A Multi-level perspective on a transition towards Green IT in the Netherlands

How could a transition be accelerated?

By

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Abstract

Global warming is one of the biggest societal problems in 2023. The share of IT usage within this problem has been growing rapidly in the last decades, and this is likely to continue. To stop the increasing footprint of IT (usage) a significant change is required. However, due to the pervasive nature of IT integration in our daily lives, this is a very complex undertaking. Greening the IT sector would require multidimensional changes in technologies, behaviors, regulations and so on. Apart from the need of IT in society, most people within society are not aware of the consequences of IT usage.

Green IT is the collective term for environmentally responsible IT executions. Even though this collective term is gaining ground when it comes to awareness, execution, and knowledge it is still rather limited. There exists an initial body of scientific knowledge on Green IT. However, these studies rarely address the Netherlands. Beside the absence of knowledge about Green IT in the Netherlands, there is no knowledge on how a transition towards Green IT could be accelerated. This research aims to shed light on this knowledge gap and provides scientific knowledge about how Green IT looks like in the Netherlands, what the dynamics are and how a transition could be accelerated. More in general this research contributes to sustainable transitions literature.

The aim of this research is to *"To contribute to accelerating the transition towards Green IT in the Netherlands.".* The research question is *"How could a transition towards Green IT in the Netherlands be accelerated?*

To answer the main research question a case study is conducted within the context of the Netherlands. To analyze the developments concerning Green IT in the Netherlands the multi-level perspective framework is used. This framework is used to analyze socio-technical transitions. For this framework, I proposed a phase-based framework based on the multi-level perspective framework, beside the usage for this research this contributes to the multi-level perspective literature. To use the framework data is collected concerning the developments, drivers, and barriers of Green IT. The data is collected by conducting interviews and desk research.

The result of this research is that Green IT is currently stabilizing in the Netherlands, there are significant drivers motivating Green IT implementation. The technology improves, attention is growing, and the first pioneers are actively executing Green IT. However, there are significant barriers slowing down a transition. The most important barriers that must be overcome to accelerate the transition are lack of transparency and lack of standardization. Addressing these barriers help to phase out the old system (how IT usage is currently equipped) and creates space for Green IT. The Dutch government has an important role in this transition. It must enforce transparency and sustainability in the market. Transparency will have a snowballing effect on the industry, improving technology and the societal perspective on Green IT. Beside sustainability, government should take an active role in creating standardizations, to provide more clarity to organizations. With the upcoming CSRD the first step towards phasing out is almost taken.

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1. Introduction

1.1. Background

Global warming is a growing, worldwide problem. Without any climate action, the average temperature could rise by 3,2 to 5,4 °C by 2100, compared to the pre-industrial era (IPCC, 2022). Because of this growing problem, 196 countries signed the Paris Agreement (Rijksoverheid, 2020). One of the primary goals of this agreement is to keep global warming below 2 degrees Celsius above pre-industrial levels, and to pursue efforts to keep this below 1.5 degrees Celsius (Rijksoverheid, 2020). All countries are committed to drawing up their Nationally Determined Contribution (NDCs) containing targets and measures to limit their greenhouse gas emissions (mitigation) that reflect their highest possible ambition (Rijksoverheid, 2020). In the Netherlands, one of the NDC's is the goal to reduce greenhouse emissions in 2030 by 49% compared to 1990 (Rijksoverheid, 2020).

One of the sectors that must face a transition because of this regulation is the Information (and Communications) Technology (ICT or IT) sector. Information Technology is "any use of computers, storage, networking, and other physical devices, processes to create, process, store, secure and exchange all forms of electronic data" (Garimella, 2018). IT is widely used by individuals and within organizations (Walsh et al., 2016). IT is crucial in almost every organization nowadays (Walsh et al., 2016), and in the last few decades ICT has become a necessity rather than the exception (Bosamia, 2013). IT drives economic growth (Ministerie van Economische Zaken en Klimaat, 2018) and can provide competitive advantages to organizations (Walsh et al., 2016. However, all this IT usage is not without consequences, as it has been responsible for a significant part of society's environmental problems (Salles et al., 2022).

