelkar, 2012, p. 34).

A medium benefit of *groupware* is that its use reduces the need for printing because documents can be used and sent digitally. This can include selective solutions (e.g., use of cloud storage), as well as a complete shift to the use of online office suites.

Table 2. Measures that can be implemented in the medium term

Benefit	Category	Measure	References
High	Hardware Energy Management	Dynamic shutdown and network power management of hardware Monitoring of server power consumption	(Bose & Luo, 2012; Loeser, 2013; Pon Kumar & Kannegala, 2012)
	Hardware Procurement	Adoption of energy-saving hardware (e.g., thin clients, notebooks, LED monitors)	(Curry & Donnellan, 2014; Erek et al., 2010; Loeser, 2013)
	Sustainability and Green IS Strategy	Development of Green IT strategy and sustainable IT principles	(Curry & Donnellan, 2014; Loeser, 2013)
	Virtualization & Cloud Computing	Virtualization of hardware Use of (energy efficient) cloud computing	(Curry & Donnellan, 2014; Garg & Buyya, 2012; Loeser, 2013; Sheridan et al., 2012)
	Data Center Cooling Managemen	Measurement and improvement of air flows and cooling (e.g., elimination of hot spots and use of in-line cooling)	(Erek et al., 2010; Loeser, 2013)
Medium	Hardware Procurement	Centralized procurement Procurement of standardized systems	(Erek et al., 2010; Loeser, 2013; Zhou & Mandagere, 2012)
	Hardware End-of-life Management	Development of an (IT) disposal guideline Recycling of hardware	(Bose & Luo, 2012; Loeser, 2013)
	Hardware Energy Management	Development of an energy management guideline Implementation of an Energy Management System	(Bose & Luo, 2012; Loeser, 2013)
	Facility Management	Separation and tracking of recyclable materials Development of a waste management system	(Loeser, 2013)
	Asset Consolidation	Consolidation of applications and hardware (especially printers)	(Bose & Luo, 2012; Loeser, 2013)
	Sustainability and Green IS Strategy	Organizational integration of Green IS	(Loeser, 2013)
	Network Management	Green Networking Use of scheduling and workload management	(Loeser, 2013; Zhou & Mandagere, 2012)
	Sustainability Corporate Culture	Adoption of a sustainability culture Training of the workforce Creating incentives for sustainability	(Curry & Donnellan, 2014; Erek et al., 2010; Loeser, 2013)
	Collaborations	Participation in sustainability initiatives Exploring subsidy opportunities	(Erek et al., 2010)
	Printer Management	Reduction of imaging equipment	(Bose & Luo, 2012)
	Stakeholder Management	Collaboration with suppliers and knowledge sharing	(Loeser, 2013)
Low	Resource Management	Tracking of environmentally harmful materials	(Loeser, 2013)
	Facility Management	Introduction of a shared-desk concept	(Erek et al., 2010)
	Cooperation between provider and supplier	Establish a dialogue with relevant stakeholders	(Loeser, 2013)
	Hardware Procurement	Consideration of environmental criteria in resource management	(Loeser, 2013)
	Data Lifecycle Assessment	Manage the life cycle of stored data	(Loeser, 2013)
	Stakeholder Management	External sustainability marketing Publication of corporate sustainability reports	(Curry & Donnellan, 2014; Loeser, 2013)

4.3 Short-Term Means with Low Benefits

One of these measures is *manual energy management*. Devices and chargers, for example, can be unplugged manually when they are not in use (Pon Kumar & Kannegala, 2012, p. 30). While this can prevent energy waste, it is not always possible or practical due to the many specialized devices in companies. It also requires specific cultural changes (Puvaneswaran & Alsdorf, 2021, p. 7) and the goodwill of staff, as they very likely cannot be enforced by top management. Hence, their benefits are relatively low, and measures like this may therefore be seen as those that underline the sustainability orientation of a highly engaged company.

4.4 Medium-Term Means with High Benefits

The *consolidation of data centers* first reduces the number of physical components (Bose & Luo, 2012, p. 72; Loeser, 2013, p. 7). In addition, the utilization of the remaining devices can be increased, which is often relatively low and thus wastes energy when idle (Meisner et al., 2009, p. 205). With the help of *virtualization*, desktop PCs can be replaced with thin clients, for example, which only requires about 20% of the energy (Clausen et al., 2013, p. 22).

Another option is to use energy-saving hardware and accessories (Bose & Luo, 2012, p. 70). Notebooks, in particular, have smaller power supplies and therefore require less energy than desktop PCs (Pon Kumar & Kannegala, 2012, p. 41). Implementing certain automated power hardware management also takes a long time. For example, using a network power management system can reduce power consumption by dynamically shutting down servers and activating them only when needed (Loeser, 2013, p. 7). This can save between US$25 and US$75 per desktop computer (Bose & Luo, 2012, p. 73).

4.5 Medium-Term Means with Medium Benefits

Green IS measures, such as the *development of a Green IS strategy* or the initialization of a *sustainable corporate culture*, fall into this category. Both require considerable planning, such as establishing sustainability governance policies (Opitz et al., 2014, p. 13) or training employees (Loeser, 2013, p. 8). Employees are especially crucial, as they are required to behave in an environmentally friendly manner on a daily basis (Erek et al., 2010, p. 22). It will very likely take longer than three to twelve months to alter a corporate culture credibly and tangibly. Hence, these are also prime examples of measures that will probably only be initialized in the medium term.

4.6 Medium-Term Means with Low Benefits

Certain Green IS measures in this category relate to *stakeholder management*, e.g., by establishing a dialogue or through eco-marketing (Erek et al., 2010, p. 23; Loeser, 2013, p. 8).

However, these are rather documenting supplements to substantial changes and therefore are categorized as benefits with low outcomes.

Table 3. Overview of measures that can be implemented in the long term

Benefit	Category	Measure	Reference
High	Asset Consolidation	Consolidation of servers	(Bose & Luo, 2012)
	Hardware Procurement	Data center certification	(Erek et al., 2010; Loeser, 2013)
	Groupware	Use of anytime-anywhere technologies	(Bose & Luo, 2012)
	Sustainability and Green IS Strategy	Defining a Green IS strategy Definition, measurement, and reporting of sustainability metrics Alignment of business and Green IT	(Curry & Donnellan, 2014; Loeser, 2013; Unhelkar, 2012)
	Data Center Energy Management	Redesign of data center hardware to improve energy efficiency	(Curry & Donnellan, 2014; Sheridan et al., 2012)
	Virtualization & Cloud Computing	Virtualization of data center hardware Use of a storage area network	(Bose & Luo, 2012; Erek et al., 2010; Loeser, 2013; Zhou & Mandagere, 2012)
	Collaboration between provider and supplier	Selection of only sustainable suppliers	(Curry & Donnellan, 2014)
	Product and Service Portfolio Management	Analysis of customer requirements for sustainable products Development of a portfolio of sustainable products and services	(Loeser, 2013)
Mittel	Facility Management	Use of Building Automation Systemen / Smart Buildings	(Curry & Donnellan, 2014; Loeser, 2013)
	Hardware Energy Management	Implementation of an Environment Management System Certification according to an environmental standard	(Curry & Donnellan, 2014; Loeser, 2013)
	Hardware Lifecycle Assessment	Life Cycle Assessment of hardware (Total Cost of Ownership)	(Curry & Donnellan, 2014; Erek et al., 2010; Loeser, 2013)
	Collaboration between provider and supplier	Implementation of supplier audits	(Erek et al., 2010)
	Sustainability and Green IS Strategy	Introduction of company-wide environmental management systems	(Loeser, 2013)
	Product and Service Portfolio Management	Analysis of customer requirements for sustainable products Development of a portfolio of sustainable products and services	(Loeser, 2013)
	Data Center Energy Management	Reduction of energy conversion steps (AC to DC)	(Loeser, 2013; Sheridan et al., 2012)
	Data Center Cooling Management	Improvement of air circulation Use of liquid cooling Use of a computer room air conditioning system	(Bose & Luo, 2012; Loeser, 2013)
	Enterprise Supply	Use of smart grids Use of water treatment and management	(Loeser, 2013)
	Data Center Facility Management	Implementation of an energy-efficient data center layout	(Bose & Luo, 2012; Erek et al., 2010; Sheridan et al., 2012)
	Sustainable Production	Use of smart technologies in design and production	(Loeser, 2013)
	Fleet Management	Use of dynamic vehicle routing	(Loeser, 2013)
Low	Stakeholder Management	Publication of an IS sustainability report	(Loeser, 2013)
	Resource Management	Tracking and optimization of resource and material flow	(Loeser, 2013)
	Supply of the company	Use of renewable energies	(Loeser, 2013)

4.7 Long-Term Means with High Benefits

These measures require extensive planning and are often part of a long-term sustainability strategy. Specific green IT measures, such as *hardware procurement*, fall into this category

because they affect the operation and management of data centers. *Deploying blade servers* and upgrading to *energy-efficient processors and storage* (Erek et al., 2010, p. 24; Loeser, 2013, p. 7), as well as some *virtualization and cloud computing measures* (e.g., virtualization of storage (Zhou & Mandagere, 2012, p. 119) or servers (Curry & Donnellan, 2014, p. 4)), require time and certain investments, but have a considerably high impact.

Green IS measures in this category concern the *development and implementation of a Green IS strategy*, which must be carefully synchronized with the corporate strategy, primarily through the development of a sustainable product and service portfolio (Loeser, 2013, p. 7; Unhelkar, 2012, p. 164). They thus require considerable planning and alignment measures that are not only time-consuming but also require consulting many corporate stakeholders.

4.8 Long-Term Means with Medium Benefits

This category includes *facility and office management*, whose ecological balance can be improved on the one hand by technical solutions (e.g., the use of sensors to control the lighting of office spaces actively). But organizational measures, such as the *implementation of a shared desk concept*, which can increase the utilization of workstations or save office space overall (Erek et al., 2010, p. 24), contribute to this. As this also requires specific cultural changes that take a longer time to be initialized and adopted, we categorized them as long-term measures.

Specific measures in *data centers* also fall into this category. Measuring energy consumption and heat emissions can improve the environmental performance of a data center (Curry & Donnellan, 2014, pp. 5–6). However, the necessary measures are not easy to implement, as they require a change in the cooling or power supply and, thus, the overall data center layout (Sheridan et al., 2012, p. 107).

4.9 Long-Term Means with Low Benefits

Three Green IS measures fall under this category, including *customer/investor management*. The *publication of sustainability reports* is often only voluntary and non-binding and can thus be seen more as documentation than an explicit effort to increase an organization’s sustainability (Loeser, 2013, p. 8). It also only has specific regulations but hardly any environmentally positive effects, and hence is categorized as a means with low benefits.

5 Discussion

5.1 Quick Wins as Purely Hardware-Related Measures

Though we identified only hardware-related measures as measures with high benefits, this does by no means mean that socio-technological actions, like establishing a sustainability supporting corporate culture (medium-term measure with medium effects), are not necessary or can be neglected. On the contrary, we see that especially measures that seek to alter underlying and employee behaviors are not only crucial but one of the most influential factors (Baggia et al., 2019, p. 26) for i) achieving long-term benefits and also ii) extending the benefits.

Without establishing an understanding of why employees need to or should alter their established behaviors, they might find ways to circumvent the technologically implemented benefits. A company might, for instance, change the energy settings of their laptops in such a way that displays shut off quickly when the device is not in use. Without seeing the necessity as well as the ecological (and economic) benefits, employees might find straightforward ways to bypass the automatic setting (e.g., by putting the computer mouse on an analog watch, whose finger movements will move the mouse cursor and thus keep the display activated).

These cultural changes, however, need longer times to be credibly implemented and established and also to be internalized by the employees. They thus take longer to manifest and have a supportive but essential character whose non-establishment (or establishment for the reasons that contradict the general corporate strategy) can also lead to the complete failure of the overall sustainability initiative (Brockhaus et al., 2017, p. 945).

5.2 From Quick Wins to a Long-Term Sustainability Strategy

Specific measures, such as the procurement and replacement of hardware, can be found in more than one category. This shows that these are the basis for a long-term commitment to sustainability. However, organizations must not only achieve more significant environmental benefits by committing to greater sustainability but also clearly distinguish themselves from ‘greenwashing’ (Brockhaus et al., 2017, pp. 937–938). Therefore, the identified quick wins should rather be seen as the first steps toward testing and establishing long-term sustainability measures.

Although many measures may be beneficial on their own, they must be considered dependent on other actions. The increased use of groupware, for example, depends on computing and network capacities. If these have to be improved, this can mitigate or offset the intended ecological benefits. For this reason, all measures to be implemented should be embedded in an overall strategy to take into account the corresponding adverse and synergetic effects.

5.3 Relativity of the Benefits

It is challenging, in some cases even impossible, to measure or define the explicit environmental benefits. This is due to both the limited measurability and the significant differences between organizations in many respects (e.g., the organizational structure and the dependency on IT and IS). Companies that provide their services solely with and through IT and IS will be able to implement many of the measures mentioned and achieve more significant benefits than, for example, manufacturing companies. Nevertheless, specific actions can have a lasting positive effect on these companies since, for example, the increased use of video conferencing has a positive environmental impact, even if it does not directly affect the company's activities.

5.4 Alignment of Sustainability with Other IT-Domains

Many of the measures identified overlap with other known strategic IT activities. For example, the actions identified for hardware procurement, the introduction of groupware, and virtualization can also be located in enterprise architecture management. They cover not only ecological issues but also the long-term design of the IT infrastructure and use of operational IS, as well as the business strategy (Ahlemann et al., 2012, p. 61). Therefore, ecologically sustainable efforts should be seen as a related cross-cutting issue within a company. Otherwise, the technologies used may be more ecological on the one hand, but their use may lead to a significant increase in IT costs, which in the worst case, may jeopardize the continued existence of the company.

6 Conclusion

By increasing their use of IT and IS, companies have the opportunity to initiate ecologically sustainable changes. The measures summarized in this article provide an overview of which actions can be implemented relatively quickly and which are more strategic perspectives. It was shown that many Green IT-related changes can be seen as quick wins as well as a foundation for a long-term eco-strategy. The limitations of the results are that few concrete statistics are available for the benefit of the individual measures. The effective positive effects are, therefore, difficult to estimate. Companies should, consequently, first select individual measures whose benefits they can concretely measure (Searcy, 2012, p. 247). They should also check overlaps and dependencies with other actions. This allows for less strategic, tactical, and operational uncertainty and, thus, more stable conditions for the entire company (Engert et al., 2016, p. 2834). In addition, we have only been able to identify and work through a relatively low number of articles. Future research could address both limitations and specify results for individual industries. Thus, relevant indicators could be defined, and comparable measurement methods could be derived.

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IV

GREEN IS DOES NOT JUST SAVE ENERGY – INSIGHTS FROM A SURVEY ON ORGANIZATIONS' USES OF SUSTAINABLE TECHNOLOGIES

Abstract

Organizations are increasingly challenged to transform themselves digitally and to respond to calls for increased sustainability. While the adoption of sustainable innovations, such as green information systems (Green IS), is one way to address both challenges, there are only a few insights that provide non-technology or company-specific insights into specific positive and negative Green IS outcomes. We address this shortcoming and shed light on Green IS adoption outcomes, as well as their interconnection to general sustainability initiatives in organizations. In a descriptive survey, we find that many organizations already employ sustainability principles, but few incorporate Green IS. We confirm organizations almost exclusively report positive outcomes of Green IS usage, such as reduced resource consumption, increased compliance with regulations, and social acceptance. Based on these findings, we suggest to especially further research on the process of Green IS adoption.

Keywords: *Green IT, Green IS, survey, sustainability, innovation adoption, outcomes*

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1 Introduction

Information technologies (ITs) and Information systems (IS), as drivers and supporters of business innovations in globalized industrialization (Kuo & Dick, 2010, p. 1), significantly contribute to the welfare of societies and the development of economies. They also trigger one of the toughest, most imminent challenges for humanity: the preservation of the natural environment (Malhotra et al., 2013, p. 1265).

Producing IT goes along with the mining of valuable and rare minerals and processing toxic and hazardous materials, which have severe consequences for our soil and groundwater (IPCC, 2014, p. 13). Their use increases energy consumption (Massachusetts Institute of Technology (Cambridge), 2007, p. xi), resulting in higher greenhouse gas emissions (IPCC, 2014, p. 63). Their obsolesce results in increasing electronic waste. Thus, the effects on the natural environment are becoming increasingly imminent. The atmosphere and ocean temperatures are rising, causing glaciers and polar caps to melt and sea levels to rise; there has also been a marked increase in potentially dangerous weather-related phenomena (IPCC, 2014, p. 77; Malhotra et al., 2013, p. 1265).

Hence, sustainability has become a topic in corporate management (Lubin & Esty, 2010). While it has many connotations and synonyms (e.g., eco-efficiency, eco-advantage, or corporate responsibility), all definitions bring together the underlying paradigm to preserve an ecological but also socio-economic system for future generations (Erek et al., 2009, p. 2). Research noted that sustainability enables “individuals, organizations, governments and society to transform towards environmentally sustainable practices” (Loeser et al., 2017, p. 504). Further, implementing green innovation may, especially for organizations, meaningfully contribute to performance and competitiveness, besides being a way to protect the natural environment (Yang et al., 2016, p. 12).

Also in the IS domain, researchers have begun to investigate the influence of sustainable innovations to address IT infrastructure and business process management challenges (Molla, Pittayachawan, Corbitt, et al., 2009, p. 9). In recent years this has become closely connected to the terms Green IT and Green IS (Loeser, 2013, p. 4). As principles and activities that “aim to decrease resource consumption” (Lunardi et al., 2013, p. 4), Green IT is often only linked to the addressing of IT-related resource and energy consumption issues (Erek et al., 2009, p. 4). Green IS comprises measures and activities to minimize resource consumption (Dedrick, 2010, p. 174) as well as controlling, guiding, and communicating practices with direct (e.g., cost savings, competitive advantages) and indirect benefits (e.g., optimizing information production and processes) (Lunardi et al., 2013, p. 5).

Research into Green IS has mainly been conceptual (e.g., the development of a research agenda for Green IT and IS (Dedrick, 2010, pp. 180–181); Jenkin et al., 2011, pp. 28–34; Malhotra et

al., 2013, p. 1267), exploratory (e.g., the exploratory operationalization and development of measures for Green IT (Lunardi et al., 2015, p. 11)), or focused on technological issues (e.g., building automation systems (Simmonds & Bhattacherjee, 2015, pp. 2–3)). Moreover, there has been little empirical research into Green IS, and it has only selectively highlighted the benefits of Green IS outcomes. Some studies found long-term benefits of general environmental performance (Lunardi et al., 2013, p. 9) or highlighted organizations' environmental, social, strategic, and thus economic value (Simmonds & Bhattacherjee, 2015, pp. 8–9) but relied on user perceptions. Others found green practices (e.g., recycling, energy management) are beneficial for organizations (Molla et al., 2014, p. 141) or have benefits at the individual (e.g., adoption and routinization), organizational (e.g., competitive advantage), and/or societal levels (e.g., lower energy consumption and pollution) (Malhotra et al., 2013, p. 1265; Wang et al., 2015b, p. 676).

There is a need for empirical research on demonstrable effects (Malhotra et al., 2013, p. 1269). To provide a basis for further empirical work and to partially address these limitations, we catalog specific sustainability and Green IS actions (Chen et al., 2009, p. 14; Corbett, 2013, p. 343) and describe how these translate into increased organizational sustainability (Wang et al., 2015a, p. 403, 2015b, p. 676). As a conceptual base, we relied on a Green IS adoption framework that abstracts specific actions and outcomes on four levels: the natural environment, the society, the organization (as the adopting unit), and individuals (Schmermbeck, 2019, p. 2047).

In addition to these academic reasons, we chose to report on outcomes because many organizations still resist integrating Green IS into long-term strategies (Deng et al., 2015, p. 11). Although there is principally willingness to adopt (Seidel et al., 2011, p. 3), Green IS adoption is primarily not pursued because organizations seem uncertain about Green IS benefits (Loeser et al., 2017, p. 504). This paper, hence, seeks to answer the research question (RQ):

RQ: *What are the outcomes of Green IS initiatives as part of organizations' general sustainability actions?*

We chose to answer this practice-based research question (Ijab et al., 2011, p. 2; Leidner et al., 2018, p. 5064) by descriptive reporting on companies and documenting their most undertaken sustainability and Green IS actions. A descriptive survey fits our goals best since we seek to report on both positive and negative outcomes. Our insights into sustainability actions and outcomes may also be achieved by current non-adopters and used as a basis for more profound research into the effects of sustainability, and Green IS initiatives.

The remainder of this paper is structured as follows. We provide conceptual foundations for outcomes of sustainable innovations, and Green IS and describe the research approach. Then we present our results, which we then discuss and end with a conclusion.

2 Conceptual Foundation

2.1 Sustainability Innovations

Organizations seek to innovate themselves as well as their processes, products, and services. They try to differentiate from their competitors and ultimately create a sustainable competitive advantage (Dedrick, 2010, p. 174; Hart, 1995, pp. 998–999). Innovation – the introduction of resources and/or development of capabilities that are new to an adopting organization (Hameed et al., 2012, pp. 358–359) – is one way to achieve this goal. Organizations may, for instance, use process innovations to enhance their profitability by improving resource and energy utilization as well as by producing less waste (Watson et al., 2010, p. 32). They may also adopt novel IS that may prevent or minimize the resources being used and consumed. The use of digital invoices (rather than printed ones, with lower use of printers and printer cartridges) or video conferences (instead of physical travel to meetings) can be new chances (Simmonds & Bhattacherjee, 2015, p. 4).

Traditional research into innovation adoption or into sustainable innovations can be categorized by a focus on a single technology (e.g., Karanasios et al., 2010), by taking an organizational (e.g., Molla, Pittayachawan, Corbitt, et al., 2009), or an individual perspective (e.g., Molla et al., 2014). Some studies have taken a phased approach, investigating factors that influence the pre-adoption (e.g., Radu, 2016), adoption (e.g., Deng & Ji, 2015), and outcomes (e.g., Loeser et al., 2017) of an innovation. Sustainable or green innovations – as a set of technologies and practices that benefit both an adopting institution (Yang et al., 2016, pp. 2–4) and the natural environment (Simmonds & Bhattacherjee, 2015, pp. 8–9) – are a specific innovation class. They can be described in light of the many well-researched insights (e.g., Dedrick, 2010; Hameed et al., 2012; Malhotra et al., 2013), but need expansion to address emerging global than just organizational or societal challenges.

Recent research found green innovations, especially in the current digital business environment, differ from general innovations concerning the determinants of adoption. This is not limited to innovation or technology characteristics (Lunardi et al., 2015, p. 4) but also the subsequent innovation process (Schmermbeck, 2019, p. 2051), their performance, and the consequences of adopting them (Yang et al., 2016, pp. 9–10).

Organizational decision-makers must understand these competitiveness-related and sustainability-related implications if they are to address them in use-related decisions (Molla & Cooper, 2014, p. 20). In this way, these implications can be fully integrated and used as an additional variable in general resource management (Dao & Abraham, 2018, p. 2).

2.2 Green IS

Green IS are a particular category of sustainability innovations, as it requires a reasonably long term to unfold its sustainability potential. This is due to IT equipment production causing the consumption of resources, the emission of greenhouse gasses, and potentially more non-recycled waste (Molla, Pittayachawan, Corbitt, et al., 2009, p. 5). On the other hand, IS can also be vital to addressing these issues. It can help to prevent the creation of waste (e.g., by using digital documents (Lunardi et al., 2013, p. 11)), to reduce the resources used (e.g., by video-conferencing (Simmonds & Bhattacherjee, 2015, p. 4)) and the energy used (e.g., reusing data center thermal emissions (Molla & Cooper, 2014)).

Many studies have examined the concept or factors that influence organizations' adoption of Green IS (e.g., Loeser et al., 2017). They, for instance, ascertained that if organizations evaluate their sustainability portfolio, they will also assess Green IS (Nishant et al., 2013, p. 12). Moreover, in organizations that have adopted Green IS, there is a positive alignment between general sustainability and Green IS (Yang et al., 2016, pp. 12–13).

Research also found many organizations undertake specific Green IS initiatives to increase efficiency and use Green IS to reduce electricity, the use of physical resources, and waste emissions (Karanasios et al., 2010, p. 2). Also, IT-heavy organizations seem to focus on efficiency by virtualizing servers and data centers or by improving the cooling of their remaining servers (Erek et al., 2009, p. 7). They ascertained the outcomes of Green IS can be categorized (Schmermbeck, 2019, pp. 2051–2052) into the organizational level (e.g., increased IT operational efficiency (Lunardi et al., 2015, p. 6)) or the individual level (e.g., improved social conditions for employees (Lunardi et al., 2015, pp. 4–5)), while others had sociological (e.g., increased awareness of sustainability (Wang et al., 2015a, p. 403), 2015b, p. 676) or environmental outcomes (e.g., electricity, or greenhouse gas emissions savings (Simmonds & Bhattacherjee, 2015, pp. 8–9)).