Academic studies show that the usage of IT has its consequences. According to Freitag et al. (2021), the usage of IT is responsible for 1,8 to 2,8% of worldwide greenhouse gas emissions. Research by ABN Amro (2021) suggests that this figure could escalate to 6 to 14% by 2040, owing to the increasing trend of digitalization and data utilization. The growing volume of emissions attributed to IT must change to achieve the Paris Agreement greenhouse emission targets. However, due to the pervasive nature of IT integration in our daily lives, this is a very complex undertaking, as greening the IT sector would require multidimensional changes in technologies, behaviors, regulations and so on. Because of the urge to transform this sector, stakeholders such as companies, governments, and IT experts are investigating strategies to address these emissions. The trend and research stream focused on mitigating greenhouse gas emissions stemming from IT is commonly referred to as "Green IT". When defining Green IT, it is important to make the distinction between Green IT and IT for green. This distinction may blur in public discussions or in literature and a demarcation is important for the scope of this research. Green IT is focused on how to reduce the negative ecological impact of IT (Osch and Avital, 2010) Whereas IT for green covers the impact of IT on other sectors' environmental productivity, particularly in terms of energy efficiency and carbon footprint (Faucheux & Nicolai, 2011). This thesis seeks to contribute to the stream of research on Green

IT by conducting a sociotechnical analysis[1] of the ongoing transition towards a more sustainable IT sector in the Netherlands. Currently (accelerating) Green IT in the Netherlands is underexposed in literature. The objective of the analysis is to shed light on this gap in the literature and addressing the problem of not having a clear strategy on how to accelerate the ongoing transition.

1.2. Research context and relevance

Global warming is a topic discussed daily, both in political environments and in society. In a political sense, this has led to several agreements, such as the Paris agreement. Governments address this problem by setting goals and directions to meet the agreements. Even though the industry must adapt to these government goals, currently, there is little transparency on emissions by companies. A lot of governments are implementing ESG (Environmental, Social, and Governance) regulations and standards. Still, the most important measurement yet, is the Non-Financial Reporting Directive (NFRD). This directive only affects 115 companies in the Netherlands from all sectors (Jong, 2021). Among other things, this directive obliges these 115 companies to report on how they deal with their environmental harm. From 2024, Corporate Sustainability Reporting Directive (CSRD) will be added to the NFRD; this affects all stock market listed companies, as well as companies that meet two out of these three requirements: over 250 employees, over 40 million euros in revenues, and over 20 million euros in balance sheets (Grant Thronton Netherlands, 2021). This new directive will address four times more companies than the NFRD (Grant Thronton Netherlands, 2021). In the Netherlands 500 companies are obliged to report on their ESG regulations and measurements.

Within this reporting directive, companies must include the emissions caused by their IT usage. According to Muguresan (2008), IT must be included in a company's strategy to minimize its carbon footprint. However, research shows that only 18% of organizations have sustainability in IT as a goal within their strategy (Capgemini, 2021). The combination of the environmental urge to fight global warming and the absence of Green IT practices in companies calls for a transition. A transition towards a system in which Green IT is the norm. The relevance of this research flows from the urge of the transition. Currently there is no strategy to accelerate this transition and it is highly relevant to research how to influence such transitions. Adding this knowledge to the current transitions' literature could be useful for Green IT transitions in other regions or sustainable transitions in general.

In the context of mounting concerns about global warming and environmental sustainability, the need for a comprehensive understanding of the IT sector's impact and transformation becomes increasingly evident. The intricate interplay between evolving government regulations, expanding corporate reporting mandates, and the imperative for greener IT practices creates a demand for research on the sociotechnical transition dynamics of the IT sector.

[1] A sociotechnical analysis refers to the notion of a sociotechnical system, which refers to an interconnected arrangement of people, processes, and technology along different dimensions (social, political, economic etc.) that work together to achieve a common goal while considering social and technical aspects.