Few studies brought together these two streams. One we refer to took prevailing conceptual and empirical insights and abstracted them into a general Green IS adoption framework (Schmermbeck, 2019). It is a first step toward a comprehensive picture of the determinants of sustainability, the adoption of Green IS innovation, adoption, and its outcomes. Especially the results of Green IS adoption are of interest since they seem to be the most appropriate way to evaluate the success of the adoption of innovation.

3 Research Approach

3.1 Study Conceptualization and Creation

We chose a quantitative approach for the following reasons. First, we seek to confirm the selective insights into the maturity and diffusion of organizations' Green IS use (Lunardi et al., 2013, p. 11) and the outcomes of sustainability in institutions (Larrán Jorge et al., 2016, p. 673; Sayeed & Gill, 2009, p. 6; Simmonds & Bhattacherjee, 2015, pp. 8–10). Second, we seek to confirm and enrich previous conceptual findings that frame organizational adoption and use of Green IS as a process. It is not only influenced by the factors of the adopting organization and its members but also by society and the natural environment (Schmermbeck, 2019, p. 2047). Third, we aim for high rigor and a sample that allows us to categorize and investigate relationships within the generated data sufficiently. Fourth, we chose breadth over depth in order to get potentially better generalizable results.

Publicly available data on sustainability tends to be hardly comparable, as it provides a superficial understanding of an organization's environmental actions and outcomes (Hilpert et al., 2014, p. 2). We, therefore, chose to sample and question organizations directly and theoretically. For this, we conceptualized and created a questionnaire that contains extracted and self-developed items, and that addressed five constructs in six sections (see Table 1).

In section 1, the participants were welcomed. Section 2 was about respondents' demographic data and organizations' characteristics. Section 3 contained questions about IT department characteristics. Section 4 asked about organizations' sustainability means and Green IS adoption status. Section 5 had questions about the outcomes of general, and Green IS actions. In section 6, we thanked and dismissed the respondents.

Since not all studies contained detailed information about the specific items used, and since some were qualitative studies, the identified items needed to be modified or operationalized to fit our means. For instance, we took the job title descriptions (Molla, Pittayachawan, Corbitt, et al., 2009, p. 7) but extended the answer options to the job titles of CEO, Chief Financial Officer (CFO), Middle Manager, and Others. To fit the open question "Is there an environmental or sustainability action plan in your company?" (Sayeed & Gill, 2009, p. 3) to our needs, we altered it to a closed three-point Likert scale (with the three options: 'Yes, a corresponding strategy or directive has been implemented', 'No, but the implementation of such a strategy or directive is being planned', and 'No, an appropriate strategy or guideline has not been implemented and is not being planned'). We used specific questions ('Does your organization have a CIO?', 'Does your organization pursue a strategy to protect the environment or is there a sustainability policy?', and 'Does the environmental or sustainability policy cover the IT department?') as filter questions to direct respondents to only relevant questions.

With regard to a globalized working environment, we had the questionnaire translated into the lingua franca by an external, non-native, yet fluent English-speaking researcher. Hereby, language barriers and misunderstandings could be avoided. We jointly reviewed and then implemented the translations in an online survey tool (Loeser et al., 2017, p. 521). The pre-test of the questionnaire took place with a group of four researchers from the IS domain, two practitioners from an IT service provider, and a non-IT-related practitioner.

Table 1. Construct overview

Construct	Conceptualization	References
Use and administration of sustainability	The use, promotion, and support of general sustainability innovations, actions, and processes in the organization that, based on its current economic and social structures, seek to positively influence its environmental sustainability.	(Erek et al., 2009; Larrán Jorge et al., 2016; Lunardi et al., 2013; Molla, Pittayachawan, & Corbitt, 2009; Sayeed & Gill, 2009)
Use and administrative support of Green IS	The use, promotion, and support of Green IS innovations, actions, and processes, as a dimension of the organization's general sustainability actions, that seek to positively influence its IT department, organizational structures, and external markets.	(Erek et al., 2009; Molla, Pittayachawan, & Corbitt, 2009)
Non-adoption of Green IS	The non-use or non-adoption of Green IS innovations, actions, or processes.	Self-developed
Status of Green IS initiative	The extent and maturity of the use, promotion, and support of Green IS innovations, actions, and processes in an organization.	(Erek et al., 2009; Molla, Pittayachawan, & Corbitt, 2009)
Outcomes of general sustainability and Green IS initiatives	The outcomes of i) generally sustainability and ii) specific Green IS innovations, actions, and process outcomes that affect the organization's environmental sustainability.	(Sayeed & Gill, 2009; Simmonds & Bhattacherjee, 2015)

3.2 Data Collection and Sample

We searched and sampled for companies in Germany that had undergone any sustainability initiative (e.g., the use of environmentally certified products or practices) or also used Green IS. We identified the sample by means of websites that offer an overview of sustainably engaged companies. Blauer Engel is, for instance, an eco-label of the Federal Government and publishes a list of these companies. Through a purposive, confirmative (and thus theoretical) sampling frame, we identified companies i) linked to any sustainability initiative or ii) that produce or use environmentally friendly products or services. By this thorough evaluation basis, our results may also be tested and further developed with a sample of companies that i) have not yet started a sustainability initiative or had contact with sustainable technologies, or ii) in which these or Green IS adoption had failed.

Since the study is intended to investigate general IS adoption outcomes as part of the organization's general sustainability initiatives, we asked for CIO, CFO, or Chief Green/Sustainability Officer (CGO/CSO) to fill out the questionnaire. We contacted the representatives either i) directly via personal e-mail or ii) via the organization's general contact e-mail with a request for the material to be forwarded. All recipients received an invitation package with an invitation letter and a project description. They were ensured of our conformance with EU General Data Protection Regulation 2016/679 as well as of anonymous participation. We asked them to participate honestly and offered to send the study report upon completion. The e-mail addresses were systematically saved separately. The survey period was from November 14, 2018, to February 28, 2019. We contacted 850 companies (N) and received 105 clicks and 55 fully filled out (and thus valid) questionnaires (n) – a 6.47% response rate.

With especially Green IS as a relatively novel and practice-based topic (Sedera et al., 2017, p. 675), we took the small sample as sufficient for descriptive analysis (Leidner et al., 2018, p. 5064). We consequently did not aim for statistical theory testing or significance analysis but chose to document and outline potential trends within our data.

Most responses came from organizations of the services and craft or energy and environment sectors (each 5; 9.1%). 50.9% (28) reported their organizations' strategy is to proactively open new markets, also by using novel technologies, while 10.9% (6) reported only addressing stable markets by using established technologies. Concerning employee numbers, the organizations were categorized into four classes: i) very small (up to 50) with 20 (36.4%); ii) small (51 to 250) with 12 (21.8%); iii) medium (251 to 1,000) with 10 (18.2%), large (> 1,000) with 11 (20%), and 2 (3.6%) non-respondents (NR). Most respondents had the job titles CIO (14; 25.5%) or CEO (13; 23.6%); others were middle managers (10; 18.2%), CGOs (8; 14.5%), CFO (1;1.8%), and 9 (16.4%) in other positions. They were asked how long they had been working in their current organization and current position. Concerning overall membership, the span was 1 (MIN) to 32 years (MAX) (AVG = 12.109; SD = 9.150). The job activity reached 1 (MIN) to 30 years (MAX) (AVG = 8.23; SD = 7.451). Of the sample organizations, 37 (67.3%) had their own IT department; there was an IT outsourcing rate of up to 25% for 26 companies (47.3%), 26% to 50% for 9 (16.4%), 51% to 75% for 5 (9.1%), and 76 to 100% for 16,4% (else NR). Further, 34 organizations (61.8%) had an official CIO, 5 (9.1%) had a non-official CIO, and 29.1% had no CIO. 34.5% (19) reported having a CGO/CSO.

4 Results

4.1 General Sustainability Aims, Usage, and Administrative Structures

Concerning sustainability standards and product procurement of all 55 sample companies, 67.3% (37) subscribed to an official sustainability standard (14 NR), 45.5% (25) followed a certified standard (e.g., ISO 14001) (17 NR), and 67.3% (37) procured and used products with an environmental seal (e.g., der Blaue Engel) (17 NR). These standards, for instance, regulate water (23; 41%), electricity (24; 43.6%), paper (27; 49.1%), additional resources (22; 40%), or IT use (14; 25.5%). Of the eight companies without sustainability standards, 87.5% (7) intended to soon subscribe to sustainability standards, of which 42.9% (3) intended to get a specific sustainability standard certificate.

To document how sustainability translates into organizational practices, we asked about the companies' energy use, waste, emissions, and car use management practices. While 87.3% (48) followed or introduced means to lower their energy consumption, 72.7% (40) already actively and regularly inspected their general energy consumption. For 60% (33), these energy-saving means included the use of technical equipment, and for 58.2% (32) also, the use of non-technical means. Moreover, 58.2% (32) of all sample companies used renewable energy, while 12.7% (7) planned to use such. Of the sample companies, 69.1% (38) reported having, and 9.1% (5) plan to adopt a waste management system. Regarding greenhouse gas emissions reduction, 45.5% (25) already achieved actual reductions, whereas 21.8% (12) planned to reduce greenhouse gas emissions. One specifically reported means was car use, distinguished between corporate and private car use. 36.4% (20) organizations encouraged employees to reduce personal car use (18.2%; 10 intentions). For corporate cars, 30.9% (17) encouraged, and 21.8% (12) intended to encourage employees to use these less.

4.2 Green IS Administration and Relevance

4.2.1 Green IS Usage and Administrative Support

We asked about the use of Green IS in the organization. Of the 55 validly filled-out surveys, 11 (20%) respondents reported their organizations already used Green IS, while 4 (7.3%) planned to use Green IS. Of these 11 organizations, 81.8% (9) fully agreed or agreed on aiming at being a Green IS leader. Of these, 72.7% (8) reported their top management was highly committed or committed to using Green IS; in 90.1% (10) corporate procurement decisions. Of the sample, 45.5% (5) reported encouraging employees to use IT assets sustainably. In 54.5% (6) of these organizations, the CIO was responsible for coordinating Green IS activities, while 36.4% (4) defined a specific role to support organizational Green IS activities. Further, 18.2% (2) of the organizations had not yet but were about to introduce such a position.

4.2.2 Reasons for Non-Adoption

We also asked about reasons why organizations did not (yet) undertake a sustainability initiative. Of the respondents, 4 (7.3%) provided insights. Two of them specifically mentioned sustainability is "Not on the board's agenda" and "At the bottom of the management priority list." Another reason, as noted by two respondents, was sustainability would not be a customer requirement or not a strong one. The absence of "short-term benefit in relation to costs." was a third reason.

Table 2. Reasons for non-adoption of Green IS

Responses	Reason for Green IS non-adoption
40.9% (9)	No, too little relevance – IT and the IT department consume too few resources compared to the rest of the organization (e.g., production lines).
18.2% (4)	A lack of resources – the IT department has insufficient resources (esp. time and personnel) to initiate Green IS initiatives.
13.6% (3)	No clear benefit – Green IS is not part of top management's agenda since its benefits are unclear.
9.1% (2)	No suitable products or services – organizations are bound to use mainstream and established product and service providers for reasons of product performance and service quality.
9.1% (2)	No demand – a lack of legislative, societal, or customer demand, or customers ask for cheap and reliable rather than sustainable products and services.
4.5% (1)	Other IT priority – the IT department must focus on other aspects, e.g., customer acquisition and the meeting of service levels.
4.5% (1)	No potential – it is not possible to save additional resources (e.g., in R&D activities).

The reasons 40% (22) of organizations did not pursue Green IS activities or initiatives were more diverse and fell into seven classes (see Table 2). For most (40.9%) organizations, IS sustainability, would have too little impact on the organization's overall sustainability outcome. Further, 18.2% would like to use Green IS but either lacked the resources or could not communicate the benefits to top management. Notably, some companies actively used sustainable products (e.g., Fairphone) but reverted back to using mainstream ones for reasons of higher product and service quality.

4.3 Status of Specific Green IS Actions

For reasons of better comparability, we chose to report on specific Green IS initiatives of the 11 organizations using Green IS by distinguishing between actions that aim at benefits for the natural environment, society, the organization, and employees (Schmermbeck, 2019, p. 2047). Here, we did not report on initiatives that specifically address the natural environment since this is considered as an initiative's overall goal and is hence separately reported on.

4.3.1 Societal Level Actions

Two questions covered this level. We asked Green IS using organizations i) if they selected vendors according to sustainability criteria and ii) if they donate equipment they no longer require. 54.5% (6) selected and 9.1% (1) had selected vendors along sustainable criteria, and also 54.5% (6) donated, and 18.2% (2) had donated unused equipment.

4.3.2 Organizational Level Actions

Concerning the broad spectrum of these initiatives, we distinguished between reporting on i) equipment use, ii) IT equipment use, iii) IT management, iv) energy management, and v) resource management.

Equipment use: All 11 organizations (100%) reported on recycling equipment (printers and other hardware) and using multipurpose equipment; 81.8% (9) used products wholly or partially made from recycled components; 90.9% (10) collected recyclable materials; 63.6% (7) used or had used trade-in and exchange options for old hardware, while 18.2% (2) of organizations were considering this option.

IT equipment use: Of all 11 companies using Green IS, 81.8% (9) reported on i) consolidating and virtualizing of servers, ii) virtualizing desktops, and iii) constantly updating their data center(s); 90.9% (10) reported suitably disposing computing equipment; and 63.6% (7) reported they were exchanging or exchanged monitors for more energy-efficient ones.

IT management. 90.9% (10) of organizations increased their IT hardware's product lifecycle while the remaining organizations planned to do the same; 54.5% (6) reported using and 18.2% (2) intending to use IT for ecological facility management; 45.5% (5) actively perform energy-efficiency analyses of IT equipment; 27.3% (3) had a sustainability board.

Energy management. Most of the organizations (90.9%; 10) used renewable energy; 63.6% (7) also used energy management systems and/ or selected software along energy-efficiency criteria. A minority (27.3%; 3) reported reusing or having reused IT equipment heat for other purposes (e.g., heating of facilities) (9.1%; 1).

Resource management. The use of recycled paper is one of the most frequently named Green IS resource management means, implemented in 90.9% (10) of all organizations using Green IS, followed by non-use of devices made of or with hazardous materials (72.7%; 8); 36.4% (4) used or had used (9.1%; 1) environmental control systems (e.g., checked or had checked gas emissions or water quality).

4.3.3 Individual Level Actions

The use of Green IS also influences every employee in an organization (Schmermbeck, 2019, p. 2052). We found employees of 90.9% (10) of all organizations utilized Green IS employed

teleworking or video-conferencing instead of physically traveling to a meeting. The same number of respondents reported using digital rather than physical documents. Addressing employee printer use seems to be essential since 90.9% (10) of organizations encourage their employees to print double-sided, 81.8% (9) limited employee printer use by consolidating and reducing the number of devices, and 54.5% (6) monitored employees' printer use. We also found 72.7% (8) had or had had a campaign to make employees aware of Green IS-related topics, while 18.2% (2) intended to take a campaign up.

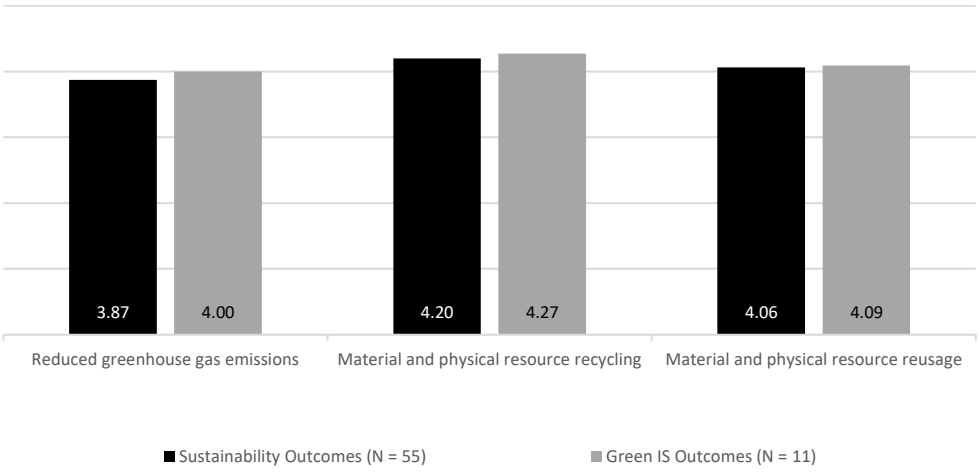

Figure 1. Average scores for natural environment outcomes on a Likert scale ranging from 1 (very negative) to 5 (very positive)

4.4 Sustainability and Green IS Outcomes

We asked if organizations' sustainability and Green IS actions had negative, positive, or no neutral effects and categorized results into four levels (Schmermbeck, 2019, pp. 2051–2052).

4.4.1 Natural Environment-Level Outcomes

We measured these in terms of the recycling of materials, the use of recycled materials, and greenhouse gas emissions. For all three items, we derived slightly better average values for Green IS outcomes than for general sustainability outcomes (see Figure 1).

For reducing greenhouse gas emissions, the numbers also suggest fairly positive outcomes on the natural environment (positive or very positive general sustainability outcomes for 60% of organizations and 72.7% Green IS outcomes). We observed a trend toward conserving natural resources via the recycling of used materials and physical resources (positive or very positive outcomes for general sustainability for 56.4% of organizations, and 81.8% outcomes for Green IS), the reuse of recycled materials (positive or very positive general sustainability outcomes for 61.8% organizations and 72.7% Green IS outcomes). Notably, on average, 33.3% (general sustainability) and 39.4% (Green IS) outcomes had no or a neutral effect on the natural environment.

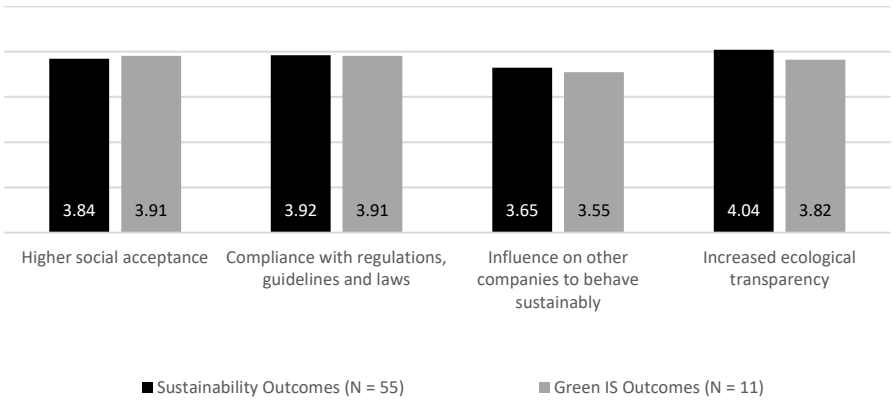

Figure 2. Average scores for societal outcomes on a Likert Scale ranging from 1 (very negative) to 5 (very positive)

4.4.2 Society-Level Outcomes

We measured these in terms of social acceptance, legislative compliance, increased transparency, and influence on competitors. We derived mixed average values for Green IS outcomes as for general sustainability outcomes (see Figure 2). Three specific results are worth highlighting: First, although observed for only one organization (1.8%), general sustainability can negatively affect social acceptance (positive or very positive effect for 58.2%, and not observed for Green IS). Second, the societal outcome to influence other organizations to behave sustainably was relatively low. 49.1% report a neutral or no effect of general sustainability, and 63.6% for Green IS. Third, sustainability's overall social visibility was likewise very low, with an average of neutral or no effect of 34.1% for general sustainability and 47.7% for Green IS.

4.4.3 Organizational-Level Outcomes

We measured these categories of resource and energy procurement and used them as well as respective costs, for which we also highlighted three results (see Figure 3 for average value comparison). First, we found general sustainability outcomes may also have negative consequences for organizations. 5.5% reported higher repair costs, 3.6% longer processing times, and 1.8% uncertainty concerning energy use forecast. Second, 65.5% reported positive or very positive general sustainability outcomes for the reduction of general resources consumed, and 67.3% reduced energy consumption. Third, we ascertained Green IS has positively influenced energy consumption and the cost of the energy used (both 90.9%). However, it may often affect processing times (63.6%) as well as repair costs and performed work (both 45.5%) neutrally or not positively.

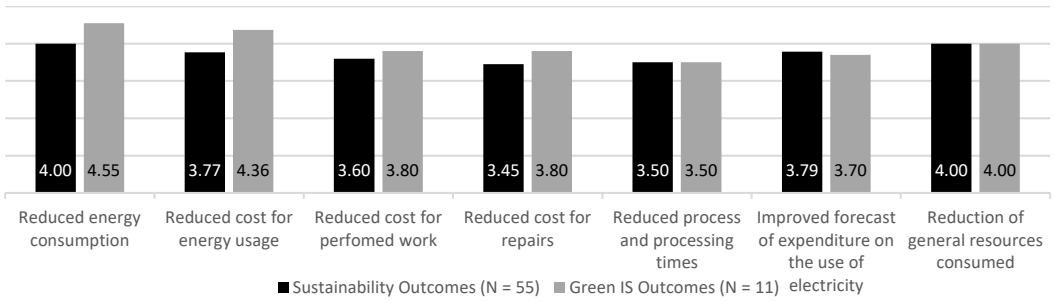

Figure 3. Average scores for organizational outcomes on a Likert Scale ranging from 1 (very negative) to 5 (very positive)

4.4.4 Individual-Level Outcomes

We measured employee compliance, awareness of sustainability, and Green IS (see Figure 4). General sustainability actions were reported to influence both dimensions positively. 70.9% reported positive or very positive outcomes on employee awareness and 60% on compliance with sustainable behaviors. Green IS seems to have only a medium influence on both aspects since 36.4% of the respondents reported no or a neutral effect.

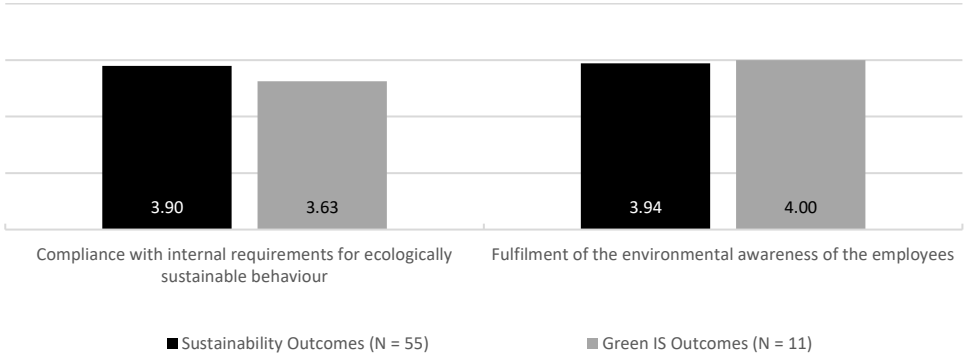

Figure 4. Average scores for individual outcomes on a Likert Scale ranging from 1 (very negative) to 5 (very positive)

5 Discussion

The results of our documentative study provide detailed insights into organizational sustainability, and Green IS practices and their outcomes, but also why organizations choose not to pursue sustainability and Green IS endeavors. We will now discuss selective findings and compare sustainability and Green IS outcomes before noting limitations, paths for further research, and the contributions of this study.

5.1 Sustainability and Green IS Outcomes

We discuss three findings in detail. First, organizations that use Green IS have a top management that is very committed to it. Thus, sustainability and Green IS efforts seem to be introduced and progressed in a top-down way (Deng & Ji, 2015, p. 16749). The conceptualized individual level (Schmermbeck, 2019, p. 2052), hence, seems to be of primary importance in the outcome and not the introduction phase.

Second, many sustainability and Green IS initiatives had no or a neutral effect. Some reasons may be sustainability technologies, and Green IS i) require a long time for their effects to materialize (Olson, 2008, p. 28), ii) are not as sustainable, or their outcomes are not as sustainable as desired (Lunardi et al., 2015, p. 3), or iii) still require different measurement sets (Schmermbeck, 2019, p. 2052). None of these potential reasons is easily be explained or eliminated. Researchers could seek detailed insights into i) long-term effects and outcomes, ii) the production and conception of Green IT and Green IS, or iii) other likely benefits, including intangible ones.

Third, we found 40.9% of organizations that did not use Green IS reported non-use because of foreseeing insignificant benefits. They argue that departments, such as manufacturing and production, contribute far more to organizational sustainability balance. A reason for neglecting Green IS's benefits may be organizations' understanding of Green IS as only saving energy. They ignore that Green IS also includes IS support of organizational production processes and the use of IS-based environmental management systems (Loeser, 2013, p. 6).

5.2 Sustainability and Green IS Outcome Differences

5.2.1 Natural Environment-Level Outcomes

As other researchers suggested (Hart, 1995, pp. 992–993), we confirmed that Green IS has positive impacts on the 'end of the pipe' of products. Especially for innovations, which require significant amounts of resources to produce and operate, the sample organizations reported that Green IS reduces greenhouse gas emissions and increases the recycling of material and physical resources. This indicates the benefits to the natural environment of consolidating IT (e.g., servers and data centers) and the recycling of unused hardware.

5.2.2 Society-Level Outcomes

Our results indicate that while Green IS had positive outcomes for organizations, general sustainability had a more positive impact overall. This is especially visible in increased ecological transparency and influence on other organizations to behave sustainably. Both results may originate from Green IS being the single organizational sustainability initiative of the entire spectrum in organizations. If IT is of little strategic importance in an organization, for instance, compared to production and manufacturing, its visible contribution is – similarly – of lower priority.

Notably, Green IS has had a slightly higher impact on social acceptance compared to sustainability initiatives generally. This may be an indicator that Green IS can contribute to selectively raising awareness and acceptance, although other sustainability factors are more critical for some organizations. An organization may, for instance, decide to reduce the number of meetings for which its employees must travel to other locations (Olson, 2008, p. 24). This highly visible decision may lead to higher social acceptance of the organization and its sustainability decisions, as it is yet more accustomed to traveling to customer meetings.

5.2.3 Organizational-Level Outcomes

Regarding organizational outcomes, we highlight three results. First, Green IS is reported to clearly lower the amount of energy consumed as well as its costs. This may be explained by observations that organizations consolidate IT hardware or replace it with more energy-efficient hardware. Moreover, it does not only highlight Green IT as a first step (Loeser, 2013, p. 6) but cores a Green IS practice set (Ijab et al., 2011, p. 4). Second, Green IS was reported to reduce repair costs. This may be unexpected since extending the lifecycle of IT as the underlying Green IS practice is commonly also associated with the cost of repairing and replacing malfunctioning hardware. A potential reason for this observation may be the necessary communication of extending IT lifecycles to users, leading to the more careful treatment of hardware. Apparently contradictory to the first findings, we commented on respondents' reporting on a worse forecast of expenditures for electricity use. This may be explained through changes in electricity use dynamics. For instance, we assume that before introducing Green IS, energy use was reasonably constant (e.g., servers were running permanently, and monitors and computers stayed switched on). The introduction of energy-saving software or hardware automatically switches to idle or energy-saving modes and causes demand-based electricity use that is harder to predict.

5.2.4 Individual-Level Outcomes

On the individual layer, the sample organizations reported far worse compliance with Green IS behaviors in contrast to general sustainability behaviors. Two facets of Green IS innovation may explain this. Green IS use, continued, and Green IS-related behaviors are significantly

influenced by the respective technologies' ease of use (Deng & Ji, 2015, p. 16751) as well as personal benefit (Simmonds & Bhattacherjee, 2015, pp. 4–5). If none is sufficient, neither top management as a decision-making unit to use Green IS nor individual users will use it.

5.3 Limitations, Further Research, and Contribution

This study has limitations. Notably, we only surveyed a small sample size. Though surveys among top-managers commonly have low response rates (Loeser et al., 2017, p. 519), it greatly limits our results' generalizability. Further, we only found a relatively small number of organizations that publicly reported on using sustainable and ecologically friendly products. This also negatively influences our results' generalizability to organizations using Green IS.

Moreover, as most respondents were not just CIOs but also came from non-IT-related positions, they may have been unaware of Green IS actions or uninvolved in respective sustainability initiatives. This further biases these studies' results. We, thus, encourage further research that i) comparatively investigates organizations whose offerings rely on IS and that only use IS for support and ii) specifically addresses CIOs and CGOs.

We call to address our study's limitations but also to build on our results. For instance, we found specific organizations stopped using Green IS and have suggested reasons for this. In addition, while we found positive sustainability and Green IS initiative outcomes, we recommend shedding light on the clear assignment – which initiatives result in which benefits – as well as on the underlying innovation and adoption processes.

Our work is also beneficial for practitioners. The specific insights may serve as productive arguments to introduce Green IT, as we also found some organizations do not pursue Green IS, as its benefits are unclear to top management. Our results may also provide fruitful arguments to advance both sustainability and Green IS initiatives and extend these initiatives aimed at outcomes to additional levels.

6 Conclusion

As environmental issues are becoming increasingly pressing to the global community, organizations must consider sustainability aspects. Adopting sustainable innovations such as Green IS is one way to address this challenge. We addressed shortcomings in contemporary research by providing a comprehensive documentation of both sustainability and Green IS actions and their respective outcomes. We found that Green IS' outcomes can substantially help to reduce energy consumption and greenhouse gas emissions, although few organizations have embraced Green IS as part of their sustainability portfolio so far. These insights, which are also helpful for practitioners, provide a solid basis to further research. In particular, initiatives that have no or neutral effects should be further researched, as well as organizational reasons for stopping the use of Green IS.

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V

RELEVANCE AND SIGNIFICANCE OF SUSTAINABILITY – GREEN IT/IS AS A NIECE TOPIC IN SMES IN THE DACH REGION

Abstract

Green IT and Green IS have been a topic of discussion for some time and are becoming increasingly important components for companies on the path to environmental sustainability. However, it is unclear how widespread sustainable information technologies (ITs) and information systems (IS) measures are in practice, with what goal they are used for, and how their impact is measured. To address these questions, we conducted a survey study with small and medium-sized enterprises (SMEs) in the German-speaking DACH region. This paper provides insight into the responses of 1,535 companies showing that although most consider environmental sustainability relevant (70.8%), only a few (23.7%) implemented metrics to examine the sustainability of their business. An even smaller proportion adopted Green IT (11.2%) or Green IS practices (9.4%). This indicates a need for research on the successful adoption and use of Green IT/IS in companies and its contribution to the company and the environment.

Keywords: *Green IS, Green IT, SME, sustainability, international survey*

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1 Introduction and Motivation

Addressing the global ecological challenges seems to be the central task for the world community. General research interest in the topic is continuously growing, and also the IS community is paying visibly greater attention to this topic (Engert et al., 2016, p. 2833). While this primarily concerned technical and engineering questions (e.g., research on wind turbines or solar panels (Watson & Kranz, 2021, p. v)), research interest in managerial aspects of corporate sustainability (Seidel et al., 2017, p. 42) is growing. Also, an increasing number of companies have discovered that environmentally friendly behaviors are not only worthwhile (Watson et al., 2010, p. 25) but that they can use digital transformation initiatives to reduce their environmentally harmful influences (Bohas & Poussing, 2016, p. 5).

There are many ways how companies can use information technologies (ITs) and information systems (IS) to improve their corporate sustainability (Gonserkewitz et al., 2021, p. 168). Two concepts that are frequently associated with digitally enabled corporate sustainability are Green IT, and Green IS. While *Green IT* sees the respective technologies as a 'problem' that needs to be addressed (Deng & Ji, 2015, p. 16738) and focuses on the sustainable design of IT devices and their life cycle (Loeser, 2013, p. 5). *Green IS*, on the other side, considers IT, but also IS, as a potential solution to these challenges. Their aim is thus not only to reduce negative impacts of IT use (e.g., increased resource efficiency) (Gonserkewitz et al., 2021, p. 173) but to (re)design and improve organizational processes to reduce and avoid damage to the social and ecological environment (Brockhaus et al., 2017, p. 938).

Research on Green IS/IT is still dominated by rather conceptual contributions (Harnischmacher et al., 2020, p. 3). For instance, there are various papers that examine the concepts of Green IT/IS (e.g., Loeser, 2013; Watson et al., 2010), the process of their adoption (e.g., Molla, 2008; Schmermbeck, 2019), and their use in organizations (e.g., Hu et al., 2016; Lunardi et al., 2013). Other studies suggest guidelines for their application. Lunardi et al. (2015, p. 9), for instance, postulate the creation of organizational policies, procurement, and monitoring as critical measures of Green IT adoption. Hu et al. (2016) identify the factors that determine a company's Green IT practices but focus primarily on external factors (e.g., government regulations and industry standards) and exclude internal factors and processes. They do not identify specific Green IT measures but base their findings on "efforts to integrate environmental principles and energy-efficient operations into the technology lifecycle" (p. 1150).

Empirical Green IT/IS studies primarily examine specific groups of companies, regions, or a relatively small number of companies. For example, Brezavšček et al. (2019) studied 156 Slovenian small and medium-sized enterprises (SMEs) and concluded that implementing Green IS can lead to improved environmental and social performance. Bohas and Poussing (2016)

studied 815 Luxembourgian companies. They identified different types of Green IT adoption whose drivers are economic (e.g., cost reductions) and social factors (e.g., Green corporate image). The findings of these studies are interesting and relevant for Green IT/IS research but limited by their focus on one country.

Ultimately, there is a lack of comprehensive insights into how widespread Green IT/IS are adopted and used beyond individual regions or industries. This insight is not just interesting for organizational decision-makers but also for researchers. For practitioners, a study that explores the degree of diffusion of these technologies would, of course, serve them in primarily two ways: First, it would set a relative benchmark and give them the opportunity to compare and evaluate their own companies' sustainability, and Green IT/IS initiatives against a broad spectrum of other companies. Second, it would also offer them to assess the potential of initial or advanced sustainability and Green IT/IS adoption and usage with which they can potentially create or extend a natural resource-based competitive advantage over their competitors (Deng & Ji, 2015, pp. 16745–16746; Hart, 1995, p. 991).

For researchers, such a study might uncover an underlying problem of the current Green IT/IS body of knowledge that needs further addressing. The insight that sustainability, as well as Green IT/IS, are not or only sparsely spread across a greater set of companies might indicate a fundamental issue with corporate sustainability initiatives. It would contradict the relatively frequently made statements that sustainability is vital to them, and, for instance, identify them as greenwashing (i.e. corporations spend more time on stablishing a sustainability image than actually undertaking sustainability measures (Hazel & Brittany, 2020, p. 2)).

It would also underline that companies seem not to see the benefits of sustainability and sustainability innovations, such as Green IT/IS. The latter would indicate the need for significantly more practitioner-based and oriented Green IT/IS groundwork, like the one from Gonserkewitz et al. (2021), who collected and categorized Green IT/IS means by the time-horizon of their implementation and potential environmental benefit. If the outcome, on the other side, uncarved signs for relatively widespread adoption and usage, research could focus on deriving best practices and potential for improvement (e.g., Bohas & Poussing, 2016).

To contribute to research and practice in the outlined ways, we conduct a multinational survey that sheds light on the status quo, as well as the internal and external factors that lead to the adoption and use of Green IT/IS in organizations. The following research question (RQ) summarizes the focus of the study:

RQ: *How relevant is environmental sustainability and the use of Green IT/IS to companies, and how do they use and manage the measured deployed?*

To answer this question, we are conducting a quantitative survey study that aims to

i. with which goals companies pursue an explicit sustainability strategy,
ii. whether (Green) IT/IS are part of this strategy, and
iii. which Green IT/IS practices the companies have implemented.

We focused on SMEs in Germany, Austria, and Switzerland, as an increasing number of these companies consider sustainability as an essential differentiation and competitive factor (Hammann et al., 2009, p. 38). Moreover, they are a cornerstone of the economies of these countries and account for more than 60% of industrial pollution in Europe. Furthermore, these countries share commonalities (e.g., language and organizational culture) as well as differences (e.g., legislation, innovation aspects), which make a later analysis of the framework conditions attractive.

In the following, we first present relevant theoretical concepts. This is followed by an overview of our research method and an insight into the results of our survey. Finally, we discuss the results and conclude the article with a conclusion and outlook.

2 Conceptual Foundation

Most publications on Green IT/IS either explicitly or implicitly build up on two central IS theories that are also core to this work: The Diffusion of Innovation (DOI) theory (Rogers, 2003) and the Resource Based View (RBV) (Barney, 1991; Wernerfelt, 1984) or its modification of the Natural Resource Based View (NRBV) (Hart, 1995).

The first illustrates and describes the process of how innovations – as anything new or unknown to an organization – are accepted and adopted by a population of adopting entities (i.e., individuals or organizations). It is heavily influenced and closely linked to the Innovation-Decision Process, which models a five-stage process through which an entity "passes from first knowledge of an innovation to forming an attitude toward the innovation, to a decision to adopt or reject, to implementation" (Rogers, 2003, p. 170).

The second describes that organizations can build a relatively strong competitive position – compared to their competitors – based on acquiring and developing resources (i.e., "those (tangible and intangible) assets which are tied semipermanently to the firm" (Wernerfelt, 1984, p. 172)) that are, for instance, of high value, rare, or imperfectly imitable (Barney, 1991, pp. 106–107). The NRBV takes this argument and transfers it to the context of the natural environment. It argues that the theory's negligence of the biophysical (natural) environment leaves a significant strategic white spot (Hart, 1995, p. 986) and suggests a multitude of interconnected strategies with which companies can address it.

These fundamental views are implicitly relevant to our project since the integrative Green IT/IS adoption framework (Schmermbeck, 2019) builds up on them. It follows these theories and illustrates our understanding of Green IT/IS adoption and use. The framework distinguishes four dimensions of influencing factors: Factors of i) the natural environment, ii) society, iii) the adopting organization itself, and iv) the individuals within the organization. As in the DOI, it distinguishes several phases: i) pre-adoption, ii) adoption, and iii) post-adoption. These phases of adoption are framed by an initial (outset) and final (outcome) phase, which can be understood as specific snapshots. In these, the typical (positive or negative) behavior of the company is determined. In this way, the framework also enables the degree of goal achievement or a before/after state to be recorded.

We chose to rely on this framework for two reasons: First, it extends the (yet) dominant views of Green IT/IS as regular innovations. Similar to the argumentation of modifying and expanding the RBV by the factors of the natural environment (Hart, 1995, p. 986), this view excludes the aspect that Green IT/IS adoption and usage are heavily influenced by factors of the natural environment (Deng et al., 2015, p. 1). It thus not only draws an incomplete picture of immediate adoption determinants but also of their interrelation with the other aspects (Schmermbeck, 2019, p. 2047). Second, it provides a relatively encompassing and holistic but also a

simple view of the complex matter of the Green IT/IS adoption and usage process, which gives it potentially higher explanatory power.

2.1 Research Method

As outlined, there are few empirical and almost no multinational studies on the adoption and use of Green IT/IS. The topic of sustainability in connection with IT/IS seems to be frequently discussed (Lunardi et al., 2015, p. 2) but not yet in such demand (Engert et al., 2016, p. 2834) as to be a driver for entrepreneurial practice (Brockhaus et al., 2017, p. 938). Companies seem yet to realize Green IT/IS potential on a broad scale, and we consequentially saw a great need for an observant study that sheds first and fundamental insights (Recker, 2013, p. 32) on the prevalence and relevance of Green IT/IS for companies and chose an exploratory quantitative approach.

We are aware that it is traditionally qualitative approaches that are seen as suitable for exploratory research (Recker, 2013, p. 34) and that – to achieve a large number of cases for analysis – often literature reviews are undertaken. Schiederig et al. (2012), for instance, investigated 8,516 publications to identify the most relevant publications and consequently draw a picture of green innovation management to identify the most active scholars and institutions (p. 180).

Non-literature-based exploratory quantitative studies are nevertheless also not unknown – also in the IS research domain. Abramova and Böhme (2016), for instance, used the approach to representatively investigate the perceived benefits and risks of Bitcoin usage in European countries. Like our approach, they were also interested in factors that influence the use of innovation. They designed a large-scale survey and collected 6395 responses from users in Estonia, Germany, Italy, the Netherlands, Poland, and the United Kingdom, and effectively identified and explained key determinants and barriers to using Bitcoin as an alternative payment system (p. 14).

Similarly – and with a focus on Green IT – Dick and Burns (Dick & Burns, 2011) took a similar quantitative exploratory approach to investigate corporate Green IT usage. They surveyed "a small number (16) of small businesses in the north Georgia area" (p. 62) and hence also fall in the category of studies we criticized earlier (small number of cases and narrow geographical focus) and therefore have only a merely methodological relevance to this study.

Non-literature-based analyses, however, require having identified a number of promising cases that can be used for analysis. There also exist specific databases and lists that list sustainability-associated companies (e.g., Blauer Engel, Deutscher Nachhaltigkeitskodex). Our tries to make beneficial use of these, nevertheless, resulted only in results with limited explanatory power (see paper 4). This result also leads to selecting this somewhat unusual approach.

2.2 Questionnaire Design

The questionnaire was designed in two phases: i) a phase of conceptual grounding and literature work, and ii) questionnaire design. Our overarching goal was to create a questionnaire that was thematically focused but also sufficiently short to elicit a meaningful set of responses.

We first reviewed literature dealing with quantitative Green IT/IS research. The foundation for this was our understanding of Green IT/IS and related practices (Loeser, 2013). The search terms 'Green IT', 'Green IS' were combined with 'quantitative' to search the primarily English language (Green IT/IS) literature (El-Rayes et al., 2022, pp. 3–4). To use literature primarily relevant to business information systems, we used AISeL and Scopus as search engines. 2007 – the year Green IT was first coined (Harnischmacher et al., 2020, p. 2) – was set as the base year, and we obtained 326 hits. After sifting through the titles, keywords, and abstracts, 31 relevant articles remained. We then analyzed the constructs used (e.g., socioenvironmental awareness) and items (e.g., "The company has well-defined environmental policies and strategies"), reducing the sample to four articles (Larrán Jorge et al., 2016; Lunardi et al., 2013; Molla et al., 2009; Sayeed & Gill, 2009).

From the identified items, we created a questionnaire whose final version included 16 questions and included descriptive information (e.g., "In which state is your company's headquarters located?"), general (e.g., "How relevant is environmental sustainability to your company?"), and specific questions about sustainability and green IT/IS relevance (e.g., "In which of the following IT/IS areas are environmentally sustainable criteria taken into account?") were queried. The questions were grouped into four thematic blocks:

- Demographic information (e.g., number of employees)
- Sustainability orientation (e.g., the relevance of sustainability)
- Sustainability measurement and reporting (e.g., the definition of targets and KPIs)
- Green IT/IS practices (e.g., sustainable procurement of IT)

A filter question was formulated for each block to ensure that respondents answered only the questions relevant to them. If filter question 1 ("Has your company defined concrete, measurable targets for environmental sustainability?") or filter question 2 ("Do the KPIs include the use or utilization of IT/IS use?") were answered positively, the participants were forwarded to the next question block. Otherwise, respondents were thanked, and the survey was closed. Accordingly, in deviation from the basic population (N_0), we labeled the complete set of responses to the questions after filtering questions 1 and 2 as N_1 and N_2, respectively.

2.3 Survey Conduction

We did not focus on specific industries but only paid attention to the fact that the SMEs' business models or operations rely on IT/IS use. To select the SMEs, we used the Amadeus database and filtered for companies headquartered in Germany (D), Austria (A), or Switzerland (CH). This resulted in a sample frame of 126,961 companies (D: 99,945 (78.7%); A: 12,588 (9.9%); CH: 14,428 (11.4%)).

Potential participants were contacted by email in the fall of 2020. This mail included a description of the research objective with a link to the survey. We received 1,684 fully completed responses (response rate: 1.3%), of which 149 cases were excluded (e.g., if the same answer was given for all questions). This resulted in 1,535 (N_0) valid responses (D: 82.4%; A: 8.0%; CH: 9.6%). Of the participants, 60.7% were from high management, 26.0% from middle management, and 9.3% from lower management (4.0% no answer). 1.5% of the participating SMEs were founded before 1850, and 78.6% after 1950. More than half of the respondents (57.9%) worked in SMEs with fewer than 50 employees (D: 54.8%; A: 59.1%; CH 59.9%).

3 Results

Our survey shows that, on average, only 7.8% of all participating SMEs regard sustainability as irrelevant (70.8% as relevant). It is striking that this is higher in Austrian and Swiss SMEs than in Germans (see Table 1). After all, 60.0% of all respondents stated that their company has an explicit environmental strategy (15.6% already for more than seven years). Further, 12.2% of the companies questioned plan to integrate sustainability into their corporate strategy in the near future. This shows that sustainability seems to be an essential and growing topic for SMEs.

However, it is striking that only 23.7% had defined KPIs. This supports the finding that while a large proportion of companies consider sustainability important, they either do not consider it sufficiently necessary to advocate for it (Brockhaus et al., 2017) or lack the know-how or resources to build an appropriate KPI system (Gonserkewitz et al., 2021, p. 178). 51.0% of the participating SMEs stated that they considered IT/IS to be relevant for sustainability. This is remarkable, as only 25.9% of the companies were from the IT, services, or communications industries. The discrepancy indicates that companies not closely dependent on IT/IS also seem to be aware of the sustainability impact of these technologies.

Table 1. Relevance of sustainability, KPIs, and Green IT/IS

Respondents who stated that in their SME ...	**A n = 122**	**CH n = 148**	**D n = 1264**	**Total N_0 = 1535**
Sustainability is considered relevant.	73.8%	76.4%	69.9%	70.8%
Sustainability is explicitly implemented in the corporate strategy.	68.0%	63.5%	58.8%	60.0%
Sustainability is measured and monitored on the basis of targets/KIPs.	22.1%	26.4%	23.3%	23.7%
IT/IS are considered relevant components for corporate sustainability.	53.3%	50.0%	50.9%	51.0%
The contribution of Green IT/IS measures is measured and controlled using KPIs.	10.7%	12.8%	12.2%	12.1%

Of all SMEs that reported measuring sustainability (N_1 = 364), 50.8% used both quantitative and qualitative KPIs; followed by 33.2% that applied only quantitative KPIs. Most companies collected data on an annual basis (61.3%). This may be of interest, as especially the increased use of Green IS – e.g., to redesign processes (Brockhaus et al., 2017, p. 939) – opens up the possibility to measure changes continuously (Engert et al., 2016, p. 2834).

Regarding the intention of why sustainability is measured, we asked if the companies aim to reduce or increase certain aspects or values. In terms of reduction, we found that the majority of SMEs measured the consumption of energy (81.3%) and (raw) materials (80.2%), as well as the cost of energy consumption (78.0%). This was to be expected, as these data can be measured with little effort and derived from, e.g., procurement or invoice data.

Although greenhouse gas emissions are a frequently mentioned sustainability indicator in the literature, they were measured by only 53.8% of all SMEs. This is probably due to the fact that emissions are complex and often only indirectly measurable or calculable (Gonserkewitz et al., 2021, p. 169). In terms of desired gains resulting from the collection of sustainability KPIs, compliance with laws and regulations seems to be crucial for SMEs (65.8%), followed by the desire to improve the environmental awareness of employees (60.4%).

It is worth noting that we found differences in the goals of the companies of the individual countries: Swiss SMEs seem primarily interested in increasing the number of recycled materials (CH: 92.3%; D: 77.8%; A: 69.8%). For Austrian SMEs, there was a strong tendency to want to reduce electricity consumption (A: 85.2%; D: 81.2%; CH: 79.5%), comply with prescribed laws and regulations (A: 70.4%; D: 66.5%; CH: 57.7%), and establish greater environmental transparency (A: 59.3%; CH: 56.4%; D: 46.6%). German SMEs, on the other hand, focused more on raising employee awareness (D: 61.1%; CH: 59.0%; A: 55.6%). These objectives could be due to different political or social boundary conditions, the comparison of which could be informative in further research. It could also be investigated whether sensitization is understood merely as an objective or also as a means to greater sustainability.

Table 2. Green IT/IS KPIs

Respondents who stated that they consider environmentally sustainable criteria in ...		**A n =13**	**CH n = 19**	**D n = 154**	**Total N_2 = 186**
Green IT	IT-Sourcing	76.9%	68.4%	64.9%	66.1%
	IT-Operations	76.9%	73.7%	71.4%	72.0%
	IT-Disposal	84.6%	94.7%	64.9%	69.4%
Green IS	IT/IS-Governance within the IT-Department	46.2%	42.1%	33.1%	35.0%
	Sustainable (re)design of processes in the organization	69.2%	78.9%	63.0%	65.1%
	Development and distribution of products and services	15.4%	52.6%	24.7%	26.9%

The responses of those participants who stated that they included (Green) IT/IS in their sustainability KPIs (N_2 = 186) revealed differences in the implementation of the individual Green IT and Green IS measures (see Table 2). The most frequently used KPI is the sustainable disposal of IT equipment, presumably because it is the easiest to collect and measure (Gonserkewitz et al., 2021, p. 171). This is particularly relevant for Swiss SMEs (94.7%) (but only for 69.4% on average).