1.3. Problem analysis

The overarching problem, surpassing the scope of this research, is global warming. Several researchers (Anders & Edler, 2015; Belkhir & Ahmed, 2018; Malmodin & Lunde, 2018a; Malmodin & Lunde, 2018b) have shown that the usage of IT is partly responsible for this issue. Nevertheless, despite heightened awareness of global warming, there has been limited change in how and to what extent we use IT. In fact, forecasts even indicate a substantial projected increase of 20.5% in the enterprise IT carbon footprint between 2023 to 2025 (Capgemini, 2021). The study of and practice of reducing the negative ecological impact of IT, called Green IT, has yet to be widely adopted (Alsdorf, 2022). Even though the escalating integration of IT in our daily lives and forthcoming requirement for reporting its environmental consequences within a span of two years, the majority of organizations have yet to operationalize a Green IT agenda.

According to the literature, many factors hamper Green IT implementation and execution. One issue, for instance, is the lack of awareness: many organizations still need to be made aware of their own IT footprint. Globally, only 43% of the executives say they know their organization's IT footprint (Capgemini, 2021). Another issue is the lack of regulatory or societal pressure: many companies only slowly adopt sustainability practices such as Green IT and only seem to react to pressures, for example, from governments or social interest groups (Alsdorf, 2022).

The underlying problem statement extracted from the preceding analysis can be framed as follows:

Despite its importance, Green IT has yet to be widely adopted, necessitating a clear strategy to accelerate the transition.

This research seeks to shed light on how to improve such strategies, providing insights into the challenges, drivers, and barriers that shape the ongoing transition towards a more sustainable IT sector in the Netherlands.

1.4. Research objective

The problem analysis identified that a clear strategy to accelerate the transition is needed. This research explores the transition towards Green IT in the context of the Dutch IT system.

The aim of this research is:

"To contribute to accelerating the transition towards Green IT in the Netherlands."

The topic explored is identifying the current state and practices of Green IT in the Netherlands. Identifying the current state will give an overview of drivers and barriers for Green IT in the Netherlands. The contribution of this research is an understanding on how to exploit the drivers and overcome the barriers to accelerate the Dutch Green IT transition. Addressing this will contribute to the strategies of accelerating Green IT transitions, and the goal of meeting the Dutch government's emission targets.

1.5. Research gap

To identify a research gap, an initial literature review was conducted, with the objective of providing an overview of the current state of scientific knowledge on the crucial topics pertinent to this research. Both *Web of Science* and *Google Scholar* were used to perform the review. Several search strings were tested, combining keywords such as “Green IT”, “innovation”, “factors”, “transition”, “practices”, “drivers”, “barriers”, and “the Netherlands”. The strings resulted in a sample of articles relevant to the thesis’ objective, which are summarized in Table 1.1.

Table 1.1: Reviewed articles

Author(s)	Title	Year	Summary and relevance to this research
van Osch, W; Avital, M	From Green IT to Sustainable Innovation	2010	Clarifies the distinctions among Green IT, green IS (information systems), and sustainable innovation by detailing the specific actions inherent in each concept, where Green IT primarily entails energy and waste reduction.
Faucheux, S; Nicolai, I	IT for green and Green IT: A proposed typology of eco-innovation	2011	Differentiates between Green IT and IT for Green, offering insights into the environmental contributions of both approaches.
van Osch, W; Avital, M	The Green Vistas of Sustainable Innovation in the IT Domain	2011	Highlights the potential of a sustainable innovation approach to stimulate creativity and innovation across business, environmental, and societal domains, emphasizing the collective efforts required to reshape norms and values.
Bose, R and Luo, X	Integrative framework for assessing firms' potential to undertake Green IT initiatives via virtualization: A theoretical perspective	2011	Proposes an integrative framework to evaluate firms' readiness for IT-enabled virtualization, concentrating on identifying drivers and barriers as put forth by Molla (2009).
Harmon, R; Moolenkamp, N	Sustainable it services: developing a strategy framework	2012	Explores driving factors for Green IT adoption and initiatives within Chapter 3 of the research.
Herzog, C; Lefèvre, L and Pierson, J	Actors for Innovation in Green IT	2014	Identifies essential actors for Green IT, while also outlining the interactions between these actors.
Cecere, G; Corrocher, N; Gossart, C; Ozma, M	Technological pervasiveness and variety of innovators in Green ICT: A patent-based analysis	2014	Researching and illustrating evolving patterns of innovative activity in green ICT. Indicating that the innovative activity in green ICT domains is characterized by high growth and high levels of technological pervasiveness, considerable entry of new innovators and a variety of actors – with a prevalence of large ICT firms and universities
Thomas, M; Costa, D; Oliveira, T	Assessing the role of IT-enabled process virtualization on Green IT adoption	2016	Introduces distinct adoption phases within Green IT (initialization, integration, maturation) and investigates the influence of variables like company size on IT adoption.
Bohas, A., & Poussing	An empirical exploration of the role of strategic and responsive corporate social responsibility in the adoption of different Green IT strategies	2016	Identifies several factors that influence the adoption of Green IT strategies, including firm size, industry sector, and environmental regulations.
Sedera, D., Lokuge, S., Tushi, B., & Tan, F	Multi-disciplinary Green IT archival analysis: A pathway for future studies. Communications of the Association for Information Systems	2017	Advocates the need for interdisciplinary research, urging collaboration across engineering, social sciences, and economics to holistically address the intricate challenges posed by Green IT.
Abu Al-Rejal, HME, Et al.	Green Information Technology Adoption Antecedence: A Conceptual Framework	2020	Examines Green IT adoption and failures through a compilation of articles discussing various factors contributing to these dynamics.
Nanath, K; Pillai, R	Towards a framework for sustaining Green IT initiatives: an empirical investigation	2021	Explores factors that impact the adoption and long-term sustainability of Green IT, acknowledging the potential challenges faced by large firms in maintaining Green IT initiatives.
Alsdorf, H	It's Just Not Sexy: How Managerial Assumptions Adversely Affect Corporate Sustainability Engagement and Sustainable Technology Adoption	2022	Discusses drivers and barriers for companies contemplating Green IT adoption, offering insights into the reasons behind non-implementation and assessing current practices.

Based on the literature review, one can conclude that an initial body of knowledge on Green IT already exists. Various researchers share a common understanding on the scope of Green IT, encompassing aspects related to sourcing, usage, and disposal of IT products. Given this definition, multiple studies researched the practices of Green IT in a specific country or the dynamics within the sector. Some studies even go deeper into researching the factors influencing the adoption of Green IT practices, including drivers and barriers to implementing them. Frequently identified obstacles to Green IT adoption are lack of awareness and lack of technological knowledge.

However, most of these articles primarily conclude whether companies have integrated Green IT practices and why (not). What remains to be explored is the subsequent phase: how to overcome the barriers and exploit the drivers. Notably, many conclusions are drawn on the organizational level rather than on the broader transition (systemic level). Furthermore, scant attention has been given to comprehending the dynamics that drive or impede the transformation of entire countries or sectors. The investigation into these broader transitions and the key factors in the process remains largely underdeveloped[2]. This notable gap underscores the need for further exploration and examination of the dynamics of Green IT at the sociotechnical system level.

As indicated, while some countries and regions have been researched, the exploration of Green IT in the Netherlands remains absent. Such research could result in important insights, given the Netherlands' status as an advanced economy with a strong information infrastructure. The Netherlands could become a pioneer in the transition to Green IT and provide lessons to other countries. The combination of the lack of articles researching the broader transition of IT systems (towards Green IT) and the need for more research on the Dutch (Green) IT system represents a knowledge gap.

1.6. Research questions

Based on the knowledge gap identified in the previous section, the following main research question is formulated:

"How could a transition towards Green IT in the Netherlands be accelerated?"