Overall, we observed that Green IT measures and metrics are used much more frequently than Green IS measures/metrics. It is striking that IT/IS governance practices – i.e., appropriate management structures for individual IT/IS resources and processes – are significantly un-

derrepresented (Ø = 35 %), especially compared to the sustainable design of business or production processes (Ø = 65.1 %). This was not to be expected, as redesigning governance practices is critical to establishing Green IT/IS (Molla et al., 2009, p. 11). Accordingly, it would be interesting to find out how SMEs have redesigned their business processes without changing the underlying governance structures and how effective these are. It is also striking that Swiss companies seem to be far ahead in the use of Green IS, not only redefining their business processes but also including them in the development and distribution of sustainable IT products and IS services.

4 Discussion, Limitations, and Outlook

This paper provides an overview of the relevance of environmental sustainability and the adoption of Green IT/IS innovations in SMEs in the DACH region of Austria, Germany, and Switzerland. Specifically, it looked at i) with which goals companies pursue an explicit sustainability strategy, ii) whether (Green) IT/IS are part of this strategy, and iii) which Green IT/IS practices have been adopted.

We documented a variety of reasons and goals for SMEs to behave in a measurably more sustainable manner. Primarily, the use, consumption, and output of materials (e.g., raw materials and supplies, energy) shall be reduced, while the optimization of processes (e.g., labor costs, throughput times) seems to play a subordinate role. This may be related to the fact that the consumption of physical materials is relatively easy to measure, and – as illustrated by the (N)RBV (Barney, 1991, p. 112; Hart, 1995, p. 989) – the value contribution can be explicitly calculated. The fact that many SMEs strive for higher compliance with laws and regulations (Ø = 74%; N1), higher ecological transparency (Ø = 68.5%; N1), as well as better forecasting of energy consumption (Ø = 57.1%; N1) is certainly also related to the fact that these are in turn prerequisites for reducing resource use and consumption.

Furthermore, many SMEs want to behave more sustainably in several categories that cannot be measured directly. On average, 70.3% of all SMEs (N_1) stated that they wanted to improve the ecological awareness of their employees. 61% (N_1) also want to increase the social acceptance of SMEs. The motives for this behavior do not seem to be explainable by traditional arguments – e.g., there is no economic value contribution – but in the effort to have a positive impact on social society or the natural environment (Schmermbeck, 2019, pp. 2051–2052).

With regard to the question of whether (Green) IT/IS are part of the sustainability strategy, we found that only a small proportion (12.1%; N_0) of SMEs have adopted Green IT/IS. This underlines that these actions (yet) remain non-mainstream business practices (Brockhaus et al., 2017, p. 941), and Green IT/IS seems to continue to be a niche topic (Dick & Burns, 2011, p. 62). It, on the other side, also underlines the tremendous competitive potential of Green IT/IS (Barney, 1991, p. 108; Brezavšček et al., 2019, pp. 1048–1049).

We see three reasons for this – which should be illuminated in follow-up studies: First: The contribution of Green IT/IS is not known to the companies – regardless of which industry they belong to. Second: The contribution of Green IT/IS is known but is considered low or insufficient. Third: The contribution of Green IT/IS is known and is considered sufficient or high, but no investment has been made (yet). The reasons and their implications should be investigated in further studies, that, for instance, focus on a single of few case companies, in which the way to corporate Green IT/IS adoption can be exemplarily investigated (Recker, 2013, p. 95).

Against the background of the Green IT/IS adoption framework (Schmermbeck, 2019) – which we also used – studies like these would not only provide further insights into its applicability and explanatory power but also shed light on i) how sustainable benefits can be communicated positively (outcome phase), ii) at what threshold it is worthwhile for companies to invest in technologies whose contribution cannot be measured by traditional KPIs (pre-adoption phase), and iii) what reasons prevent companies from investing in environmentally sustainable technologies even though their positive benefits are known (outset phase).

The third objective was to investigate which Green IT/IS practices the SMEs have adopted. Here, there is an apparent discrepancy in the adoption and use of Green IT (Ø = 69.2%; N_2) and Green IS (Ø = 42.3%). This is presumably due to the fact that it is easier to make the procurement and disposal of IT, in particular, sustainable, for example, by extending the service life of equipment, procuring more energy-efficient hardware, and donating or recycling hardware to be retired (Gonserkewitz et al., 2021, p. 172). It is also relatively easy to optimize the operation of IT ecologically, for example, activating existing software solutions to manage the energy consumption of the hardware. Changing governance or business processes, as well as developing and selling sustainable products and services, is far more complex and requires more profound strategic changes (Brockhaus et al., 2017, p. 934).

Furthermore, our study shows a clear contrast between the majority of SMEs that consider sustainability to be relevant and the SMEs that also measured and managed this (e.g., through KPIs). On the one hand, this indicates differences in the strategic relevance of sustainability and Green IT/IS (Brockhaus et al., 2017, p. 938). This, of course, is perfectly fine, as companies seek to differentiate against their competitors to clearly define and improve their competitive position (Hart, 1995, p. 1008). On the other hand, the sustainability efforts of some companies seem to exist only on paper, which can also be described as greenwashing (Lyon & Maxwell, 2011, p. 10). It seems, therefore, not only advisable but necessary to discriminate and clearly separate from these claims and transparently and truthfully communicate aims, proceedings, and outcomes.

However, many companies may also lack the knowledge of how to integrate tangible sustainably procures into their corporate action portfolio (Engert et al., 2016, p. 2834) and which Green IT/IS factors (e.g., employee attitudes and behaviors) can be meaningfully measured (Gonserkewitz et al., 2021, p. 169). This seems to be reflected in our data as well, as 17.9% of all SMEs reported considering IT/IS for their sustainability for less than three years.

The results presented here provide only a descriptive overview of the status quo of green IT/IS use by SMEs in the DACH region. Our correlation analyses were unable to identify any significant correlations. It is also not known to what extent the participating companies rely on IT/IS use; a crucial aspect that also needs to be addressed in further studies. A limiting factor

is the composition of the sample: significantly more companies from Germany responded, which should be considered when interpreting the differences between the countries. Overall, it would be interesting to see to what extent increasing digitalization influences the role of IT/IS in the context of sustainability or whether the respective countries expect digitalization to influence their environmental strategies. Another limitation is that companies may not be aware that they are already using Green IS/IT.

Another way to build on this study is to conduct qualitative studies. For example, companies that are currently initiating or implementing Green IT/IS initiatives could be accompanied in order to gain specific insights into the relevance of the identified factors for the adoption of Green IT/IS. It would also be possible to scientifically document and process the change processes within the organization(s).

5 Conclusion

This paper presents the relevance of environmental sustainability and the use of Green IT/IS in SMEs in the DACH region. It provides insights that make it clear that while most SMEs consider sustainability and Green (IT/IS) initiatives to be relevant, only a few seem to have done anything substantial in this direction – e.g., by defining KPIs. An even smaller number of companies have adopted Green IT or Green IS practices, although these are recognized as enablers for greater sustainability. With this study, we have contributed empirical results to the research field of environmental sustainability and Green IT/IS practices in SMEs, which has so far been heavily dominated by theoretical papers. These results can now be further built upon and we invite other researchers to do so.

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VI

IT'S JUST NOT SEXY: HOW MANAGERIAL ASSUMPTIONS ADVERSELY AFFECT CORPORATE SUSTAINABILITY ENGAGEMENT AND SUSTAINABLE TECHNOLOGY ADOPTION

Abstract

The negative effects of the global climate disruption are becoming increasingly severe, and they are putting pressure on companies to behave in a more environmentally friendly manner. Although some have started to (ecologically) innovate and acquire sustainable resources and capabilities, some seem to be only reluctantly adopting sustainability. In this paper, we report on two consecutive qualitative studies in which we investigated this divergence. In the first—which involved 25 interviewed sustainability managers from a diverse set of German companies—we found that: i) sustainability was perceived as unattractive and not innovative, ii) the benefits of sustainable technologies only seemed to be beneficial in the long term, and in non-traditional dimensions, iii) green information technologies (Green IT) and green information systems (Green IS) usage often only focuses on end-of-the-pipe measures. In the second study, we discussed these findings with four representatives from two very large German companies, and we concluded that — to become sustainable and make meaningful use of sustainable (IT/IS) technologies — they require external incentives from core interest groups, such as legislators and investors.

Keywords: *sustainability engagement; sustainability technology; innovation adoption; Green IT; Green IS; corporate environmental responsibility; managerial assumptions*

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1 Motivation and Context for Increased Organizational Sustainability

To ‘go green’ and protect the natural environment has become popular among companies. Many seek to reduce their negative impacts on the natural environment (Bohas & Poussing, 2016, p. 240), offer sustainable products and services (Brockhaus et al., 2017, p. 938), and issue sustainability reports that document the environmental impacts of their corporate actions (Threlfall et al., 2020, p. 10).

The reasons for such actions are diverse. Some companies see it as their obligation and a moral responsibility (Brockhaus et al., 2017, pp. 940–941). Some are taking this change in societal priorities as a chance to develop their business models further (Watson & Kranz, 2021, pp. v–vi), adjust their companies’ strategic orientations (Lichtenthaler, 2022, p. 77), or increase their operational and organizational efficiencies (Brockhaus et al., 2017, pp. 939–940).

Similarly, the means of achieving sustainability are also numerous. In the current ‘era of digital transformation’, an ever-growing number of companies realize that they need to become both more digitalized and more sustainable (Watson & Kranz, 2021, p. v), and they see the adoption of information technologies (ITs) and information systems (IS) as a potential way to achieve digitally enabled sustainability (Belkhir & Elmeligi, 2018, p. 448). This realization has consequently led to a similarly increasing demand for technologies and solutions that bridge both needs (Schrade-Grytsenko et al., 2022, p. 1).

The associated technologies are often referred to as Green IT, which describe the usage and management of IT during their lifecycles, as well as Green IS, which coins governance practices, internal processes, and operations that connect a company to its external market (Loeser, 2013, p. 8). These IT resources and IS capabilities (Puvaneswaran & Alsdorf, 2021, p. 8) offer not only utilitarian benefits (Ijab, 2019, p. 1) but also a sustainability-based competitive advantage (Lichtenthaler, 2022, p. 77). They improve a company’s environmental sustainability “by informing stakeholders of the need to make changes to business as usual, by motivating them to take actions to achieve environmental objectives, and by assessing the impact of such actions on economic and environmental performance” (Melville, 2010, p. 12).

Although technological and sustainability benefits such as these seem promising, and various companies have developed successful pro-environmental strategies and actions (Handrito et al., 2021, p. 2241), “sustainability has failed to become a game-changing, mainstream business practice” (Brockhaus et al., 2017, p. 941). Many companies only slowly or reluctantly adopt sustainability practices, and they seem to only act as the pressures from governments (Citizens’ Climate Lobby, 2021), societal interest groups (IPCC, 2022), and ethically aware consumers (Leidner et al., 2022, p. 595) continue to grow. For instance, accusations have been aimed at Unilever, Shell, and Nike that they only “use sustainability to build either brand image or act

as an insulator in brand risk management" (Brockhaus et al., 2017, p. 938). In the case of Shell – which is a leading global oil and gas company – the Dutch district court in The Hague saw it as imminent that Shell would breach its obligation to reduce its carbon dioxide emissions and ordered it to lower them by 45% by 2030 compared with their 2019 levels (Lichtenthaler, 2022, p. 87). Other companies have been directly confronted with greenwashing accusations, such as BP, another oil and gas company, which frequently highlights "the company's investments in renewable energy without mentioning their major efforts in petroleum exploration" (Lyon & Maxwell, 2011, p. 4).

Academic insights into the genuine relevance of sustainability to companies and the reasons that they might avoid real sustainability changes are rare. Some researchers address this topic as a side note, such as Zimmermann (2019), who documented that – because companies are driven by multiple motives – they integrate corporate sustainability practices into their core business practices differently (e.g., from strict to non-existent). In other studies on energy- and material-saving technologies, researchers have found comparable results. They have found that manufacturing companies only rarely adopt these technologies (Palčič et al., 2013, p. 410) and that, at the overarching country level, there are substantial differences in the statuses and further development of different countries around the globe (Cunha et al., 2018, p. 165).

In addition, there is only limited research on why Green IT and Green IS are still not being widely diffused and implemented (Ijab, 2019, p. 1). There are some practitioner insights (e.g., Walker, 2015) that view misaligned incentives, competing priorities, and a lack of expertise as the core issues of proper institutional Green IT usage. However, current academic research seems primarily focused on general aspects of Green IT/IS (Harnischmacher et al., 2020, p. 2), such as the understanding of Green IT and Green IS (e.g., Loeser, 2013; Watson et al., 2010), or their roles in different areas or literature (e.g., Brooks et al., 2010; Sedera et al., 2017). Specific insights into the innovative process of their systematic adoption and the factors that affect it are few (Ijab, 2019, p. 1). Schmermbeck (2019), for instance, proposed a framework that captures the reasons, processes, and potential benefits of sustainable technology and Green IT/IS adoption. Although the author generated novel insights into a variety of environmental, societal, organizational, and individual factors, they remained conceptual.

Studies that present an overview of multiple companies from different countries and their sustainability initiatives – which might allow for a more detailed evaluation – are even more scarce. That of Alsdorf et al. (2022) is one of the few. These authors undertook a multi-national study assessing 1.535 companies and found that – although more than 70% regarded sustainability as relevant – only about 24% also defined their performance indicators to measure and steer their strategic sustainability goals. This substantial discrepancy raises

questions about the sincerity of the respective sustainability strategies being followed and the reasons why so many companies are not adopting tangible means of sustainability.

We thus sought to provide a better understanding of the factors that negatively influence or prevent companies from meaningful pro-environmental engagement and/or hinder them from adopting and using sustainability-engaging technologies, such as Green IT/IS. We specifically ask:

RQ: *Which aspects negatively influence a company's sustainability engagement and its subsequent adoption and usage of sustainability technologies, such as Green IT and Green IS?*

We consequently aim to enrich and deepen the understanding of this area, as well as provide detailed descriptions of the background and context of why companies (do not) adopt sustainability and sustainable technologies, such as Green IT/IS. We focus on (top) managerial perceptions, as their leadership is the key to leading and coordinating sustainability efforts (Batulan et al., 2021, p. 4775).

The current paper is a continuation of previous work that provides empirical insights into the corporate adoption and relevance of Green IT/IS in Germany, Austria, and Switzerland (Alsdorf et al., 2022), but also into the conceptual foundations, such as the process of Green IT/IS adoption, and the influential factors inside and outside of an organization (Schmermbeck, 2019).

Because there was limited previous research to build our work on, we chose an exploratory approach because it allowed us to add the intended context data (Mayring, 2015, p. 50). As a starting point, we used qualitative data from an ongoing study on the adoption and usage of Green IT/IS. We extracted insights from the 21 interviews that we conducted, and we summarized them into specific statements that describe the constraints on i) the determinants of sustainable technology adoption, ii) the determinants of sustainability as a societal phenomenon, iii) more specific details on the adoption and usage of Green IT/IS. We used these statements as a basis for a follow-up round of interviews with four representatives of two companies from the initial study.

The results from this follow-up interview study seem beneficial for both research and practice. They provide details on why sustainability, as well as sustainable technologies, needs to be treated, evaluated, and managed differently than traditional innovations (e.g., Schmermbeck, 2019). Furthermore, they also underline that corporate sustainability efforts indeed face certain hindrances, such as prejudices or hidden assumptions, that can be addressed, for instance, by extending and transparently addressing the evaluation criteria of impending traditional and sustainable innovations.

The remainder of the paper is structured as follows: In Section 2, we provide a brief overview of the central concepts and terms of this research and how we understand the organizational adoption process. Section 3 contains detailed descriptions of the research design, with a focus on the collected data that serve as the core of this work, and on the recent interview study, including the data analysis. We also describe how we addressed the credibility, transferability, dependability, and confirmability quality criteria of the qualitative research (Lincoln & Guba, 1985 ch. 11). Sections 4–6 contain the results of the initial and current studies, followed by a brief discussion of each. We thematically sorted the sections according to general sustainability (Section 4), sustainable technology adoption (Section 5), and Green IT/IS adoption and usage (Section 6). In Section 7, we draw conclusions and state the limitations of the studies, as well as the potential for further research.

2 Conceptual Foundations of Sustainable Technology Adoption

In this section, we outline the conceptual foundations of sustainable technology adoption, starting with an outline of the general sustainability concept. We then link the concept to the primarily entrepreneurially relevant triple bottom line. Going deeper into the corporate context, we lay out selected academic perspectives on how a corporate strategy is directly or indirectly influenced by sustainability. Finally, we present Green IT and Green IS technological options that enable or support corporate sustainability.

2.1 Sustainability and the Triple Bottom Line

In the academic discussion, sustainability is frequently linked to the understanding of sustainable development, which is defined as a development "that meets the needs of the present without compromising the ability of future generations to meet their own needs" (Brundtland Commission, 1987, p. 24). This understanding is rather abstract, but it is nevertheless one that is generally agreed upon and that links the interest of economic prosperity with those of environmental quality and social justice (termed the Triple Bottom Line) (Elkington, 1998, p. viii).

As it is challenging to investigate all three goals in one study fully, many researchers have focused on one aspect of sustainability. In the business information systems literature, many researchers consider the ecological aspect (e.g., Alsdorf et al., 2022; Brockhaus et al., 2017; Gürlek & Tuna, 2018; Leidner et al., 2022). This tendency seems to be fueled by the ever-worsening prognosis of the state of the natural environment (e.g., IPCC, 2022), the consequentially growing voices of environmentalist groups (e.g., Fridays for Future, Scientists for Future, Extinction Rebellion), and governments around the globe that pass increasingly strict environmental protection laws and legislation. For instance, as of 2021, 44 OECD countries – which are responsible for 80% of the global carbon emissions – have a carbon pricing policy in effect (OECD, 2021, p. 2).

Clearly separating the stated and intended causes of organizations and their sustainability actions is often difficult. In a similar way, it is often impossible to clearly link the stated causes to the tangible sustainability means and outcomes. For example, take the often-referred-to towel-washing notes in hotels. Many hotels ask their guests to reuse towels and to put used ones on the floor if they want them to be cleaned. The hotels' stated intention is to save water and hence reduce their negative impact on the natural environment (Orange, 2010, p. 30). Although messages such as these are clearly framed with an ecological intent, their usage is often criticized as 'greenwashing' (i.e., "the act of misleading consumers regarding the environmental practices of a company or the environmental benefits of a product or service."

(TerraChoice Group Inc., 2009, p. 1) when the intention is clearly and primarily set up with the economic intent of saving money (de Freitas Netto et al., 2020, p. 9), despite the certain ecological effects).

Nevertheless, focusing on only the ecological dimension increases the specificity, conceptual clarity, and explanatory power of our study. It allows us to dig deeper into the respective strategic decisions and contexts of the associated innovation adoption decisions. Hence, when talking about sustainability, we refer to the ecological perspective and the organizational aim to efficiently use resources and redesign their processes to achieve a balance between the desires of the present and the needs of the future (Watson et al., 2010, p. 29).

2.2 Strategic Relevance of Sustainability

Respecting sustainability and sustainable practices in corporate settings is a complex endeavor (Elkington, 1998, p. 2). One reason for this may be that sustainability often seems to be an (involuntary) additive to an already outlined and pursued corporate strategy.

The governments of Germany (Presse- und Informationsamt der Bundesregierung, 2019) and most other European countries incentivize companies to eliminate, reduce, or at least compensate for their corporate CO_2 emissions by charging them for their emissions (Bray, 2022). Many governments also require companies to issue sustainability reports regularly and to outlay their impacts on the natural environment transparently (Threlfall et al., 2020, p. 13). They also enforce return policies, which require companies to take back old, broken, or unused products to reduce the amount of electronic waste (Bundesministerium für Umwelt, Naturschutz, nukleare Sicherheit und Verbraucherschutz, 2022). Consequently, companies need to integrate and consider sustainability as a key strategic factor (Baumgartner & Ebner, 2010, p. 78).

Sustainability initiatives are not only forced upon companies but companies often also intentionally and purposefully adopt them with the objective that the chosen investments will pay off in the long term (Orsato, 2009, p. 131). Many academic perspectives that address the reasons and means for such actions often respect this premise and assume that a company possesses the resources and capabilities (i.e., the resource-based view (RBV) of a firm) that it needs to achieve a lasting advantage over its competitors (Barney, 1991, p. 102; Wernerfelt, 1984, p. 173). We agree with and share this view, and we thus also want to outline how it influences our work by highlighting three different works on three distinct levels of abstraction that link the RBV to corporate sustainability initiatives.

In the first work, we conceptualize the natural-resource-based view (NRBV) of firms (Hart, 1995), which is a direct modification of the RBV that acknowledges that companies not only need to respect the “political, economic, social, and technological aspects” (p. 986–987) but

also need to interact with the natural (i.e., biosphere) environment. Neglecting these factors is not only problematic due to the growing magnitude of the ecological problems but also because companies miss the opportunity to use these natural constraints to their advantage. The NRBV posits that by pro-actively minimizing i) emissions and waste, ii) the lifecycle cost of products, and iii) the environmental burden of corporate growth, companies can create a "competitive advantage based upon the firm's relationship to the natural environment" (p. 986). The NRBV is relevant as an underlying concept, and especially its core premise, which states that management theory traditionally neglects aspects of the natural environment.

Brockhaus et al. (2017) put forward the view that takes up this concern for the natural environment, and they investigated how it can be translated into specific corporate and operational goals. Their investigation of 28 European and US companies resulted in a typology of four categories of companies: (1) *image enhancers*, who are only driven by creating sustainable images with green marketing and separate line(s) of eco-products; (2) *efficiency maximizers*, who fall between the former two extremes and are categorized as those companies that are primarily driven by their aim to improve their operational efficiencies; (3) *resource acquirers*, who also fall between the first two extremes and who seek to save natural resources and the human talent for the future; (4) *true believers*, who view sustainability as deeply woven into their companies and sustainable actions as an ethical responsibility. We find these typologies relevant to our work, as they underline that there are not only different approaches, means, and ends to the ways in which sustainability can influence corporate actions but also that these approaches can serve as practical guidelines that can be used to transform sustainability into a competitive advantage.

The third and most specific view combines and specifies the other ones. It posits that companies may choose to adopt sustainable innovations—as one potential tactic to achieve a sustainable competitive advantage by respecting environmental concerns. This view conceptualizes a corporate innovation adoption process that begins with companies gaining initial knowledge. They then form an attitude toward the innovation and decide to either adopt and implement or reject it (Rogers, 2003, p. 168). The framework on Green IT/IS adoption takes this process and specifically adds a natural environment layer as an influencing factor category to the traditionally respected ones of social (e.g., national and international legislative requirements), organizational (e.g., internal: corporate citizenship; external: customer expectations), and individual (e.g., intrinsic motivations) influences (Schmermbeck, 2019, p. 2049). The factors at these four levels do not just influence the specific decision to adopt or not adopt a sustainable innovation. The matter is far more complex, as these factors have already influenced the company before it engages with technological scoping and evaluation as part of the organizational pre-adoption process. For instance, a top manager's attitude towards and concern for the natural environment is highly relevant to whether and how a company engages in sustainability

actions. Thus, we can use this framework to not only visualize our understanding of the corporate adoption process but also how specific (managerial) assumptions and concerns influence corporate sustainability and sustainability technology adoption.

2.3 Green IT/IS and Their Potential for Increased Ecological Sustainability

Green IT and Green IS are concepts that are closely linked to sustainable corporate development (Schmermbeck et al., 2020, pp. 903–904). Green IT considers IT throughout its lifecycle to be the central cause of an organization's unsustainable operations, which can be addressed by purchasing, operating and disposing of IT equipment in a more sustainable way (Loeser, 2013, p. 7). Green IS, in contrast, regards not only IT but also IS as fundamental solutions for a more sustainable organization. Green IS seeks to not only reduce the negative effects of IT usage (e.g., increase resource efficiency or reduce resource consumption) (Loeser, 2013, p. 6) but also to address environmental issues by (re-)designing actively and monitoring the organizational processes to avoid unnecessary harm to the societal and environmental surroundings (Brezavšček et al., 2019, p. 1048; Brockhaus et al., 2017, p. 939). Thus, it is important to distinguish both concepts and to acknowledge that their adoption does not only primarily concern aspects related to technology and resources but also the building of capabilities, such as establishing the required regulatory and governance processes or fostering a sustainability mindset and shared language among employees (Puvaneswaran & Alsdorf, 2021, p. 7).

While Green IT and Green IS are rather novel concepts (Brooks et al., 2010, p. 1; Harnischmacher et al., 2020, p. 2), there is a growing number of researchers who discuss their concepts (e.g., Loeser, 2013; Watson et al., 2010), the process of their adoption (e.g., Molla, 2008; Schmermbeck, 2019), and their usage in organizations (e.g., Hu et al., 2016; Lunardi et al., 2013). They are often considered to be innovations (Gürlek & Tuna, 2018, p. 468) that organizations use to achieve various benefits.