To answer the main research question, the following sub-questions are also raised:

SQ1: How could the transition phases for Green IT look like?

In this sub-question I will provide an answer by providing a blueprint with transition phases for Green IT. This blueprint is an addition to the MLP framework, creating a phase-based framework. These theoretical phases are not specified for the Netherlands. This sub-question is answered through desk research, identifying conceptual phases in transition studies. The

[2] The search string combining "Green IT" and "transition" in Web of Science yields no academic papers addressing the delineated topics. Furthermore, the term combination of "transition" and "IT sector" offers no substantial information related to Green IT.

result of this research will be a blueprint of theoretical phases of transition, to compare these with the Dutch Green IT system.

SQ2: What are the drivers and barriers for implementing Green IT in the Netherlands?

This sub-question is naturally divided into two parts. In the first part, it is researched what the drivers are to implement Green IT according to the several actors in the Netherlands. It is necessary to understand what the drivers are that contribute to organizations implementing and developing Green IT. The second part has the same set-up; here the barriers that slow down the acceleration of Green IT transition on a wide scale are researched. Both parts together result in an overview of drivers and barriers currently experienced in the Netherlands. To answer this sub-question, I conduct interviews with experts on Green IT. The outcomes of these interviews are triangulated with other sources through desk research. This sub-question contributes to the main research question by identifying the required steps to overcome barriers and exploit drivers to accelerate the transition process.

SQ3: In which phase of transition is Green IT in the Netherlands currently?

The third sub-question uses the results from SQ1 and SQ2 to identify at which phase of the Green IT transition the Dutch sector is. To answer this sub-question, I also use the results from interviews. I compare the data gathered from the interviews with Green IT transition phases indicators outlined in answering SQ1 to describe the current status of Green IT in the Netherlands. The current drivers and barriers from SQ2 are as well compared to the theoretical phases of SQ1, helping to identify the phase of transition. The identification of the phase of transition gains insight into how to proceed to later phases.

1.7. Research scope

This research on Green IT transition is scoped based on several different criteria. First, this research sheds light to Green IT (reduce the negative ecological impact of information technologies), excluding IT for Green (the impact of IT on other sectors).

Furthermore, this study follows the definition of what constitutes Green IT practices, as described by Loeser (2013). This includes IT sourcing, IT operations, and IT disposal. A visualization of this is visible below in Figure 1.1. Narrowing the research down to these three concepts causes that this research mostly focusses on energy efficiency and equipment utilization within organizations. This includes internal actions and direct interactions, such as supplier selection, as organizations may choose where they buy their laptops based on environmental consequences. Further upstream in the supply chain is out of the scope of this research as including this is unfeasible considering the time constraint of this research. Green IS, which refers to information systems that enable sustainable business processes and end products (Loeser, 2013) is also out of the scope of this research. Green IS addresses more mature and more complex processes (e.g. IT systems that monitor traffic congestion to minimize energy consumption in transport). An important clarification to make is the word “system” in Green IS, this refers to technologies that function as a system (e.g. computer system, monitoring system). This should not be confused with “system” in socio-technical system, in which Green IT is a technology that interacts with number of different actors.

Green IT addresses (partly) different technologies compared to Green IS. Green IS could be placed in a socio-technical system as well, as for this technology there is interaction with other actors as well, it is out of the scope of this research based on its complexity and its related maturity needed.

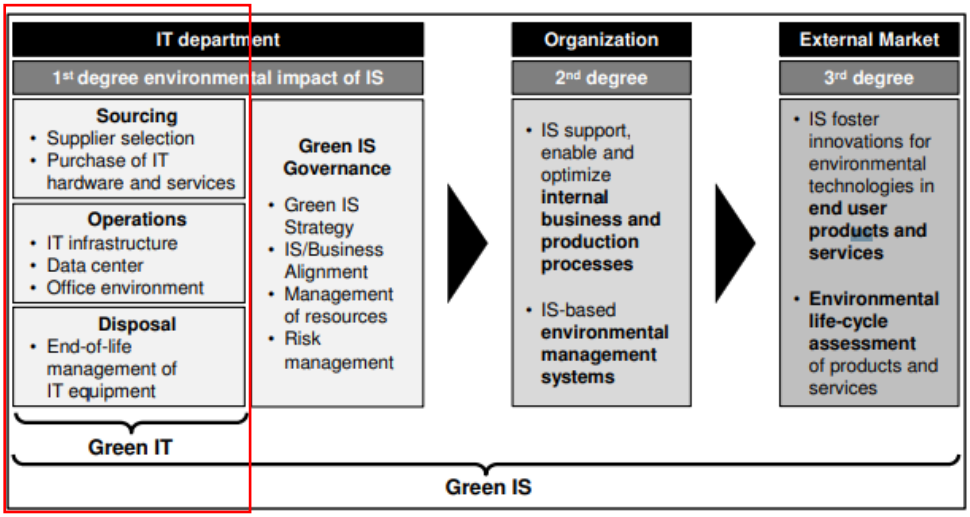

Figure 1.1: Green IT scope (Loeser, 2013, p. 6)

The final research boundary of this research is the Netherlands, which is the focus area in this study. This study investigates Dutch organizations with the IT socio-technical system, which include institutions and actors within different dimensions (e.g., socio-cultural, economic, political etc.) and the influences of external pressures (stemming from outside the system dimensions). Expanding the research scope to broader perspective (such as Europe) would introduce many complexities in attempting to map all relevant interactions. In addition, given the timeframe of the research, gathering all necessary information for all countries would prove unfeasible. Finally, establishing at which stage Europe is in the Green IT transition process would be complicated by the fact that different countries are likely to perform differently and be in different transition phases.

1.8. Structure of the thesis

The first chapter serves as an introduction to the research, outlining its purpose, identifying the problem under investigation, formulating the research objective, and presenting the research questions. The next (second) chapter provides a theoretical foundation for the research, based on the literatures on socio-technical systems and socio-technical transitions (to sustainability), synthetizing relevant concepts for the analysis in a phase-based Green IT transition framework. This framework provides an answer to sub-question 1. In the third chapter, the methodology for the research is explained. In chapter four, the case study results are presented, answering sub-question 2. These results are subsequently discussed in chapter five, which answers the final sub-question. Chapter six then concludes by answering the main research question, highlighting the study's scientific and societal contributions, and discussing its limitations that suggest areas for future research.

2. Research background

In this second chapter the theoretical framework is discussed. First, I describe the transition literature and I motivate the fit of the theories to this research. By creating a funnel, I specify the broader concepts that are introduced for Green IT. Eventually, in this chapter the first sub-question *"How could the transition phases for Green IT look like?"* is answered in section 2.6.1.

2.1. Socio-technical systems

In this research, the Green IT sector is approached as a socio-technical system. A socio-technical system is defined as "the linkages between elements necessary to fulfill societal functions" (Geels, 2004). Socio-technical systems do not function anonymously, they are the outcome of human activities (Geels, 2004). Examples of Socio-technical systems are energy, mobility, or food systems. While different authors consider a different set of elements, most approaches usually include actors, technologies, and institutions. According to Geels (2004), one of the advantages of researching a socio-technical system is that the co-evolution and interaction of technology and society lie within the attention focus. Focusing on a socio-technical system could form a bridge to align technology to the user and regulatory environments.

Some researchers investigated ICT as a socio-technical system. Morris (2009) follows the definition of socio-technical systems by Baxter and Sommerville (2008), stating that socio-technical systems are "systems that involve a complex interaction between humans, machines and the environmental aspects of the work system". Kling and Lamb (1999) Argue that information technologies should be regarded as a socio-technical system, because they involve the interplay between complex technological components and social aspects, such as organizational processes, roles, and practices, which together shape their functioning and necessitate a systemic understanding beyond mere technical tool perspective. Given the definition of Baxter and Sommerville and the fact that computers, being machines, interact with each other and humans, one could agree on this. Adding the term "green" to IT, the environmental aspects of the work system become increasingly important. A more extensive description of the Green IT system within this case study follows in Chapter 4.