For instance, Brezavšček et al. (2019, p. 1048) highlighted that the three general strategic capabilities, pollution prevention, product stewardship, and sustainable development (Hart & Dowell, 2011, p. 1466), can lead to better corporate environmental and social performances. Loeser et al. (2017, p. 530) documented more specific benefits. They found that sustainable innovations, such as Green IS, may have at least three types of benefits for organizations: (1) an overall cost reduction through the increased process and resource efficiency; (2) reputation enhancement through the measurement of and improvement in an organization's environmental performance; (3) the installment and facilitation of novel organizational capabilities that can lead to competitive and organizational advantages.

In a similar study, Schmermbeck et al. (2020, pp. 907–908) also used the four levels of environmental, societal, organizational, and individual outcomes (Schmermbeck, 2019, p. 2047),

and they not only documented a multitude of benefits, but they also compared the specific outcomes of both the general and specific forms of sustainable technologies. In this way, they highlighted that Green IT and IS are not only prime means of boosting material and energy savings, but they also instill a greater social acceptance of sustainability means and thereby increase the environmental awareness of employees.

Despite these advantages, companies seem to be only slowly acknowledging and adopting Green IT/IS. For instance, Alleau et al. (2021, p. 3) undertook an international study assessing 1,000 organizations with revenues of more than USD 1 billion from a multitude of sectors, and they came to rather sobering conclusions. They found that only 43% of the companies' executives were aware of their companies' IT footprints, and only 50% had compelling sustainability strategies. Consequently, only 6% of them were IT classified as highly mature. Alsdorf et al. (2022) describe a similar scenario. In their study on 1535 Austrian, German, and Swiss small- and medium-sized companies (SMEs), they found that while more than 70% regarded sustainability as relevant, only about 24% had also defined performance indicators to measure and steer their strategic sustainability goals. Furthermore, only 51% regarded IT/IS as relevant components of their organization's sustainability.

Thus, it seems beneficial to investigate the divergence between these two streams of companies: those that find sustainability and Green IT/IS to be a meaningful and multilayered contribution and those that do not acknowledge or see their potential. Shedding light on the assumptions and reasons of the latter group might help not only to understand them better but to assist them in achieving a meaningful competitive and (ecological) sustainable advantage.

3 Research Design and Process

In this section, we elaborate on our research process. Although the published research is still dominated by research methods that can be regarded as quantitative (Kang & Evans, 2020, p. 931), we chose a qualitative approach. Our aim is not to gain insights into the influence of specific factors and the relationship (Deng et al., 2015 ch. 3.2) between them or predict outcomes (Willig, 2008, p. 9) but to enrich and deepen the understanding (Creswell, 2013, p. 131). We seek to better understand a complex phenomenon (Kang & Evans, 2020, p. 941) and to provide detailed descriptions of the background and context of why companies do or do (not) adopt sustainable practices and sustainable technologies, such as Green IT/IS.

To structure this elaboration, as well as the overall process, we used the four-step outline based on Mayring (2015, pp. 61–62): (i) planning the research; (ii) conducting the interviews; (iii) preparing the analysis; (iv) conducting the analysis. Researchers also frequently use this generally accepted approach for qualitative data generation and analysis to, for instance, investigate the contextual factors of organizational structures and organizational effectiveness (Hagerer & Hoppe, 2020), evaluate the dimensions of digital transformation success (Liere-Netheler et al., 2018), or develop new constructs for technology acceptance and adoption (Vogelsang et al., 2013).

However, we should not mistake this for a standardized process that is to be strictly followed. Rather, it is a guideline that may be adjusted to specific research goals, materials, and insights (Mayring, 2015, p. 61).

3.1 Planning and Aligning the Research

This research project is the continuation of a larger and still-ongoing research endeavor on corporate sustainability technology and Green IT/IS adoption at our research institute. Through this endeavor, which sets the overall theme, we seek to provide insights into (i) adoption intentions, (ii) the contextual factors of sustainable technology and Green IT/IS adoption, and (iii) the measurement of the adoption and usage of these technologies. Previous work has been both conceptual and empirical. The conceptual work has provided insights into (i) the nature of Green IT and Green IS as resources and capabilities that organizations use to generate a lasting competitive advantage (Puvaneswaran & Alsdorf, 2021, p. 11), (ii) the overall Green IT/IS adoption process and its ties to factors that are both internal and external to an organization (Schmermbeck, 2019, p. 2049), and (iii) quick wins, with which companies can achieve long-lasting sustainability improvements as a first step towards increased corporate sustainability (Gonserkewitz et al., 2021, p. 171). On the empirical side, we build on works that (i) underline the benefits of sustainable innovations and Green IT/IS in

organizations that have already been using these resources and capabilities for a considerable timespan (Schmermbeck et al., 2020) and (ii) underline the relevance of sustainability and the associated technologies across Austrian, German, and Swiss companies (Alsdorf et al., 2022).

We also build on three currently unpublished studies (referred to as initial studies), which we explicitly report on in Section 3.5. In Study I, we focused on the reasons for corporate Green IT/IS adoption and the measurement of the specific benefits of these technologies. In Study II, we focused on the acquisition and development of Green IT and Green IS capabilities. In Study III, we focused on the influence of the internal and external factors that influence a company's Green IT/IS adoption and usage.

With their ties to the overall research endeavor, all the studies share the same conceptual and empirical bases, which were also synchronized between the individual data collections, and allowed them to be interlinked, compared, and jointly worked up. We present an overview of the overall research process with the conceptual basis, results of the initial studies, and take aways from the current study in Figure 1.

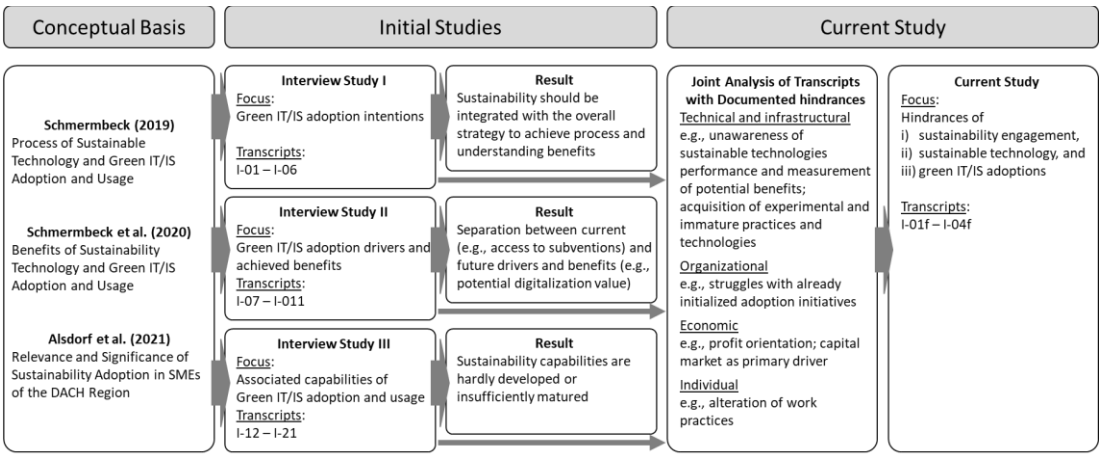

Figure 1. Scheme of the overall research process

3.2 Selection of Expert Interviews

The initial studies – as well as this one – are of a qualitative nature and relied on expert interviews. We chose experts (i.e., corporate decisionmakers whose work concerns strategic or tactical work on sustainability or Green IT/IS matters) due to their core role in leading and coordinating corporate sustainability efforts (Batulan et al., 2021, p. 4775). The active participants were specifically educated in the areas of interest (i.e., strategic decision making, IT/IS planning and operations; an understanding of Green IT/IS) (Diener & Špaček, 2021, p. 7), and they offered us "privileged access to information and knowledge on the subject" (Kuebel & Zarnekow, 2015, p. 7) and rich insights into the promises of and hindrances to sustainability management (Lichtenthaler, 2022, p. 88).

We used semi-structured interviews as the research instrument, the prime benefit of which is that we can address the key dimensions of interest in a structured manner while also maintaining an open conversation with the interviewee (Kuebel & Zarnekow, 2015, p. 7). The method not only allowed us access to personal insights, views, and feelings, but it also allowed us to dig deeper into matters that we did not anticipate during the design of the study and the creation of the interview guide.

3.3 Performing Initial Studies

In the three initial studies, we focused on German companies, and we specifically investigated those with business models that either heavily relied on IT/IS usage (e.g., software developers, IT infrastructure providers), were linked to IT/IS (e.g., IT service providers, IT strategy consultancies), or were highly dependent on IT/IS usage (e.g., energy providers, industrial manufacturing). We acquired the companies and their representatives in diverse ways. We chose some through their publicly accessible sustainability listings and websites (e.g., Blauer Engel, Deutscher Nachhaltigkeitskodex), while we chose other representatives because they were personally known to the researchers or because they had already taken part in one of the previous studies (i.e., Alsdorf et al., 2022; Schmermbeck et al., 2020)).

Table 1. Overview of conducted interviews

	Company			Interviewee
	Industry (Focus)	**Size** *	**#**	**Position**
I-01	Energy	XL	2 **	Digital Technology Strategy Team Member
I-02	Energy	XL	2 **	IT-Service Management Head
I-03	Industrial Manufacturing	XL	2 **	Director of Sustainability
I-04	Energy	XL	2 **	Chief of Staff, CEO Office
I-05	Industrial Manufacturing	XL	1	Purchasing Manager
I-06	Energy	XL	1	Sustainability and Social Responsibility Manager
I-07	Consultancy	S	1	Deputy Managing Director
I-08	Software Development	S	1	CEO *
I-09	IT Infrastructure Provider	S	1	Authorized Officer
I-10	Software Development	S	1	Member of the Executive Board
I-11	Software Development	XS	1	Sales Manager
I-12	Industrial Manufacturing	M	1	Project Lead
I-13	Consultancy	XS	1	CEO *
I-14	Insurance	XL	1	CIO
I-15	Financial Services	XL	1	Head of Data Centers
I-16	Public Utility and Water	L	1	Head of IT Services
I-17	Financial Services	M	1	CIO
I-18	Financial Services	L	1	Head of IT Governance
I-19	Financial Services	S	1	CIO
I-20	IT Hardware Refurbishment	M	1	CRS Manager
I-21	Public Transport	XL	1	Head of Data Centers

Notes. Size categories: XS: up to 50 employees; S: 51–250 employees; M: 251–1000 employees; L: 1001–10.000 employees; XL: 10,000 employees or more. * Female interviewee; ** initial interviews are marked as I-01, and follow-up interviews as I-01f.

We initially contacted all the potential interviewees via email with an invitation to participate in a qualitative interview study. This email contained a brief description of the overall endeavor (see Section 3.1), a more detailed description of the respective study, and a link to a bookable calendar so that the interviewees could easily schedule the dates of their interviews. After they booked their timeslots, we sent them confirmatory emails.

We conducted the interviews via phone or video conferencing tool. We had conducted 21 interviews as of September 2019: six for Study I (I-01–I-06), five for the initial Study II (I-07–I-11), and 10 for Study III (I-12–I-21). Overall, two interviewees came from a company with 50 employees or less, seven interviewees came from a company with up to 250 employees, three came from a company with 251 to 1,000 employees, and nine came from a company with more than 10,000 employees. Regarding the industry, four interviewees came from a financial services company or energy provider, 3 were from industrial manufacturing or software development, and two were from consultancies (see Table 1). We transcribed the conducted interviews of the initial study and sent them to the interviewees with a request for approval.

3.4 Data Analysis of Initial Study Data

The transcripts of the initial studies formed the unit of analysis of our research, and we analyzed them using MAXQDA 22. We first followed an open coding approach and marked all passages that provided any insight into i) the context of organizational sustainability intentions and actions, ii) sustainability technology adoption and usage, and iii) hindrances to sustainability or sustainable technology adoption and usage.

We performed the coding in the following way:

1. We read the transcript and marked the interesting statements or passages. We then paraphrased these with in vivo codes (as the transcripts were in German, and the language of the overall research project is English, we formulated all the in vivo codes and the following further categorizations in English);
2. We summarized all the in vivo codes that belonged together in one category. For instance, we merged the marked text passages “So our entire data center is refurbished” (I-11; l. 89) and “Besides the data center itself also […] all the new acquisitions […] for all the developers and also for all the other employees are "refurbished" goods” (I-11; l. 100-103) under the in vivo code “purchasing of refurbished hardware”;
3. We thematically grouped all the summarized codes. For instance, we thematically grouped “KPI for energy usage in data centers” (I-14), and “measurement of power usage efficiency in the data center”’ (I-21) under “energy supply (data centers)”;

4. We merged constructs that fit together into one thematic construct. Certain code constructs and families had already been outlined and defined before the analysis (deductive category development (Mayring, 2015, p. 85)), such as the previously addressed code family for the definition of the 'Green IT' concept (Loeser, 2013, p. 6).

   Other code constructs were the result of the data analysis (inductive category development) (Schreier, 2014 ch. 2.1). For instance, we categorized the following statement under the code family "Not realized Green IT means": "If we were to sell the [IT equipment] to our employees, we would still have [...] the problem that we are asked when something does not work and to get around this, we said no." (I-17; l. 63 – 65);

5. If needed, we summarized the thematic constructs by an additional superior construct. For instance, we summarized the constructs 'Data Center', 'General IT Management', and 'Office Environment', for instance, were summarized by the superior (first order) construct of 'IT Operations'. We summarized inferior constructs as second-order constructs, and we summarized superior constructs as first-order constructs;

6. (a) If there was a further transcript, then we began the process again from Step 1. However, we did not separately group the additional merged in vivo codes but integrated them into the already existing thematic categories (Step 3); (b) If there was no further transcript, then we took the list of codes and constructs and assessed whether the present merged constructs could be further worked up and summarized by a code family;

7. The cleaning consisted of two rounds. We first started from top to bottom (from constructs to in vivo codes) to ensure that all the code families and constructs were on the same level of abstraction. The second round was from bottom to top to ensure that all the codes of the respective constructs were thematically fitting.

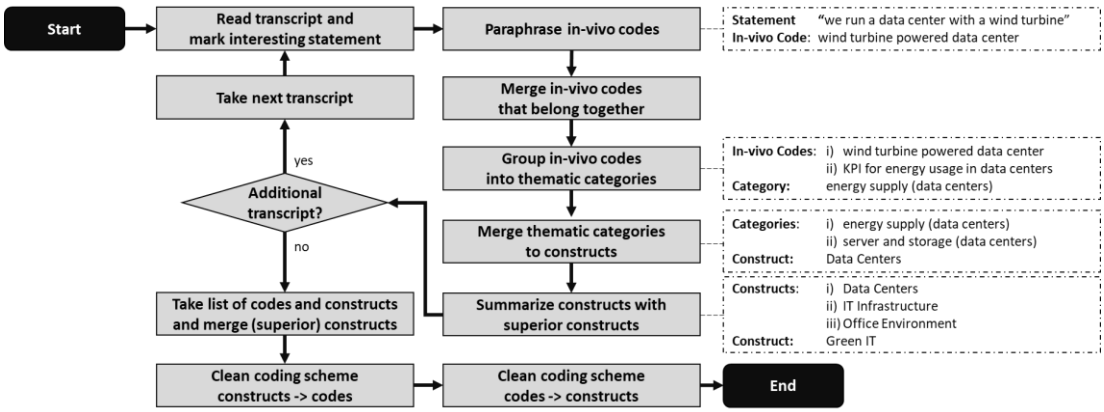

Figure 2. Overview of the transcript analysis process

We visualized the overall analysis process and presented it in Figure 2. An overview of the logic of the marked passages, in vivo codes, code constructs, and code families is presented in Figure 3.

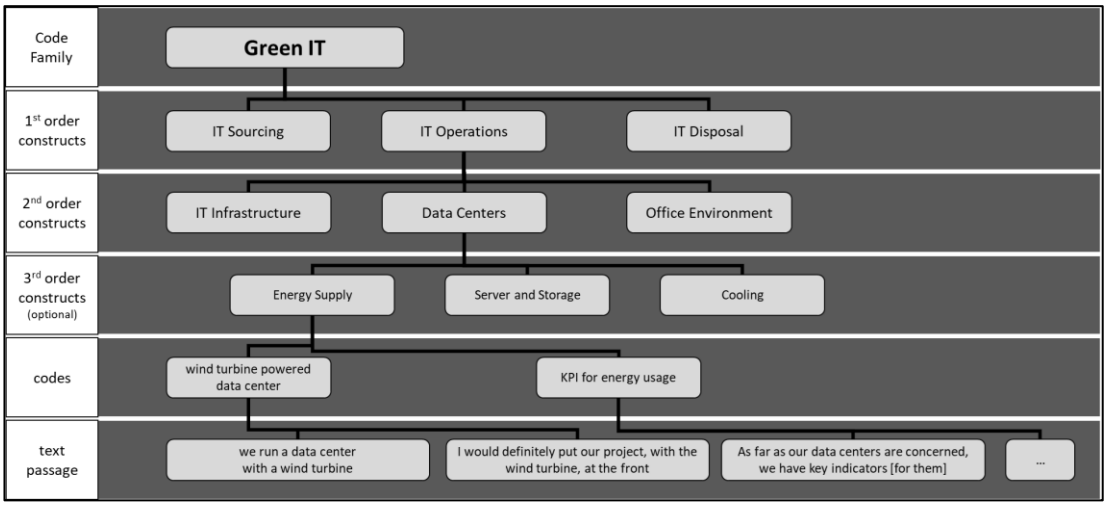

Figure 3. Overview of exemplary code and construct structure.

3.5 Description of Key Findings of Initial Studies

3.5.1 Findings and Implications of Study I

In the initial study, we focused on large companies in Germany. We investigated the specific corporate adoption intentions and preadoption drivers (Schmermbeck, 2019, p. 2049) that initialize the adoption process itself. We conducted six interviews in two companies (I-01–I-06). We selected them based on the leading positions that they took in their respective markets and thus also on their potential to be relatively important influencing and guiding forces on markets, competitors, and the value chain. The generated insights shared certain similarities. For instance, both companies viewed sustainability as something that needs to be fully integrated into the other strategic goals rather than as a separate entity. Moreover, both also valued IT and IS as enablers of the goals of simplifying and rationalizing the processes and deepening their understanding of them. Furthermore, both organizations seemed to see the immense potential in incorporating sustainable IT/IS innovations into a broad range of their products and processes, and to, for instance, further improve their carbon tracking. Despite this, I-01 mentioned that only a few of these alterations are actually put into practice and that more action could be taken. I-01, similar to I-02 and I-04, attributed this to a lack of commitment from the top management and to the fact that — as an economic hindrance — organizations such as theirs are driven by investors, the capital market, and customers.

3.5.2 Findings and Implications of Study II

In the second study, we focused on SMEs in Germany. Although individually, they are not as powerful as the large players on the market, taken together, they have a nonnegligible influence on national and international markets and the economy. In the European Union, SMEs account for approximately 99.8% of all active companies (Evertsson, 2019, p. 31) and for 53% of the European gross domestic product (Bundesministerium für Wirtschaft und Klimaschutz, 2022 para. 1). They also have substantially higher innovation speeds than large companies (Allocca & Kessler, 2006, p. 279). Both reasons could be important factors for increasing the overall corporate sustainability of markets.

In the study, we asked the following: What are the reasons that SMEs adopt Green IT/IS? How do they measure the specific benefits of the technologies used? The first question is primarily relevant to this study because it is also specifically focused on the preadoption phase (Schmermbeck, 2019, p. 2049). To answer this question, we interviewed five representatives of five SMEs (I-7 – I-11). The representatives had taken part in a previous study (i.e., Alsdorf et al., 2022) and were willing to be contacted again.

During the analysis of the data, we documented several adoption drivers, which we split into two categories i) current and ii) future Green IT/IS adoption drivers. Because we conducted the study in June 2021, the COVID-19 pandemic was one of the most frequently named current societal drivers, as it primarily drove the acceptance and adoption of video conferencing and remote working technologies and regulations. We also documented several drivers at the organizational (e.g., access to external funding or subventions, the promise of increased power efficiency) and individual (e.g., increased environmental awareness) levels. For the future drivers, the study documented that the companies expected that the ways of virtual and remote working that were initialized by the COVID-19 pandemic would continue to grow and become more established in the future, thus leading to the adoption of more (Green) IT/IS that, on the one hand, will drive the company' digital transformation and, on the other hand, reduce its environmental footprint. They further expected that the organizational, societal, and individual drivers would continue to interact and further drive them towards Green IT/IS adoption. For instance, I-09 expected that the changes that the automobile industry is currently facing—with altered consumer demands and increased governmental and environmental pressures—might eventually also affect the IT/IS industry with similar mandatory changes. He expected that it would soon be mandatory that data centers be connected to district heating or that their waste heat is used for heating the office buildings in which they are installed.

We also documented several hurdles to Green IT/IS adoption noted by the interviewees that are also key to this work. The interviewees noted that technical or infrastructural hindrances or difficulties were especially problematic for the adoption of Green IT/IS. For instance, I-07

stated that they had no way of installing the measurement instruments to evaluate whether the IT/IS equipment needed improvement or of knowing whether the potentially installed IT/IS would (environmentally) be beneficial (l. 164-172). I-09 stated an analogous situation. He explained that with high technological risk often comes an economic hindrance (l. 413-420). If his company, for instance, wanted to switch its data center from a conventional air-cooling system to a substantially more efficient water-cooling system, then it would have to switch to a partially experimental technology, which, in itself, would also pose a substantial financial risk, as the company and its employees have no experience setting up, operating, or maintaining the novel technology. I-08 and I-15 also mentioned certain individual-level hindrances (Schmermbeck et al., 2020, p. 906), such as that certain employees need specific trainings (I-15, l.392-394) or substantial convincing to use or adopt new technologies (I-08, l.497-502).

3.5.3 Findings and Implications of Study III

In the third study, we focused on the managerial aspects that accompany Green IT/IS adoption. We focused on the associated and needed capabilities of (a) the strategic planning and alignment of Green IT/IS objectives; (b) active process management (e.g., of technology lifecycle management or enhancing business processes with IT/S); (c) establishing and adopting a sustainability-fostering culture and language; (d) compelling governance structures with relevant corporate policy processes to establish regulatory compliance (Puvaneswaran & Alsdorf, 2021, pp. 7–8). We specifically asked how these capabilities can be gained and managed, and we thus focused on the aspects of the adoption and postadoption phases (Schmermbeck, 2019, pp. 2051–2052). To answer this question, we conducted ten interviews across ten organizations (I-12–I-21). The results were rather unexpected, as it turned out that most of the companies did not have developed capabilities, nor did they seem to be actively developing them.

Hence, we asked the interviewees for the reasons that their companies were being prevented from adopting Green IT/IS and the associated capabilities. I-13 and I-16 stated that the reason was the lack of knowledge regarding its benefits. Some interviewees mentioned that—as a technological hindrance—they were not only unaware as to how the technology performed compared to the current state (I-13–l. 293–302), but they were also unaware of certain aspects of the performance of the current technology (I-16–l. 216–218). For instance, they were aware that their data centers consumed energy, but they were unaware of how much of it specifically accounted for running the hardware, cooling it, lighting the facilities, etc. For others, such as I-14 (l. 76–78), Green IT/IS simply had no management priority. I-14 saw no benefit to engaging in a Green IT/IS adoption endeavor because the current digitalization initiatives were already a struggle (l. 67–72). I-15 guessed that this strategic neglect was rooted in a fundamental issue that is primarily observable in the IT/IS industry: “Companies in the IT industry

lay little value on the green. There is a very high emphasis on selling and, if possible, to throw away and buy new" (l. 112–114).

3.6 Creation of Semistructured Interview Guide

We based the semi-structured interview guide used in this study on the extracted findings from the 21 interviews that we initially conducted. We structured it into four thematically interconnected topic blocks: (I) interviewee background; (II) general sustainability; (III) adoption and usage of sustainable technologies; (IV) adoption and usage of Green IT/IS. While Block I only contained questions, we split Blocks II – IV into two parts. The first part consisted of questions that aimed to provide context on the interviewees' views, standpoints, and experiences. In the second part, which was the focus of our attention, we confronted the interviewees with specific statements that we derived from the analysis of the initial interviews.

Taking the analyzed data from Studies I–III (see Section 3.5), we evaluated them for the context factors of sustainable technology and Green IT/IS adoption and usage. To shed light on the research goal of providing a better understanding of the factors that negatively influence or prevent companies from meaningful pro-environmental engagement, we primarily focused on the risks, challenges, or otherwise negatively or critically perceived aspects of (i) sustainability in general (Block II); (ii) sustainable technologies and innovations (Block III); and (iii) Green IT/IS (Block IV). We not only synthesized specific ideas and arguments that, in our view, mirrored the crucial aspects in the respective categories, but we also decided to formulate statements out of these insights (in the following claims) that interviewees might consider potentially provocative or at least exaggerated, while not missing the content specificity. We did this with the clear intention of appealing to the interviewees' emotions, encouraging them to speak more freely and answer more honestly, and to thereby creating more interesting and meaningful insights into the contextual factors of sustainability and Green IT/IS adoption and usage, and also potentially into the rather delicate matter of why a company, or its decisionmakers, might decide against a specifically sustainable course of action.

Blocks II – IV comprised two organizational blocks: A welcome block and a farewell block. In the former, we welcomed the interviewees, and we presented the researcher and study aim. We also informed them that we wanted to record them, and we read them a statement about the purpose and ethical standards of the study (e.g., voluntary participation, confidentiality, anonymity). After the participants agreed, we began the recording.

After the fourth block of questions and obtaining the respective statements, we asked the interviewees whether they had additional comments or concluding remarks to the interview.

After this, we stopped the recording, thanked the interviewees for their participation, and outlined the further proceedings (i.e., transcription of data, data analysis, and workup). We present an excerpt of the interview guide in Table 2.

Table 2. Basic interview guidelines (translated excerpts).

Thematic Aspects	Guiding Questions and Claims
Welcome	Presentation of the researcher and the study. Information about research ethics and confidentiality.
Block I: (Interviewee) Background	Questions - How long have you been working in the company/your current position? - Which role does sustainability play for the company/your position? - Which role do IT and IS play for the company/your position?
Block II: General Sustainability	Clarification and Synchronization of the terms: (i) sustainability, (ii) corporations, (iii) innovations Questions: - What makes an innovation sustainable for you? - Is there a difference between 'regular' and sustainable technologies? Claim: - Sustainability is not sexy.
Block III: Adoption of Sustainable Technologies	Questions: - The adoption of any technology/innovation faces challenges. Which particular challenges do you see for the adoption of sustainable innovations? - How can these challenges be addressed and overcome? Claims: - Sustainable innovations are also only investments that must pay off in the long term. - Many of the highly visible sustainability measures have very little real impact on sustainability. - If you want to be climate neutral, you first must open your wallet to realize measurement points in order to have meaningful data to optimize towards. Otherwise, everything is just kind of a rough estimate, and the measures may not be efficient at all.
Block IV: Adoption of Green IT/IS	Clarification and Synchronization of the terms: (i) Green IT, (ii) Green IS Questions: - Is there a difference between regular IT/IS and Green IT/IS? Why? - What are the challenges when using Green IT/IS? Claims: - Current Green IT/IS measures in companies focus too much on end-of-the-pipe measures—i.e., measures that seek to reduce the environmental impact of the IT/IS used by means of downstream measures and do not change the product or the production process itself - The usage of Green IT/IS carries a high risk of rebound effects—i.e., the risk that increased use of Green IT/IS lead to ecologically opposite effects
Farewell	Additional comments or remarks and farewell

3.7 Planning and Performing the Study

We selected the energy and industrial manufacturing companies for further analysis for two reasons: (1) focusing on these industries had the benefit that similarly large companies could be selected of which the interviewees would have similar or at least comparable views on sustainability and sustainable technology usage; (2) the focus on two large companies and their

representatives also made it possible to interview decisionmakers that had similar positions and obligations. All of them were also part of their corporate sustainability strategy teams, and they thus had the required experience with the companies' sustainability plans, as well as with their internal and external influences. We contacted all six interviewees. Only four interviewees were willing to participate in the follow-up study (I-01f–I-04f).

After conducting the interviews, we transcribed them, sent them to the interviewees for their approval, and formed the unit of analysis for the investigation of the constraints. We analyzed the transcripts for their direct and indirect statements and responses to the statements, and we worked up the analysis.

3.8 Transferability as the Core Quality Criterion

As with any other study, the initial and follow-up studies also faced the challenge of adhering to certain quality criteria. The usual quality criteria for research used to establish generalizability are reliability and internal and external validity (Schreier, 2014, Chapter 1). As qualitative research results cannot be and are not intended to be generalizable but rather transferable to other contexts, we undertook our decisions as to our courses of action (as described in this section) with the intention of ensuring credibility, transferability, dependability, and confirmability (Lincoln & Guba, 1985 ch. 11).

To ensure credibility, we aimed to interview persons with long-term engagement within our areas of interest, and we assessed and ensured that they were from the top or a higher level of management and that their responsibilities included general strategic management, corporate sustainability management, or IT/IS management. We also briefed them about the intentions of the studies, and we asked them to provide honest, spontaneous, and truthful answers.

To address the transferability criterion, we provided a detailed description of our study, its context, and the results. We also ensured, in every interview of the initial and the follow-up studies, that the understanding of the core terminology between the researcher and interviewee was synchronized. The term 'sustainability' and the concepts of Green IT and Green IS especially needed clarification, as they were core to the data collection but are also often ambiguously understood (as previously outlined).

We achieved high dependability by purposefully sampling the companies and adhering to the ethical standards of data generation (i.e., the confidentiality of the interviewees and their companies), as well as through a thorough analysis of the data and detailed descriptions of them. To achieve confirmability, we thoroughly transcribed the interview recordings, and we asked the interviewees to assess and approve the transcripts. We also separated the descriptions and the discussion of the findings of the initial and follow-up studies (see Section 4).

4 Constraints on Sustainability and Sustainable Technologies

In the following sections, we present the statements on the constraints on sustainability and sustainable technologies that we derived from the initial studies, which represent the context factors and reasons that companies do not adopt sustainability (Section 4) and sustainable technologies (Section 5), such as Green IT/IS (Section 6). We present them first, followed by a summary of the comments, thoughts, and insights into the statements from the follow-up study, as well as a brief discussion.

4.1 Sustainability Is Considered Unattractive and Not Innovative

When adopting technology, companies frequently only look at the financials and neglect other categories. Regarding the purchasing department, one interviewee (I-12) personally felt that "sustainability plays a rather subordinate role" (l. 41). Another was glad that he had the freedom to "decide some things against our purchasing department, which tends to only look at the money." (I-15; l. 78–80). Consequently, although sustainability seems to be of great interest to companies (Alsdorf et al., 2022, p. 167; Schmermbeck et al., 2020, p. 906), they often seem opposed to sustainable innovations, and sometimes not just because of reasons directly linked to technology, but because of external factors, such as political and social factors, or internal factors, such as the value system or personal attitude of the adopting entity, which play important roles (Stryja et al., 2017, p. 2885).

Using a digital or mobile device for more than two years seems to have become a sign of being old-fashioned or not innovative. For instance, one interviewee stated that, especially for digital devices, "one always seems old school, or […] are perceived as un-innovative when you use something for a long time" (I-02; l. 316–317). This individual adoption phenomenon also translates to organizational adoption practices and standards. Of course, it is individual managers and decisionmakers that set the standards for how long technology is used within a company, as well as which technology is purchased and adopted in the first place. One interviewee reported this link between corporate and private decisions, describing a situation in which a company replaced the corporate car fleet of internal-combustion-engine cars with electric cars, as "the private [behavior] has […] also had an impact on the professional [behavior]" (I-11; l. 76–79).

We translated these observations (see Table 3) into a statement, with which we confronted the interviewees in the follow-up study: "Sustainability is not sexy". We felt that this not only captured and reflected the (still) predominant societal sentiment but also captured the reason why (i) sustainable products and services are still niche products on the mainstream markets;

(ii) companies do not substantially alter their internal processes towards increased sustainability.

Table 3. Summary of relevant statements on sustainability and sustainable technologies

Category	Constraints and Observations
Sustainability and Sustainable Technologies	**I) Sustainability is considered unattractive and not innovative** • You would just have to combine it with something that gives the decision-maker an additional benefit. Just for the environment, he would not do it. (I-13; l. 109-110) • At the moment, the environment itself is in the unfortunate situation that it does not charge for what is done to it by humans. Well, if every tree were to smack you down, so to speak, when you walk by or when a car drives by, then you would have second thoughts." (I-13; l. 122–115) • The focus we have from a board perspective is on products. Anything that is sustainable products and AI driven products and customer products, those are very welcome. Then for everything else, there is little budget. (I-02; l. 258–261) • We try [to be sustainable]. In some ways, we just decided otherwise. (I-17; l. 59) • For the customer [sustainability] is unfortunately not crucial at the end of the day. Not yet! I think the signs are that it will become more important and the trend will go in that direction. But right now, that is what is secondary. (I-11; l, 504-506) • Especially in companies in the IT sector, incredibly little value is placed on green. There is an incredible amount of emphasis on selling and, if possible, throwing things away and buying new ones. (I-15; l. 113–115) • One is always seen as old school—or how should I put it—as un-innovative if you use something old for a long time. (I-02; l. 316–317) **II) Sustainable innovations are regarded as inferior investments.** • That is not the direct decision criterion at the moment. We have already discussed this a few times, and when you see the comparison in the final bill of what we [as IT] have in electricity costs or energy costs compared to other items, then we do not actually appear on the bill at all. (I-21; l. 69–71) • I will say if we save 10% on electricity in a data center right now, that's good; also for the environment. But it is not that we'll end up with a sum where we can immediately say "Hallelujah". In the end, electricity is too cheap for that. (I-16; l. 129–131) • From the group's point of view, of course, it comes down to the levers that are the biggest at [name of company]. And IT is not one of them. (I-01; l. 104–106) • My impression is that you must come up from the economic side. For instance: If I tell a manager, "If you do it this way, you'll save something" and then mention, "And you'll also save the environment". Then he says, "That's great". But if I just say, "You're saving the environment", there's not much enthusiasm. (I-13; l. 102–105) • Yeah, it's too cost-driven for that in our country. And everything that goes there in the direction of becoming greener costs more money. (I-21; l. 109–110) • The key driver [...] is ultimately the business side. If it [sustainability] doesn't pay off, of course, you have very bad cards there. Whereas, as a rule, you will probably get to the point at some point that you can really say it pays off. (I-16; l. 343–346) • If you do it [sustainable investment] right, you increase your CAPEX and reduce your OPEX. And I think a lot of people haven't realized that yet. (I-09; l. 307–308) • At the end of the day, you still have to flip the coin left and right, and that [sustainability] is, of course, always an investment that's being made. And that's more important than this sustainability idea at the moment. (I-011; l. 489–491) • There are always […] two views. One is more the financial and management view, and the other is more the area of sustainability. […] [and] it is simply crucial that it is possible to marry both worlds. (I-15; l. 34–36) • This understanding [of the investment logic of sustainability], […] must first be developed. (I-09; l. 311–312)

Table 4. Comments on presented constraints on sustainability and sustainable technologies

Category	Constraints and Observations
Sustainability and Sustainable Technologies	**I) Sustainability is considered unattractive and not innovative.** (Rather) yes: • "Yes, that's the way it is. That is not being exemplified anywhere." (I-02f; l. 231–232) • "Yes, I would—if I took a general view—I would subscribe to that. [...] So first of all, sustainability, in the general perception, is still too much associated with restrictions, making sacrifices, and higher costs. [...] And secondly, it's not sexy because sustainability doesn't just exist. It exists because there are certain problems and challenges in this world. The 17 [UN] sustainability goals exist because we have a problem. So, I'll just say: The sustainability goal of fighting hunger in the world doesn't exist so that we can have a nice goal, but it exists because we have a problem with feeding the world." (I-04f; l. 148) (Rather) no: • "It's not like that. [...] I believe that this will then be a matter between the generations. And I think sustainability is one of the central issues of our generation. [...] But it's a very central role in the social discussion. Both in our own consumption and in terms of which employer I choose and in which field I want to work. Sustainability is a very central offer, both to customers and to employees, who also demand it. In that sense, it's not true. Sustainability is super sexy." (I-01f; l. 132–138) • "Sustainability is very sexy because it fulfills a purpose, and it gives people and employees the opportunity to actually see the positive outcome of what they do like that." (I-03f; l. 194–196) **II) Sustainable innovations are regarded as inferior investments.** (Rather) no: • "Well, I find the term difficult to separate. Well, sustainability means making something financially and environmentally sustainable, and not at the expense of the next generation. Well, I mean, clearly, my company is profit-oriented and has to be profitable in some way; also in the interest of the employees and in the interest of society, which benefits from the products. Of course, a product or project must also be financially sound; otherwise, it is not sustainable. That is the very definition. But then again, that doesn't mean that it should be done at the cost of ecology, not under any circumstances. And ideally, a sustainable product means that I can make money exactly with this idea, ecology." (I01f; l. 282–290) • "at the end of the day, everything has to pay off in some way. But I believe that—in the long run — investing in a sustainable technology is cheaper than not investing and then having to finance the environmental impact of the climate crisis. But accordingly, [a sustainable innovation] is a good investment." (I-03f; l. 357–360) (Rather) yes: • "I think we have to answer yes to that. [...] Of course, there will be the idealists who see it differently. They say, 'I'll put my solar panels on my roof and pay 10% more in electricity, calculated over a reasonable time.' There are those, too. But if it has to be in the long run, it would have to pay off somehow." (I-02f; l. 449–453) • "Yes, that is still the case today. We are not a world of idealists. Money makes the world go round, and especially from the perspective of a large public company, I have to say we are investor driven." (I-04f; l. 429–431)

As expected, we received mixed comments on and responses to this statement (see Table 4). Of the four interviewees, two agreed, and two disagreed with it. The two interviewees who agreed argued that the unattractiveness of sustainable technologies was a social issue. One said, "Innovations that are sustainable are usually also not so terribly in demand, because for most users an innovation means nice, sexy and more comfortable" (I-02f; l. 159–160). He seems to directly take up our previous argumentation that only novel (digital) products are seen as innovative and are thus valued and purchased.

A second interviewee commented that "sustainability, in the general perception, is still too much associated with restrictions, renunciations, and higher costs. […] That is why it is not attractive per se" (I-04f; l. 149–151), thereby presenting an argument that seems to support the reason that customers only seem to value new products. He also presented a reason why sustainability may always be seen as a burden: "It is not sexy because sustainability does not just exist, but sustainability exists because there are certain problems and challenges in this world" (I-04f; l. 165). The hunger in the world, he illustrates, is not nice. Addressing it is a serious goal and, hence, sustainability issues are not sexy, but dramatic (I-04f; l. 159–165).

The two other interviewees had different perspectives on this. One argued that the attractiveness of sustainability might be a generational question and that the Fridays for Future movement nicely illustrates this. In his view, the younger generations are substantially different than previous generations: "in personal consumption and in terms of which employer I choose and in which area I would like to work. Sustainability is a key offer, both to customers and to employees, who also demand it. In that respect […] [s]ustainability is super sexy" (I-01f; l. 135–138). The second interviewee supported this claim, arguing that "sustainability is very sexy, as it fulfills a purpose, and it gives people and employees the opportunity to actually see the positive outcome of what they are doing" (I-03f; l. 191–193).

In our view, the arguments both — for and against the sexiness and attractiveness of sustainability to individuals and organizations—seem legitimate. Nevertheless, we also recognize the opportunity for companies to redefine the perception of sustainability to make it sexy, offer products to clients that are revolutionary and sustainable, and redefine and open new markets, thereby standing up against unsustainable forms of consumerism. A general market in which this transition is already visible is the food market. Alternative diets, such as vegetarianism and veganism, have become, and are still becoming, more and more popular. Some established meat production companies have recognized this trend. For instance, Rügenwalder Mühle recognized this and took the opportunity to alter and extend its business model, and it is now one of the most popular brands for meat replacement products in the growing market (Ahrens, 2021, 2022).

When thinking about sustainable IT/IS products, only a few companies come to mind that has successfully established sustainability-based businesses and products aside from the mainstream. One company is Fairphone B.V., which developed and produced a smartphone (the Fairphone) that is produced and marketed as sustainably as possible while maintaining its competitiveness in the regular market. By defining innovation as something beyond the functional improvements to a device, which also happens at a company level (i.e., business values, business processes, etc.) (Says, 2020), they set a clear example that sustainable IT/IS products do not need to be 'lesser of a product' or unsexy.

Researchers have proposed many views on how companies adopt and diffuse innovations (e.g., Rogers, 2003; Schmermbeck, 2019) to establish a competitive advantage (Wade & Hulland, 2004). Especially when discussing innovations in light of their potential to add to a company's sustainability, one core question is whether sustainable innovations—or those that are labeled and described as such—need to be regarded as a separate form or whether they are merely regular innovations with alternate quality criteria.

Sustainable innovations—similar to any other impending innovation—require an initial cost–benefit analysis (Schrade-Grytsenko et al., 2022, p. 5). However, it seems as though sustainable innovations are often not welcomed or are even opposed based on contextual reasons, such as infrastructural, political, or social factors (Stryja et al., 2017, p. 2885). Hence, it seems beneficial to shed further light on this supposed difference and the potential reasons for non-adoption.

4.2 Sustainable Innovations Are Regarded as Inferior Investments

In the initial studies, we did not directly ask the interviewees whether they noticed a specific differentiation between regular and sustainable innovations, but they made various statements to this effect (see Table 3). For instance, one interviewee stated, "at the end of the day, you still have to turn the coin left and right, and of course, that's always an investment that's being made, and that's currently more important than this sustainability idea" (I-11; l. 495-498). His view underlines the traditional view that prioritizes financials first and sustainability and ecology second (Milne & Gray, 2012, p. 16). I-15, on the other hand, partially opposed this view and stated that "there are always […] two views, one is more the financial and management view, the other is more the area of sustainability. […] [and] it is simply crucial that it is possible to marry both worlds" (I-15; l. 34–36). Another interviewee also stated that, especially for sustainability innovations, "this understanding [of the investment logic of sustainability], […] must first be developed" (I-09; l. 311–312); a view that is also reflected in literature (Nishant et al., 2013, p. 12).

We were intrigued by the insight that, under certain circumstances, sustainable technologies might need to be evaluated differently than traditional technologies and that they, thus, also do not need to adhere to the traditional investment logic. We consequentially wanted to find out whether there was a differentiation between the two technology and innovation forms (traditional and sustainable) and whether this also affected the investment logic. Thus, we first asked the follow-up interviewees whether they noticed a difference between regular and sustainable technologies, and we confronted them with the proposition: "Sustainable innovations are only investments that must pay off in the long term".

We were surprised that—contrary to the initial interviewees—all the follow-up interviewees were of the view that there is no difference between sustainable and regular innovations and, consequently, that there is no difference between sustainable and regular investments (see Table 4). Regarding the difference between sustainable and regular innovations, one interviewee stated, "One could […] define that a sustainable product would be CO_2 neutral, or CO_2 positive. Also, on the other ecological components like the supply chain and resource consumption. But because I will never completely reduce this consumption to zero […] there is then somewhere an arbitrary limit to what is sustainable and what is not" (I-01f; l.95–99). For him, a sustainable innovation would only be achieved as such if it made the company more sustainable compared with its as-is state (I-01f; l. 110–112). He also complements this argument by stating that discussions on the ecological aspects of sustainable innovations are hard to separate from the economic and social aspects of the proposed innovation: "Sustainability means making something financially and environmentally sustainable, and not at the expense of the next generation" (I-01f; l. 282–283), and "of course, a product or project must also be financially sound; otherwise it is not sustainable. That is exactly the definition. But then again, that does not mean that you should do it at the expense of ecology, in no way" (I-01f; l. 286–290).

Consequentially, our interviewees all agreed that there is no difference in the investment logic between sustainable innovations and investments in them. However, there might be "idealists who see it differently and who might say: 'I'll put my solar panels on the roof and pay 10% more for electricity […]'. There are those, too", according to I-02f (l. 450–452). However, in the end, I-04f concludes that "we are not a world of do-gooders. Money makes the world go round, and especially from the perspective of a DAX company; I have to say: We are investor-driven" (I-04f; l. 429–430).

Although this seems to be a non-negligible downside to investments in sustainable technologies, the interviewees also stated that "a sustainable product means that I can make money from this very idea of ecology" (I-01f; l. 286–290) and that "in the long term—investing in sustainable technology is cheaper than not investing and having to finance the environmental impact […] and the climate crisis. Thus, accordingly, [a sustainable innovation] is a good investment" (I-03f; l. 354–357). Consequently, we propose that, compared with a traditional investment, a sustainable investment is nowadays likely to be evaluated as inferior. When sustainability criteria (i.e., ecological and social criteria) are added to the investment proposal, thus creating a more holistic view of technologies (Schmermbeck, 2019, p. 2049), this shift might likely change the balance of the investment decision, which would thus render the traditional product inferior.

5 Constraints on Sustainable Technology Adoption

5.1 Becoming Sustainable Requires Precise Measurements in Dimensions That Are Hard and Costly to Realize

As almost any business decision seems to be made based on numbers (e.g., investment cost, return-on-investment, amortization duration), it seems that sustainability and sustainability initiatives should also be precisely planned, measured, and controlled. The most fitting statement from the initial round of interviews in support of this argument was, "If you want to be climate neutral or optimize in this direction, you then first have to open your wallet to realize measuring points in order to have meaningful figures to optimize towards. Otherwise, everything is just a rough estimate, and the measures may not be efficient at all" (I-09; l. 217–220). Other interviewees also agreed with this view: "Of course, we want to reduce our CO_2 footprint. Absolutely clear. But the exciting challenge is, first of all, to determine the status [of our footprint]. Where is it, actually? How do you measure it? […] We are currently devoting a lot of energy to setting up sustainability reporting and making things measurable" (I-07; l. 153–156).

While others generally agreed with this, they also stated that purposefully operationalizing sustainability measurements was challenging for them: "It would be nice if we could control that a little bit more, also maybe make it [sustainability] more measurable" (I-08; l. 451–452). Another interviewee supported this argument by stating that sustainability was less an issue of realizing measurements and more one of investing in the right measurements: "If someone says to you, I can't measure this at all, then he has invested in the wrong place or not in the right place. […] we […] have such measurement possibilities because only if you have real numbers […] you can also go and say, now we go into optimization" (I-09; l. 183–187).

We thus wanted to find out more and to see whether the first steps towards greater sustainability are to primarily establish precise measurements or invest in tangible sustainability means (we present an overview of all the relevant statements in Table 5). We thus confronted the follow-up interviewees with a proposition that we took almost verbatim from Interviewee I-09: "If you want to be climate neutral, you first must open your wallet to realize measurement points in order to have meaningful data to optimize towards. Otherwise, everything is just kind of a rough estimate, and the measures may not be efficient at all".

Two of the four interviewees agreed with this statement (see Table 6). For instance, I-01 stated that, especially for him as a strategist, "measurability is always very important" (I-01f; l. 272). I-02 compared this issue to building a house, which requires an architect who ensures that all the measures fit together (I-02f; l. 493).

Table 5. Summary of relevant interviewee statements on sustainable technology adoption

Category	Constraints and Observations
Sustainable Technology Adoption	**I) Becoming sustainable requires precise measurements in dimensions that are hard and costly to realize.** • IT governance is basically only interested in metrics. (I-15; l. 419) • If you say as a company, "I want to be green", then there are different starting points on how you can look at this and where you can start. First of all, you have to draw up an overview of what the CO_2 emitters are in your company and which ones are in your own hands. Where do we have to rely on third parties? And then, we can shape our purchasing policy accordingly. [...] Simply saying "we want to do this" or engaging in some kind of certificate trading to make ourselves CO_2 neutral is perhaps not the ideal measure. So you really have to deal with the issue: Where do the emissions come from? How can this be solved? (I-09; l. 65–76) • What I want to do comparably, I just have to provide numbers. And that means transparency. And then it doesn't matter relatively whether it's about my computing center or the service kilometers driven or the electricity consumption or anything else. (I-13; l. 161–164) • Incentive programs would be nice with Green IT as well. [...] A sticker: 'My cell phone is three years old.' You get assigned a sticker by the sustainability department [...], and then you walk around the cafeteria with it. Everyone will ask what you have there. So that it [Green IT] becomes more visible. That you also recognize the people [...]—a relatively small group—who have an interest in sustainability. (I-02; l. 327–332) • If you want to be climate neutral or optimize in this direction, then you first have to open your wallet to realize measurement points to have meaningful numbers to optimize towards. Otherwise, everything is just somehow so by the thumb, and then the measures may not be efficient at all." (I-09; l. 217–220) • It would be nice if we could control that [the sustainability measures] a bit more, also maybe make it more measurable (I-09; l. 451–452) • Of course, we want to reduce our CO_2 footprint. Absolutely clear. But the exciting challenge is first to determine the status; where is it actually? How do you measure it? And we are currently devoting a lot of energy to setting up a sustainability reporting system and making things measurable. (I-08 l. 153–156). • The industry standard today is to buy a data center out of the box with a PUE of 1.5 to 1.55. Our data centers have a PUE of 1.3 and 1.4, which means we are far below that, i.e. we need 30 percent to 40 percent less electricity for the self-supply of our data centers than a new data center of conventional design. At the end of the day, that's where we say, yes, that's the green IT we've done. When I took the job, I promised pro forma that we would reduce CO_2 emissions by 30 percent in the data centers. We have now reduced 60 percent. (I-15 l. 286–293) **II) Adopting highly visible sustainability measures often only has a small impact on sustainability** • And of course, there have always been considerations like, you know, reducing electricity consumption and so on and so forth. Also, waste separation. But there is a huge difference if something like that is done in the head office or maybe communicated more [to all subsidiaries]. (I-13; l. 35–37) • I'm sure our technical manager, who is responsible for development as well as our own IT, also measures that [sustainability], but in the commercial area, they don't need those numbers. (I-08; l. 115–117) • There is a side strand, though, [...] the [internal sustainability project name]. So how do we actually implement all the sustainability stuff in the group? But it's more about how we manage the store to get the right key figures out of it. [...] But it's never about how green this company is. That's not what it's about. (I-06; l. 323–328).