2.2. Transitions

Transitions are defined in the dictionary as "the process or a period of changing from one state or condition to another". In the academic world, this term is used in several research fields, one of which is sustainability transitions. The research field of sustainability transitions is rapidly growing (Köhler et al., 2019). The field of sustainability transitions studies transitions in large-scale production/consumption systems and seeks to mobilize this knowledge to accelerate the processes toward more sustainable societal arrangements (Rosenbloom & Meadowcroft, 2022). Markard et al. (2012) define sustainability transitions as "long-term, multi-dimensional, and fundamental transformation processes through which established socio-technical systems shift to more sustainable modes of production and consumption" (p. 956).

This definition, focusing on socio-technical systems, captures the fact that most transition studies take a socio-technical system perspective.[3] Loorbach et al. (2011) motivate this perspective by stating that the basic idea is that complex interactions between different elements can be understood in a systemic sense. Through their interaction, elements within a system co-evolve with each other and their environment, new structures and novelties emerge, and new configurations appear through self-organization. Rosenbloom and Meadowcroft (2022) concluded the same by stating that a significant body of work within this field examines socio-technical systems. Fischer and Newig (2016) even used socio-technical transition and sustainability transition in literature searches for the same purpose. Geels et al. (2017) contribute to this general conception by advising to focus on socio-technical systems rather than individual elements when analyzing transitions. In addition, Köhler et al. (2019) highlighted the importance of this approach to overcome grand societal challenges after researching the state of the art of sustainable transitions research. In line with this field, to comprehensively investigate the Green IT transition in the Netherlands, this thesis adopts a socio-technical system perspective.

2.3. Sustainable transitions approaches

It is almost an academic consensus that sustainable transitions are best analyzed with a systemic perspective. Indeed, there are several analytical frameworks available to do this. The most widely adopted framework is the multi-level perspective (MLP), which will also be used in this research and, therefore, is discussed in section 2.4.

Apart from the Multi-level perspective, there are other frameworks suitable for a socio-technical approach. When analyzing the state of the art of sustainable transitions research, Köhler et al. (2019) concluded that the most important frameworks, apart from the MLP, are: the Technological Innovation System approach (TIS), Strategic Niche Management (SNM), and Transition Management (TM). Besides the fact that there are overlaps and interconnections among these approaches, the theories differ in perspective on technological innovation and transitions.

The Technological Innovation System (TIS) approach by Hekkert et al. (2007) focuses on understanding the complex interactions and dynamics within technological innovation processes. It emphasizes the importance of a systemic perspective, considering the various actors, institutions, and networks involved (Wicki & Hansen, 2017). The role of both internal and external factors in shaping technological innovation is recognized in this theory (Hekkert et al., 2007). This theory focuses on the emergence of innovations as a driver for change rather than the stability of the systems (Köhler et al., 2019). Compared to the MLP, both theories focus on complex interactions within socio-technical systems, both accounting for internal and external factors. Based on the earlier motivation in this chapter, one could conclude that TIS would be suitable for this research. While it would be possible to develop a TIS analysis of the Green IT transition, one disadvantage/criticism is that the TIS approach and methodology does not explain what drives the change (Kern, 2015; Markard et al., 2015). This

[3] One of my findings when researching this academic field, through an extensive search of sustainability transition studies, was indeed that sustainability transitions use socio-technical systems as unit of analysis.

absence is critical for this research as the aim is to accelerate the transition by fostering drivers of Green IT innovations and addressing barriers to it.