I-04 fully disagreed with the proposition. He stated, "The challenges are clear. […] We know that energy is an issue. We know that resource consumption is an issue. We know that recycling is an issue. We know that emissions are an issue. In this respect, it's not really about knowing exactly where I have to compensate or reduce something and how much […] It's just

Table 6. Interviewee comments on presented constraints on sustainable technology adoption

Category	Constraints and Observations
Sustainable Technology Adoption	**I) Becoming sustainable requires precise measurements in dimensions that are hard and costly to realize** (Rather) yes: • "I'm a strategist, and I'm working in the digital domain. Measurability is always very important!" (I-01f; l. 272). (Rather) no: • "One hundred percent right. […] If I build a house, I need an architect. I can save the architect, sure. Then I build the concrete foundation and put the wall on top of it and put the upper floor on top of it, and then the first wall cracks because I haven't calculated how thick the concrete foundation has to be. I need an architect to come up with a strategy for how I do it and, of course, calculate it." (I-02f; l. 493–497) • "I'm still indecisive on that one. But I think I'm with the no. [...] The challenges are clear. Well, we know exactly what the problem is. Well, we know that energy is an issue. We know that resource consumption is an issue. We know that recycling is an issue. We know that emissions are an issue. In this respect, it is not really a matter of knowing exactly where I have to compensate or reduce something and how much, or whatever it is. It's just a matter of questioning all of one's processes and structures and seeing what impact I have as a result. And I don't always have to be able to quantify that exactly." (I-04f; l. 444–454). **II) Adopting highly visible sustainability measures often only has a small impact on sustainability** (Rather) yes: • "Yes, it's this classic greenwashing accusation […]. When a company is committed to sustainability, it is natural to start with the low-hanging fruit. And these are oftentimes very effective." (I-01f; l. 259–262) • "Whether that's true for many, I don't know. It's certainly true for some [measures]. For many, it's really also a question of external presentation. In the media, the typical theme is planting trees. That is always taken with pleasure, although the effect appears only after 10-15 years and probably also exists in many places first with no effect at all. On the other hand, whether that [constraint] is the case for many, I can't say." (I-03f; l. 365–369) • "Yes, I totally agree with that. My perception is that sustainability is very much associated with, let me say, an electric fleet of vehicles. […] planting trees, creating flower meadows somewhere, or putting up insect hotels. That's all very nice. But the problem is somewhere else. If you look at global emissions, it's industrial energy, big transport, freight transport, and so on. [...] I very often have the feeling that something is being done, not with bad intentions. But, that is also well meant, in a sense that: An electric fleet is already good. It's just that it doesn't help to make a big difference. I often have the feeling that very few people recognize where the great potentials are and, thus, rather start with such quickly implementable showcase topics. So, yes, that [constraint] is unfortunately often the case." (I-04f; l. 477–488). (Rather) no: • "I don't think you can generalize that. I think there are definitely things that are sustainable, like [big German fashion brand] who are starting to set up production for jeans in Germany again. I think that's very sustainable: fewer transport costs, proper waste disposal, domestic jobs, ... I think that's sustainable enough. […] So, no, not generally. You have to look at the individual case." (I-02f; l. 477–486)

a matter of questioning all processes and structures and […] I don't always have to be able to quantify that exactly" (I-04f; l. 448–454). I-03 agreed, stating that "both are needed. Quasi activities in direct implementation, in order to implement the first step with really realized measures in order to achieve the […] mindset shift" (I-03f; l. 376–379). He argued that measurement points are needed to ensure transparent and quantifiable sustainability measures.

In our view, whether companies choose to control the sustainability benefits of sustainable innovations precisely depends on the companies' overall sustainability maturity. If they are about to implement initial changes, then it might be beneficial for them to start with general and easy-to-implement means. Otherwise, the drive for sustainability will be blocked and hindered by bureaucratic and mathematical processes. Interviewee I-04f indicated exactly this by stating, "Everyone knows that you should drive less and fly less. I can calculate for a long time how much I drive or fly per year. But it would be much cooler if I simply started taking the train tomorrow." (I-04f; l. 465–467) If a company is more mature and if it has adopted a certain drive for change and sustainability, then it is certainly beneficial and logical to assess the current measures, not just to show that they are truly beneficial but also to document and plan the areas for which the company has further room for sustainability improvement.

5.2 Adopting Highly Visible Sustainability Measures Often Only Has a Small Impact on Sustainability

During the first round of interviews, we asked the interviewees about the sustainability or Green IT/IS measures that their companies had already adopted and put into action. The most frequently mentioned initiative was the replacement of many or some of the company's internal-combustion-engine car fleets with hybrid and/or fully electric cars (e.g., I-08, I-10, I-11, I-16). Others mentioned that they had started to produce their own energy by using solar panels on company buildings (e.g., I-10), had started to separate their waste better (e.g., I-17), or had installed water dispensers and were using glass bottles (e.g., I-08). Regarding Green IT/IS measures, many seemed to have already adopted some green IT quick wins (Gonserkewitz et al., 2021, p. 171), such as reductions in the use of printers or multifunctional devices, or the implementation of restrictive printing policies (e.g., I-08, I-12, I-14, I-16; I-18).

While all of these measures have some benefit to the overall sustainability of companies, it nevertheless seems as though these low-hanging fruits were the first and sometimes the only initiatives mentioned and that some companies stopped after taking the first steps towards real sustainability improvement. Only a few of the interviewees mentioned that they had or were undertaking measures with greater sustainability impact. For instance, as a software developer, I-11 develops the company software and its respective architecture as leanly as possible so that it runs faster and consumes fewer resources (RAM, storage) and, thus, less energy (l. 166-182). I-15 also stated that completely redesigning the company data centers increased the power-usage efficiencies (from ca.1.5 to ca. 1.34) and significantly reduced the energy consumption by approximately 30%, which also reduced the respective CO_2 emissions by 60% (l. 286-293). We present an overview of the relevant statements in Table 5.

We wanted to dig deeper and understand how the sustainability experts of the follow-up study viewed this. We did not want to explicitly use the term 'greenwashing', as we felt that this

would have shifted the discussion in a rather negative direction and that it might also have put the interviewees in a rather defensive position. We thus avoided the term. Instead, we proposed the statement, "Many of the highly visible sustainability measures have a very little real impact on sustainability", and we asked the follow-up-study participants to comment on it.

Although unexpected, Interviewee I-01f opined on the greenwashing topic: "Yes, it's this classic greenwashing accusation […]. When a company is committed to sustainability, it is natural to start with the low-hanging fruit. And these are oftentimes very effective." However, his view differed from the other three follow-up interviewees, who agreed with our proposition. I-04f was critical: "Yes, I fully agree with that. My perception is that sustainability is very much associated with, let's say, a fleet of electric vehicles. Or with, I don't know, planting trees, creating flower meadows somewhere, or putting up insect hotels. That's all very nice. But that's not where the real issues are" (l. 477–486).

Interviewees I-02f and I-03f were not so sure whether the proposition was true for all cases. For instance, I-03f added that it might be the case for many initiatives, as it is "a question of external representation. In the media, the typical topic is planting trees. This is always taken with pleasure, although the effect appears only after 10-15 years and probably exists in many places also first no effect at all" (l. 363–365). I-02f, although agreeing that, in many cases, the sustainability effects are only rather marginal, urged being more cautious about it and individually evaluating the initiatives and outcomes (l. 483–486).

One potential explanation as to why companies do not do as much as they could or would rather not invest in measures that are not connected to their core businesses may be that there is no real incentive for them to become more ecologically sustainable. Oftentimes, their customers and clients do not request further sustainability, and governmental initiatives and regulations seem to be lacking, or they are at least not as effective as they could be.

Energy might be a good example of this. All businesses depend on it, but the incentives for companies to save energy and become more energy efficient are only small. Although increasing numbers of CO_2 pricing measures are being enforced (Citizens' Climate Lobby, 2021), which also subsequently affect energy prices in the long run, energy, especially for companies, is still too cheap. For instance, one interviewee stated, "saving 10 percent electricity in the data center, that's good for the environment, but it doesn't mean that we cheer for that. Ultimately, electricity is too cheap for that. […] if you have industrial tariffs, the savings effects do not pay off quite as quickly as they do for private consumers" (I-16; l. 129-134).

6 Constraints on Green IT/IS Adoption and Usage

6.1 Many Green IT/IS Initiatives Only Focus on End-of-the-Pipe Measures

Our next observation takes Constraint 5.2 into account and addresses whether the adoption of Green IT/IS is merely the treatment of a symptom or is sought to initiate real sustainability change.

In the initial studies, we asked the interviewees about their current Green IT/IS means, and we categorized their responses into the Green IT and Green IS dimensions (Loeser, 2013, pp. 6–8). We documented 212 Green IT (IT sourcing: 85; IT operations: 82; IT disposal: 45) and 76 Green IS (IT governance: 18; IT organization: 47; IT external market: 11) codes. According to this analysis, companies seem to focus more on Green IT and hardware management measures than Green IS. Although we do not claim completeness or generalizability, this finding is supported by other research, such as that of Alsdorf et al. (2022), who came to similar conclusions. When taking a closer look, we also found that many interviewees named multiple initiatives that were categorized into one of the Green IT/IS dimensions. For instance, I-02 mentioned six measures in the Green IT disposal dimension, which we further divided into two subdimensions: (i) reusing and refurbishing (i.e., giving IT hardware to employees; donating it to social projects; selling it on the market; returning it to the producer); (ii) recycling (i.e., shredding hard drives and selling them as scrap metal; disposing of parts).

Other frequently named means were making changes to the data center, printer, or office energy management by, for instance, outsourcing their data centers (3), optimizing their cooling by placing them in the northernmost departments of the companies (3), or centralizing or rearranging the structure of the data center itself (3). For reducing printer usage, many companies have already adopted initiatives of going paperless (9), reducing printers (3), and digitizing processes to reduce the necessity of printing (3). We analyzed and eliminated several nominations for each of the Green IT/IS dimensions, and we realized that most companies undertook measures that fall under the sourcing (10), operation (13), and disposal (10) categories. While six companies named means that fall under the external market dimension, only three also undertook IT governance, and only two undertook organization means.

The interviewees more frequently named hardware-related means than capability-related means (see Tables 7 and 8), but only a few Green IT/IS initiatives were focused on reducing and minimizing their environmental impacts without making grand alterations (e.g., to the overall corporate or production processes or structures) (see Table 9). We thus were keen to gain further insight into this potential adoption hindrance, and we proposed the following: “Current Green IT/IS measures in companies focus too much on end-of-the-pipe measures—

i.e., measures that seek to reduce the environmental impact of the IT/IS used by means of downstream measures and do not change the product or the production process itself".

Table 7. Overview of Green IT codes (based on the Loeser (2013) Green IT measures catalog)

Green IT	**IT Sourcing**	Sourcing of IT Products and Services	General Purchasing Criteria	19
			User Device Sourcing	11
			Data Center Sourcing	5
		Supplier Relations	General Supplier/Vendor Requirements	16
			Specific Supplier/Vendor Selection	22
			Supplier/Vendor Encouragement	12
	IT Operations	General IT Management		5
		Data Center	Servers and Storage	20
			Cooling	8
			Energy Supply	5
		Office Environment	Asset Reduction/Standardization	7
			Energy Management	8
			Printing Management	24
			Employee Education	5
	IT Disposal		Recycling	8
			Reuse/Refurbishment	37

Notes. Numbers of codes: IT sourcing: 85; IT operations: 83; IT disposal: 45. Sum of codes for Green IT: 212.

Table 8. Overview of Green IS codes (based on Loeser (2013) Green IS initiatives catalog)

Green IS	**IT Department**	IT Governance	Employee Incentivization	12
			Environmental Management System Implementation	4
			Stakeholder Dialog Establishment	1
			Publishing Best Practices	1
	Organization	Information and Transparency	Resource Consumption Measurement	17
			Environmental Footprint Reporting	11
		Process Optimization	Remote Working Practices	7
			Vehicle Routing	6
			Smart Manufacturing	3
			(Advanced) Automation Technologies	2
			Material and Energy Flow Tracking and Optimization	1
	External Market	Innovative Products and Infrastructure Solutions	Modern Technology Innovations	8
			Building Automation	3

Notes. Numbers of codes: IT department: 18; IT organization: 46; IT external market: 11. Sum of codes for Green IS: 76.

All four follow-up study interviewees agreed with the statement, and some also regarding their companies (see Table 10): "That's how I would see it at [COMPANY], yes. Well, the dialog with the employees, the view on the supply chain is not so much in focus when it comes to sustainability" (I-01f; l. 349–350). However, some saw this focus on end-of-the-pipe means as less critical than others. For instance, Interviewee I-03f stated, "That is indeed the case, from my point of view. Simply because it provides the entry point [for more sustainability means]" (l. 434–437). Others, such as I-04f, viewed this as more critical: "Yes, I would agree

Table 9. Summary of relevant interviewee statements on Green IT/IS adoption

Green IT/IS Adoption and Usage	**I) Many Green IT/IS initiatives only focus on end-of-the-pipe measures** • Many of [our] customers don't even know yet what [Green] IT could do for them. I always like to give the example of a very large company where we did the field service control, and the travel distances were reduced by 8–10%. (I-13; l. 230–233) • I think quite a lot of people don't see IT as a field where you can achieve ecological effects or social or economic effects." (I-08; l. 341–342) **II) The use of Green IT/IS is feared for adverse or rebound effects** • But still, in the end, we have to consider that one hopes for so much [...] and wants to have efficiency effects. But in the end, [one has] an extreme reduction but more energy consumption and more resource consumption than would actually be produced if one had not done it. (I-20; l. 168–172) • But how can IT support? You can say, of course, if you have an appropriate database, then you can do evaluations sooner. I am a bit hesitant now in terms of the environment. (I-13; l. 290–293) • For very few customers, this is already interesting, although the danger of the rebound effect is very, very frequently addressed [...]. And that leads to the fact that the measures for digitization in a company are considered completely independent of sustainability measures on the other side. (I-11; l. 481-485) • This danger of rebound effects that the more you transform digitally, for example, [the more you] accordingly must also control the energy consumption; this is, at the moment, still a side note. (I-11; l.223–225) • One had high hopes of high-efficiency effects, but in the end, only had an extreme acceleration and also more consumption of energy and more consumption of resource consumption that one originally not have had. (I-20; l. 168–172) • The factor that he [i.e., the client] needs less personnel with this new machine was enormously important for him. It thus was, of course, also a key performance indicator of how much less personnel is needed compared to before. (I-12; l. 175–178) • The digitalization measures in a company are considered completely independent of sustainability measures. (I-11; l.483–485)

with that. Especially since the responsibility of a company usually stops where something leaves the company" (l. 565–569). He agreed that some partners are certified to recycle or reuse hardware in a sustainable manner, but he generally criticized the lack of end-to-end responsibility: "The question of avoidance, and the question of procurement, and the question of construction, actually starting from scratch and thinking purely technically, I don't see that at all" (I-04f; l. 570–575). I-03f also observed an extended focus on cleaning-up measures as the most critical. In his view, companies have wasted too much time, and now "we don't have the time to focus on end-of-the-pipe anymore, but we really need to get to the core of the whole thing" (l. 435–437).

Consequently, it seems as though not that many Green IT innovations had been adopted, but that there was a rather strong focus on them and that only a few Green IS initiatives had been initialized and adopted. Thus, as in the digitalization context, sustainability matters, but companies seem to focus on conservative renovation. They seek to re-engineer and replace one technology with another without reimagining their companies and processes or making more fundamental changes and addressing structural issues (Schumacher et al., 2013, p. 1). For the initial adoption of sustainable technologies and Green IT/IS, this seems fine, and some changes, such as altering processes to fully digital processes, may be an ideal starting point for

companies (as indicated by I-03f). However, many companies seem to stop after this initial change, and consequently, they not only miss the opportunity to become more innovative but also more sustainable.

Table 10. Interviewee comments on presented constraints on Green IT/IS adoption

Category	Constraints and Observations
Green IT/IS Adoption and Usage	**I) Many Green IT/IS initiatives only focus on end-of-the-pipe measures** (Rather) yes: • I would see it that way at [COMPANY] like that, yes. You know, well, the dialogue with the employees, [and] looking at the supply chain is not so much in focus when it comes to sustainability. (I-01f; l. 349–350.) • That is actually the case from my point of view; simply because it provides the entry point. Because it also creates a bit of comprehensibility, which I mentioned earlier. But I absolutely agree with the constraint. Especially because we don't have the time to concentrate on end-of-the-pipe anymore, but we really have to get to the core of the whole thing now. (I-03f; l. 437–440.) • Yes, I would subscribe to that; especially since the responsibility of a company usually stops where something leaves the company. [...] And then we are out. Well, I don't see this end-to-end responsibility. In this respect, yes, exactly. One is much too much focused on the end [of the pipe], saying:, 'Yes, we found a clean solution for this'. But you don't think from the front. [...] The question of avoidance, of procurement, and the question of construction, to actually start and think purely technically from the front, I don't see that at all. I always see looking from the end: How do I deal with the problem that arises at the end of the process? And can I somehow get a clean solution there? (I-04f; l. 565–575.) **II) The use of Green IT/IS is feared for adverse or rebound effects** (Rather) yes: • This is actually an aspect that plays an elementary role for me. The more digitalization, the more energy consumption, and the less attention and care I give in choosing the whole [Green IT/IS] thing, the higher the risk that it will actually get out of hand. And then the rebound sets in. This means that we need the same awareness and the same attention, and the same sustainable implementation of digitalization, just as in all other areas. (I-03f; l. 445–450.) (Rather) No: • The basic assumption of the claim would be that, by using Green IS, I will use these [Green IS] more. I can't quite imagine what effects that would have. Well, Green IS, for example, when it comes to the use of IT, we are more concerned with the architecture level: How can I shift my computing processes and make them more efficient so that they consume less electricity? And I think that's in the backend. That has little impact on the user in the end. Ideally, there's no green rebound effect there. In the case of [Green] IT, the most that could be considered would be that the inhibition threshold of usage on the user's side would fall away somewhere. People would say, 'Okay, the iPhone is green so that I can buy one every two years instead of every five.' I don't think that's how users think. (I-01f; l. 355–363.); • I don't see it that way in the long run. It's not like that. [...] If I take a long-term solution that is more expensive to produce and costs more and maybe produces more environmental damage, I see that in the long end as still making sense. That's why I have, and in my eyes should have, an [enterprise] architect. He or she will make sure that what is purchased there has a certain sustainability. (I-02f; l. 618–628.); • Nah, I don't see it. Well, I would say if the [Green IT/IS] product is the same in terms of manageability as an alternative product, then it doesn't matter. (I-04f; l.582–583).

6.2 The Use of Green IT/IS Is Feared for Adverse or Rebound Effects

The last boundary condition for the adoption and usage that we noticed was that some interviewees mentioned that the usage of IT and IS might (sustainability-wise) lead to contrary effects. The primary issue here seems to be that users often do not see the negative impacts of their digital technology usage and that the more profound impacts are hard to measure (see Constraint 5.1). For instance, as a software developer, I-11 sought to not only use leaner coding principles (l. 165-166) but also to ensure that the dimension of the application sufficiently covered the client's needs but could be seamlessly scaled if needed (I-11; l. 473-477). However, the clients seem mostly unaware that developing software in this way also benefits them by ensuring that the software not only consumes fewer hardware resources but that it also saves money as a consequence (e.g., quicker runtimes mean less energy consumed). He stated, "this danger of rebound effects that the more you transform digitally, for example, [the more you] accordingly must also control the energy consumption; this is, at the moment, still a side note" (I-11; l. 223–225).

Moreover, some of the sustainability managers, such as I-20, feared that using Green IT/IS might not be as revolutionarily efficient as was hoped. He compared Green IT/IS with the invention of the steam engine, for which "one had high hopes of high-efficiency effects, but in the end only had an extreme acceleration, and also more consumption of energy, and more consumption of resource consumption that one originally not have had" (l. 168–172). He also feared similar effects from other digital technologies that he was not overly familiar with, such as Blockchain.

Another side effect of digital products and services is that they require the work of fewer people. Some interviewees referred to this, and one specifically described a discussion that he had with a client about a production machine in development. He stated that "the factor that he [i.e., the client] needs less personnel with this new machine was enormously important for him. It thus was, of course, also a key performance indicator of how much less personnel is needed compared to before" (I-12; l. 175–178). He also speculated that one reason for fear of rebound effects might be that "the digitalization measures in a company are considered completely independently with sustainability measures" (l. 516–517), and that "the digital technologies that are used [in a company] only make sense or can only be designed in a resilient and sustainable manner if they have also been developed in a sustainable manner" (l. 174–176).

We took this mix of speculations and insights (presented in Table 10), and we formulated the following statement: "The usage of Green IT/IS carries a high risk of rebound effects—i.e.,

the risk that an increased use of Green IT/IS will lead to ecologically opposite (negative) effects". In terms of this proposition, the follow-up interviewees had mixed verdicts.

On the one hand, Interviewees I-01f and I-03f presented reasons why the risk of sustainability rebound effects might not be unjustified. Referring to the risk caused by inadequate or non-existent planning, Interviewee I-03f (l. 442–447) stated, "The more digitalization, the more energy consumption, the less attention I pay and the less thought I put into it, the more the danger that it will actually go into overdrive and then the rebound will set in". Interviewee I-01f only partially recognized the sustainability rebound risk, and primarily for IT: "In the case of IT, one could only think, that the threshold for personal usage drops. People would say, 'Okay, the iPhone is green so that I can buy one every two years instead of every five years." (l. 361–363). However, he was rather on the contrary side, stating, "I don't think that's how users think. I think the user only has his mind only on the IT, and the idea of sustainability is not yet rooted enough for it to have an influence" (I-01f; l. 361–365). Interviewee 04 argued the same, adding that "you can't suddenly buy unlimited amounts of something that is somehow more sustainable. So no, I would say it's just a matter of replacement [i.e., a product] in existing structures. And then things will continue exactly as before." On the company side, Interviewee 03 argued that Green IS "are more on the architectural level: How can I shift my computing processes, make them more efficient so that they consume less power? And I think that's in the backend. That has little impact on the user in the end. Ideally, there is no green rebound effect" (I-01f; l. 355–360).

Overall, we conclude that our interviewees did not see the risk of the sustainability rebound effects of Green IT/IS usage. They argue that consumers will only replace a non-sustainable product with a more sustainable one, while in corporations, Green IT/IS adoption and usage will be aligned and integrated with other sustainability and innovation initiatives to address this risk.

7 Conclusion

The research on the corporate adoption of sustainability and the associated sustainable technologies, such as Green IT/IS, is constantly growing (Harnischmacher et al., 2020, p. 13; Loeser, 2013, p. 3). However, there is a lack of studies that improve our understanding of the drivers and hindrances of meaningful corporate sustainability interventions, as well as their associated risks and challenges. According to some practitioners' insights (e.g., Walker, 2015), misaligned incentives, competing priorities, and a lack of expertise are the core issues of proper institutional Green IT usage.

We addressed this shortcoming by investigating the factors that negatively influence or prevent companies from meaningful pro-environmental engagement and/or hinder them from adopting and using sustainability-engaging technologies, such as Green IT/IS. As this study is part of an ongoing research project (see Section 3.1), we took already-published work as the conceptual basis and used the insights of 21 interviews from three interconnected yet unpublished studies as our initial basis (see Section 3.5). We identified the boundary conditions of sustainability and sustainability technology adoption, and we worked them up into six statements. Then, we took these constraints and discussed them with four interviewees of the initial studies. We now elaborate on the generated insights, which are valuable for research and practice.

For the first constraint (Section 4.1), we found that sustainability and sustainable products — due to their nature of addressing global, societal, and environmental issues — are (currently) not regarded as attractive for mainstream adoption. One interviewee stated, "[Sustainability] tends to be associated with constraints or with self-constraint" (I-01f; l. 142–144). However, we, as well as the interviewees, also see that societies seem to be in a permanent state of flux. Younger generations may be seen as "sustainability natives" (I-06; l. 245–246) that demand sustainability and sustainable products (I-01f), and sustainability and sustainable innovations may thus continuously lose their stigma.

Some of the interviewees also recognized that "the topic will now [...] change dramatically, due to all the regulations that are now coming [companies] […] will simply have a certain compulsion and there will be no other way [to become sustainable]" (I-03; l. 176–180). His guess was that companies should test and experiment with these technologies not only to establish quick wins (Gonserkewitz et al., 2021, p. 171; Hahn et al., 2015, p. 303) but also to prepare themselves, analyze their motivation for sustainability, and derive the consequential means and goals (Brockhaus et al., 2017, p. 942).

Research could guide and document these processes, and it could also shed further light on the seeming unattractiveness of sustainability and sustainable technologies. It might be promising to evaluate different consumer groups and their perceptions, as well as the usage of (non-

)mainstream sustainable products and services. For IT products, the Fairphone (Says, 2020), for instance, could be one example that could be further investigated, and that might also serve as an example of positioning a sustainable product on a mainstream market and as a competing product in a corporate setting.

In terms of the second constraint (Section 4.2), regarding whether there is a difference between 'traditional' and 'sustainable innovations', and their consequential investment logic, we found it difficult to specify or pinpoint a specific differentiation, at least in terms of terminology. Sustainable technologies, while performing at least slightly worse than traditional technologies in the established categories (i.e., technological compatibility, upfront financial investments), arguably seem to have certain non-negligible benefits (i.e., for the companies' sustainable competitive advantages and environmental footprints). Our interviewees acknowledged this fact. I-09, for instance, outlined that choosing a water-cooled data center is not only a substantial technological, but also financial risk (l. 413-420), compared to an established air-cooled data center and decision-makers did not seem to understand the investment logic (I-09; l. 307–313) and that sustainable innovations will likely make up the initial disadvantage (I-01f; 282–287). Thus, sustainable innovations share certain similarities with disruptive technologies (Bower & Christensen, 1995, p. 49), which should be further investigated in future research.

As the specific contribution of an investment is traditionally associated with the financial benefits for a company, we investigated whether the sustainability benefits need to be similarly controlled (the third constraint of Section 5.1). We found that the precise measurement of sustainable benefits was generally beneficial and necessary. However, for initial sustainability initiatives, our interviewees widely agreed that the areas of engagement are rather clear and that it is a matter of initializing the change rather than specifically measuring and quantifying it. Thus, it would be fruitful to investigate further quick wins (Gonserkewitz et al., 2021, p. 171) and to specify if and how they, as well as their successive means and initiatives, can be initiated. As it seems illogical to initialize change without specifying any controlling instrument, it might also be beneficial to conceptualize and suggest easily quantifiable indicators so that decision-makers not only see the impacts of their decisions but also understand the effects that their corporate actions have on the planet's biosphere.

We investigated how our interviewees assessed the impact of highly visible corporate sustainability efforts and their sustainability benefits (the fourth constraint of Section 5.2). In their view, many of these actions undoubtedly have a positive impact on corporate sustainability. However, they make the criticism that many companies do not seem to address the aspects that companies need to make a real contribution to sustainability. A frequently referred to example was the corporate planning of trees, which undeniably has a positive effect on the planet's biosphere but takes many years to manifest. To further address this issue, we suggest

cataloging frequently used corporate sustainability actions and investigating their effectiveness (i.e., in the respective amount of reduced or compensated CO_2), as well as the time is taken to reach their highest or fullest effectiveness. This suggestion harkens back to the quick-win call (see above), and we propose combining both efforts.

Many Green IT/IS initiatives seem to only focus on end-of-the-pipe measures (the fifth constraint of Section 6.1), which is a claim that is supported by the observation that the companies adopted substantially more (hardware-related) Green IT means than (process-related) Green IS initiatives (see Tables 8 and 9). While this seems to be a viable option for initial sustainability adoption, it runs the risk that companies will miss the chance to initialize real sustainability changes. By focusing only on hardware-related issues, decision-makers might conclude that sustainability is nothing more than an alternative investment decision. However, by following this assumption, companies overlook initializing real change, which requires redesigning corporate processes and altering the governance and culture (Puvaneswaran & Alsdorf, 2021, p. 8). Further research should take up this insight and specifically investigate cases in which companies have started to develop Green IS and sustainability capabilities. These insights promise to be fruitful for other companies that first need to initialize sustainability changes or for those whose sustainability changes are not as effective as hoped.

Finally, we also assessed whether the adoption and usage of Green IT/IS has a high risk of rebound (Arnfalk et al., 2016, p. 109) or ecologically adverse effects (the sixth constraint of Section 6.2). This was only partially supported by our interviewees, and their reasoning primarily lies in the fact that sustainable IT/IS seems only to be adopted to replace another IT/IS directly. This insight needs to be regarded in the context of the fifth constraint, as it also seems to indicate that companies refrain from initializing real sustainability changes and often "only cure a symptom". This underlines that more substantial research is needed not only into why this is but also into the nature of Green IT/IS so that corporate decision-makers understand them better to select the most promising means and initiatives for their companies that can then be integrated into the organization's future architecture.

7.1 Limitations and Further Research

One limitation that should be addressed in further studies is that, in the follow-up study, we interviewed only four interviewees from two large German companies. This is a substantial limitation, as it only reflects the drivers and hindrances from the perspective of companies that, although equipped with substantial financial power, are primarily driven by shareholder and legislator interests. It would be beneficial to reflect upon and deepen our insights into SMEs. For this, we suggest focusing on Austrian, German, and Swiss companies to close the circle with the initial studies (Alsdorf et al., 2022).

In terms of the specific further research outlined before (see Section 7), we also feel that it is necessary to further investigate the general topics of the corporate adoption processes of sustainable innovations and Green IT/IS (Schmermbeck, 2019, p. 2052). In our study, we underlined that large companies, especially, seem to be primarily influenced by only societal (i.e., regulatory and financial drivers) and organizational (i.e., internal financial drivers) drivers. It would be interesting to see whether these drivers can be directly translated to other corporations, such as SMEs. Some of our interviewees doubted this and suspected that family-owned or cooperative companies, especially, were more likely to put emphasis on the social and ecological factors of the TBL (Elkington, 1998, p. 85): "I think that an owner-managed company is definitely more willing to anchor such cultural values within the corporate culture […] than a stock corporation." (I-02f; l.427–428).

Furthermore, it would be interesting to investigate Green IT/IS adoption in a long-term case or even in an action research setting (Bhattacherjee, 2012, p. 107). Selecting a company and accompanying it through the entire adoption process would offer rich insights into the proceedings, as well as into the challenges and how they can be overcome.

7.2 Theoretical and Practical Contribution

Our study is beneficial for both researchers and practitioners. From a theoretical perspective, we underline that sustainable innovations have certain crucial differences from traditional non-sustainable innovations. With a (potential) initial worse performance in the traditional financial dimensions, we underline that sustainable innovations share certain similarities with disruptive innovations (Bower & Christensen, 1995, p. 49). This insight also indicates that we need to regard the adoption process of sustainable innovations from a holistic perspective (Schmermbeck, 2019, p. 2052).

Moreover, sustainability and IT/IS strategists may find our insights fruitful, as the six constraints and evaluations provide more insights into the context than directly observable assumptions of sustainability (technology) adoption. They should thus clearly communicate the benefits of sustainable technology usage, and that initial sustainability adoption may not require exuberant planning to start but merely initiative, will, and momentum. The same is true for Green IT/IS. Green IT, especially, may be an initial way to achieve sustainable benefits, which could be followed by sufficiently planned and measured Green IS.

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SUMMARY OF FINDINGS, CRITICAL REFLECTION AND CONCLUSION

Abstract

The objective of this dissertation was three-fold: To i) further and better understand the concepts of Green IT and Green IS, to ii) investigate the status of corporate Green IT and Green IS adoption in companies and suggest easily adoptable measures with high environmental benefits, and iii) shed light on decision-makers views on sustainability as well as Green IT and Green IS. We addressed the objectives in six separate yet interrelated research papers. By reflecting on the research problem and research questions presented in the introduction, we summarize the main findings. We also outline the contributions to the academic discourse and organizational practice as well as the limitations and avenues for further research.

Keywords: *summary of findings, discussion, limitations, further research*

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1 Summary of Key Findings

This dissertation seeks to shed light on the low strategic relevance of sustainability (Brockhaus et al., 2017, p. 933; Kiron et al., 2017, para. 2) and the consequential struggle, and low corporate adoption rate of sustainable technologies, especially Green IT and Green IS (Engert et al., 2016, p. 2833; Luftman et al., 2013, p. 356). Both are technologies and managerial practices (Loeser, 2013, p. 6) that companies can and should adopt to reactively address challenges of the digital transformation (Hanelt et al., 2017, pp. 492–493), the (human-made) global climate disruption (Harnischmacher et al., 2020, p. 2; Malakoff, 2014, para. 1), as well as to also pro-actively set themselves apart from competitors and create a sustainability-based sustainable competitive advantage (Baggia et al., 2019, p. 13; Hart, 1995, p. 992).

Despite the recent interest in the topics of Green IT/IS (Zaung Nau & Marinova, 2020, p. 243), there remained certain sustainability and Green IT/IS specific issues that concerned i) the alignment of the varying conceptual understanding of Green IT/IS in research and practice (Curley et al., 2016, pp. 103–104; Henkel & Kranz, 2018, p. 11; Loeser, 2013, p. 6), ii) the potential benefits that increased Green IT/are adoption and usage can have for a company (Hanelt et al., 2017, p. 494), as well as iii) the underlying managerial assumptions about sustainability and sustainable technologies, like Green IT/IS (Henkel & Kranz, 2018, p. 11).

As the overall objective of this dissertation was to shed light on these three domains, each was summarized by a specific research question that was addressed in the respective research papers. While the detailed answers can be found in the respective papers, in the following, we present the essence of the answers to the proposed research questions:

RQ 1: *Which dimensions distinguish sustainability innovations, like Green IT and Green IS, from traditional innovations, and how does this influence their corporate adoption?*

This research question was answered in two papers (papers 1 and 2): Based on multiple thorough literature analyses, the first one finds that sustainable technologies, like Green IT/IS address and consequentially also need to be evaluated along a different set of criteria than just in a purely financial perspective. While traditionally, innovations are driven and evaluated by their organizational (e.g., economic drivers (Lunardi et al., 2015, p. 5; Molla, 2008, p. 662; Radu, 2016, p. 10)) or individual aspects (e.g., intrinsic user motivation (Koo & Chung, 2014, p. 146), employee skills (Radu, 2016, p. 10)), Green IT/IS also have significant benefits on the natural environment (e.g., reduction of waste, GHG, or toxic material emissions) and societal level (e.g., addressing of global and local social imperatives) that also companies can use to their advantage (e.g., Brezavšček et al., 2019, p. 1043; Deng & Ji, 2015, p. 16750) – although in a non-financial way (Corbett, 2010, p. 14).

The available general and Green IT/IS adoption models and frameworks (e.g., Lunardi et al., 2013; Molla, 2008; Molla et al., 2008; Yoon, 2018) consequently, do not visualize and respect these additional ties and thus remain blind in this regard. We, therefore, conceptualized a framework that models a five-step process of corporate Green IT/IS adoption (outset, pre-adoption, adoption, post-adoption, outcome) and the influencing factors of the four dimensions (natural environment, society, organization, individual).

Based on the previous argumentation, the second paper proposes an answer to the observation that also corporate adoption and maturity models – especially in Green IT/IS regard – remain rather short-sighted, as they seem to treat their adoption and maturation as a purely technological matter (Lunardi et al., 2015, p. 4). Based on a comparative and integrative analysis of literature, the paper finds that – despite the rather technology-centric connotation and conceptualization – Green IT/IS adoption and maturation is a primarily socio-technological and managerial matter. While the adoption of novel, sustainable technologies is also beneficial, most of the identified Green IT/IS categories can be achieved by addressing and further developing non-technological aspects of i) *strategy alignment* (i.e., linking and aligning the IT departments (sustainability) objectives with the overall business objectives), ii) *people and culture* (i.e., creating the required mindset for sustainability and establishing a shared language), as well as iii) *governance* (i.e., specifying the decision rights and respective accountability frameworks (Weill, 2004, p. 2) and establishing the required corporate policies). Only i) *planning of objectives* and ii) *process management* aspects are fundamentally based on the adoption of novel sustainable technologies as they are rooted in purely technological matters (Curley et al., 2016, p. 106).

While these papers improve the understanding of Green IT/IS, factors that are relevant for their adoption and usage, as well as which benefits can generally be achieved, these insights nevertheless remained rather conceptual. The second research question – answered by papers 3 to 5 – picked these limiting factors up and specifically asked for the benefits organizations can achieve in reality and how inexperienced companies may pick up their initial Green IT/IS efforts. It asked:

RQ 2: *Which are the benefits of Green IT/IS-enabled sustainability, and which Green IT/IS are suited for an initial successful adoption?*

The fourth and fifth papers provide answers to the first parts of the research question. Both are descriptive quantitative studies that underline both general and Green IT/IS-specific adoption benefits along the four proposed dimensions. Amongst others, we found that companies reported a better performance in

i) Reduction in GHG emissions, improvements in recycling of materials, and usage of recycled materials (natural environment level),
ii) compliance with sustainability regulations and laws, increased ecological transparency, and higher social acceptance of the company (society level),
iii) reduction of the consumed energy and materials (as well as the consequential costs) and improvements in processing times (organization level), and
iv) improving the ecological understanding and consciousness of the workforce as well as the consequential increased sustainability behaviors (individual level).

The third paper answers the second part of RQ2 as it illustrates that – to achieve initial Green IT/IS benefits – companies do not necessarily need to make any monetary investments. Altering energy settings of the used IT devices and adding sustainability criteria to procurement standards, and ensuring that disposed hardware is either donated or fully recycled are promising first steps that require only process changes. Further actions, like the increased usage of groupware – to enable virtual collaboration and reduce the number of business trips – or the reduction of printers, are also easily achievable but require certain process and policy changes.

These findings and outlined measures are, however, to be seen as contradictory to the findings of paper 2. While we found in the latter that Green IT/IS maturity is primarily achieved by developing and extending capabilities, we argue that technical and technology-based measures are a prime way for an organization to make initial experiences with and achieve first benefits from Green IT. If the endeavors are then extended and matured, they need to – sooner or later – further develop their Green IS capabilities. Consequently, we agree with Watson and Kranz (2021) that "organizations need to buy Green IT so they can make an environmentally sustainable difference with Green IS" (p. vii).

Despite these documented benefits, we nevertheless also found that many organizations refrain from adopting Green IT/IS and that their decision-makers are (at least) skeptical when it comes to choosing (more) sustainable innovations and practices. To better understand this observation, we chose to further investigate managerial aspects of sustainability and Green IT/IS adoption and specifically asked:

RQ3: *Which managerial assumptions, attitudes, and assertions about sustainability and sustainable technologies negatively influence corporate Green IT/IS adoption decisions?*

The sixth and final paper splits the answer to this question into three interlinked parts: i) a general sustainability, ii) a sustainability technology, and iii) a Green IT/IS part. The first one

finds that managers regard sustainability as unattractive and not innovative. Innovativeness and sustainability – in both a corporate and societal view – are perceived as excluding opposites. Sustainable innovations are thus also regarded as inferior investments as their benefits – also from a financial perspective – either take longer to manifest or are not measured with categories that are traditionally relevant for companies.

The second part takes up this argumentation and finds that sustainability actions – especially the ones that companies highly visibly praise (e.g., switching to an electric car fleet, planting trees, making financial compensations for their GHG emissions) – seem to only have a rather limited sustainability benefit and are not part of a fundamental sustainability change. The underlying issue with this seems to be that companies are highly focused on making any decision measurable and that – as argued before – sustainability benefits and outcomes are only hardly measurable or are not seen as a benefit for the company.

This consequently also affects Green IT/IS adoption and usage (third part), as they seem to be primarily adopted in order to clean up the downstream impacts (end-of-the-pipe measures). Their potential to initialize large-scale benefits and fundamentally alter underlying processes and courses of action seems to be unseen or neglected.

In sum, all papers contribute to answering this dissertation's overall research problem:

RP: *Due to a flawed conceptual understanding of Green IT and Green IS as well as their benefits, company decision-makers refrain from their adoption; this results in low Green IT/IS adoption rates and consequentially unutilized potential.*

Taking the described research results together, this dissertation provides deep insights into Green IT and Green IS as well as their current struggles and future benefits of corporate adoption. It first provides a multi-layered theoretically grounded understanding that is enriched with both quantitative (i.e., survey) and qualitative research insights (i.e., interview studies). It provides a detailed understanding of both the issue and solution to the currently misaligned understandings of Green IT and Green IS. The suggested holistic perspective enables a better conceptual understanding as well as how these innovations can be integrated into and adopted by a company. It suggests that corporate decision-makers take this more encompassing perspective to i) take up and align corporate sustainability strategy with the already present corporate strategy and ii) question their own beliefs and assumptions about sustainability and Green IT/IS as well as their potential benefits to their company.

2 Contribution, Limitations, and Further Research

The IS domain – especially in its historical context – tends to be a relatively business and practitioner-oriented field of research (Hirschheim & Klein, 2012, p. 197). This focus, however, seems to result in the communities' relative negligence to also addressing the societal grand challenge of environmental sustainability (Wolff et al., 2022, p. 8). We thus took special care that this dissertation not only links both fields of interest but also creates both academically and theoretically interesting insights, but also practically relevant and organizationally applicable means (Benbasat & Zmud, 1999, p. 13; Leidner et al., 2018, p. 5064). In the following, we outline our contribution to the academic discourse and organizational practice, and use these insights to suggest avenues for further research and also present its limitations.

2.1 Contribution to the Academic Discourse

This dissertation adds to the academic discussion in primarily three ways: First, we developed a holistic Green IT/IS adoption framework (see paper 1). It builds on the existing DOI and the associated innovation-decision process (Rogers, 2003, p. 170) and exceeds existing general IT adoption frameworks and models (i.e., Hameed et al. process model for the adoption of IT innovations in organizations (2012)) by integrating available sustainability and Green IT/IS models and frameworks (e.g., Deng & Ji, 2015; Lunardi et al., 2013; Molla, 2008; Molla et al., 2008). In this way, it creates not only a more holistic perspective for IT innovation adoption in general but also fasteners the ties between both discussions.

We suggest investigating the framework further academically and, for instance, filling the yet white spot of factors of the outset phase. These factors might – as a first step – shed light on if and how companies anticipate and react to emerging societal developments. In a second step, these insights might allow it to strategically differentiate between those that seek to sustainability-wise defend, analyze, or prospectively further develop their position (Miles et al., 1978, pp. 550–558).

It would furthermore be interesting and valuable to shed light on the interconnections of the identified factors. These interdependencies might not only be fruitful to better understanding corporate decision-making processes in general. It would also provide further insights into i) the conceptual differences and ii) resulting decision-making processes that distinguish between ‘non-sustainable’ and ‘sustainable’ to-be-adopted innovations and technology.

Second, it suggests a terminological and conceptual modification of the IT-CMF (see paper 2); one of the most popular capability maturity frameworks, and the single one that also encompasses a Green IT capability (Curley et al., 2016, p. 103). This modification not only increases the conceptual clarity of the framework but also sets it on a significantly stronger

theoretical basis. We suggest continuing this work by, for instance, conceptualizing and undertaking a case-based action research. Accompanying a company on its way towards increased Green IT/IS maturity would not only lead to an improved understanding of the IT-CMF (as well as its Green IT/IS capability) but also on how individual capabilities (e.g., the language capability) can be integrated into the present organizational context.

Third, it lines out that Green IT and Green IS – as representatives for sustainability technologies – have innovative characteristics in the way that they need to be assessed and evaluated in more than a traditional financial way (see paper 5). While the TBL suggests creating indices for the societal and ecological dimensions, we identified a variety of factors that can be used as such. This also implies that Green IT/IS have certain disruptive innovation characteristics. By addressing factors on the natural environment as well as societal level, they address an additional, if not different, set of attributes compared to the ones of mainstream technologies and also perform far worse in traditionally valued criteria (Bower & Christensen, 1995, p. 45). This also results in (yet) relatively low adoption rates (see paper 5), despite the already observable benefits (see paper 4). It seems therefore promising to further investigate this contribution and, for instance, see how all three TBL criteria can be operationalized within a company and how Green IT/IS adoption and usage can be aligned with these goals.

2.2 Contribution to the Organizational Practice

As for the practical context, this dissertation also has a five-fold contribution:

First, we suggest factors that decision-makers need to take into consideration when adopting Green IT/IS. Factors of the natural environment, as well as societal factors, are becoming increasingly important for legislators, as well as customers around the globe. They thus, on the one side, already trickle down to financial aspects but may also become stand-alone factors in the near future. This observation could be researched further by undertaking a long-term study on a single or few companies in a selected industry. By investigating how the rules and regulations – especially in regard to ecological criteria – developed over time and how these are accompanied by corporate decisions and strategic alterations would create an improved understanding of corporate decision processes that originate from or have environmental impacts.

Second, this dissertation showed that Green IT/IS adoption is primarily a socio-technological matter. Managerial fears of costly adoptions, potential mis-investments, or sunk costs can thus – especially for the suggested initial ways – easily be circumvented. After underlining the benefit of these cost-neutral or free-of-charge alterations, managers may then proceed to make the first financial investments that then can also be measured in the criteria of the first wave. We also explicitly suggested a variety of ways for companies to start adopting and experimenting with Green IT/IS (third contribution). Further research could take our

suggestions and investigate how simple these are to be implemented within a company (e.g., by undertaking a retrospective interview study) or by undertaking an action design research study in which their organizational adoption is scientifically documented and monitored.

Fourth, this dissertation underlines that the adoption of non-mainstream innovations –in the case of this thesis, sustainability technologies and capabilities – is heavily influenced by soft factors, like managerial assumptions, estimations, and assertions that are not necessarily based on facts and rationales (see paper 6). We suggest shedding further light on the matter by undertaking qualitative research on companies that successfully overcame these managerial hindrances and adopted Green IT/IS. In this way, it might be possible to design communication and action strategies for sustainability and Green IT/IS adoption initiatives.

Fifth, we also showed that yet a few companies use Green IT/IS (see paper 5) and that companies still can have a relative advantage over their competitors (see paper 4) by advancing their efforts in this direction. Also, here, we suggest shedding further light on the matter and further documenting the benefits of Green IT/IS adoption and usage.

2.3 Limitations and Further Research

Like all research, also this dissertation is not without limitations of which we want to especially highlight three and also take these as starting points for further research:

We are aware that certain insights and results may not be equally relevant to both the research community and organizational practitioners. This may, for instance, be due to the fact that we separated between Green IT and Green IS – a distinction that the practice seems not to make (Curley et al., 2016, p. 104).

It may also be that we missed out on nor neglected certain parts of the literature. This may be, of course, due to the selection of our keywords and that we missed respecting certain trends or developments. There, for instance, seems to be the trend that ‘green’ as a qualifier is starting to be replaced by ‘sustainability’ (El-Rayes et al., 2022, p. 9).

This dissertation also combined insights from studies on both SMEs, and very large companies, which was necessary due to the relatively immature field of corporate Green IT/IS usage, and, thus, the rather exploratory topic of this dissertation. Explicitly combining the specific results of both papers, however, should be done cautiously, as “a small business is not a little big business” (Welsh & White, 1981, loc. title). They feature comparable, but nevertheless, to some extent, different decision processes and adoption patterns. The determining and influencing adoption factors might be different and also have a different impact on the respective company (Iacovou et al., 1995, p. 467).

Our research was also primarily undertaken in Germany and German-speaking countries. The IS and Green IT/IS community, however, is very multi-national, with active communities in

also the USA as well as the Pacific-Asian region (Zaung Nau & Marinova, 2020, pp. 247–248). Hence, our results are not easily transferrable to these countries or regions as they are, for instance, culturally different and have very different sets of (environmental) rules and legislations.

Also, our quantitative research insights are only of descriptive nature. They thus can be interpreted as a documentation of recent business phenomena and trends, which affects the generalizability of the results.

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List of Abbreviations

Abbr.	Explanation
AI	Artificial Intelligence
AIS	Association for Information Systems
CIO	Chief Information Officer
CO_2	Carbon Dioxide
DOI	Diffusion of Innovation
GHG	Greenhouse Gasses
GITAM	Green IT Adoption Model
Green IT	Green Information Technologies
Green IS	Green Information Systems
HICSS	Hawaii International Conference on Systems Sciences
IT	Information Technology
IT-CMF	IT-Capability Maturity Framework
IS	Information Systems
ML	Machine Learning
Mt-CO_2-e	Million tons of equivalent CO_2 emissions
RP	Research Problem
RQ	Research Question
PACIS	Pacific Asia Conference on Information Systems
SME	Small and Medium-sized Enterprise
TBL	Triple Bottom Line
TWh	Tera Watt-hours

Declaration on Oath / Eidesstattliche Erklärung

Durch meine Unterschrift gebe folgende eidesstattliche Erklärungen ab:

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Dortmund, 23.03.2023