Strategic Niche Management (SNM) (Rip & Kemp, 1998) focuses on developing and nurturing innovation niches as potential sources of radical technological change. Essential in this theory are the protected spaces or niches where new technologies can be experimented with and developed (Schot & Geels, 2008). These protected spaces allow nurturing and experimentation with the co-evolution of technology, user practices, and regulatory structures (Schot & Geels, 2008). Compared to the MLP, both frameworks recognize the protected spaces at the niche level. However, MLP has a broader perspective, including other levels. Besides the fact that niche innovations could be highly important, the absence of the other levels will only deliver some needed data to accelerate a transition. The MLP is preferred as it recognizes the importance of niche innovations, as well as the mezzo "regime" level and the macro "landscape" level (see section 2.4).

Transition management (TM) is described by Lachman (2013) as "a reflexive and participative governance concept that attempts to manage transformative change (i.e., influence the speed and direction of change) towards sustainable development by combining long-term thinking with short-term action (thus complementing conventional policy) through a process of searching, experimenting and learning." In this theory, governance studies are included. The aim is to help policymakers shape transitions (Köhler et al., 2019). The goal is to change governance to facilitate transitions by bringing actors together rather than having competitive relationships between them (Köhler et al., 2019). The difference between TM and the MLP is the point of view, whereas transition management tries to inform governmental policies, and MLP analyzes system dynamics (of which policies is one aspect). As this research is concerned with broader system dynamics, the MLP is preferred (but a TM approach to Green IT could be developed based on the results of this study).

2.4. Multi-level Perspective

In line with the conception in sustainable transition studies, the MLP framework is advised for this type of research by a high number of papers (Geels, 2002; Geels, 2017; Rip & Kemp, 1998; Rosenbloom & Meadowcroft, 2022; Smith et al., 2010). It is called a "prominent approach in transition studies" (Köhler et al., 2019), and according to Rosenbloom and Meadowcroft (2022) this framework has gained particular prominence in this field. Apart from its dominance in the field, MLP has the best fit to this specific research. Green IT is a multidisciplinary topic, bringing in high complexity such as number of different actors, technological constraints, policies many more factors. Based on this complexity the opportunities and problems could be in lots of different dimensions. The MLP provides guidance to this complexity, intelligently combining all these dimensions within a broader perspective to the entire system. Based on its broad perspective and change thriving characteristics, I find the MLP the most suitable transition approach for Green IT.

The multi-level perspective theory (MLP) by Geels (2006) is a tool to analyze the transitions of socio-technical systems. It aims to answer how a transition to a new system takes place. This framework sees transitions as driven by interactions between three analytical levels

(Geels et al., 2017). The three different levels that interact with each other as well as within one level in the framework of Geels (2006, p. 172-173) are:

- **The macro level (the landscape)** refers to the broader exogenous environment. Examples of this are environmental problems and cultural changes. Landscape developments are beyond the direct influence of actors.
- **The meso level (regimes)** builds on technological regimes, which explain patterned development along technological trajectories. This is broadened with accommodates the broader community of stakeholders, their alignment of activities and the institutions that mediate these activities. Within the field, most studies focus on this level, as this is the level that must change (because of destabilization) for a transition.
- **The micro level (technological niches)** is the locus for radical innovations. At this level, novelties emerge in protected spaces to shield them from the market.

Besides those three levels, the MLP also discerns between multiple dimensions of a socio-technical system (interacting with each other):

- **Markets, user preferences (Demand side):** all market players, together shaping the market and its normal practices and preferences.
- **Industry (Supply side):** Suppliers of the market, depending on the system this could actors such as manufacturers, suppliers, service providers, responding to meet and steer user preferences.
- **Policy:** Include all the regulations and policies that affect the system.
- **Technology:** Refer to the technologies used by market players and new technologies enabled and constrained by technological knowledge.
- **Culture:** Refer to the social perception on the system, including social pressure, steering or dependency.
- **Science:** Refer to the academic knowledge about the system, shaped by the amount and the nature of the articles.

These dimensions are an interesting way to look at where the drivers and barriers of a transition process come from. Therefore, my analysis of the Green IT transition in the Netherlands will focus on them.

2.5. Sustainable transitions in MLP

The MLP aims to analyze transitions of socio-technical systems and, more importantly, the transitions towards a sustainable socio-technical system. Schot and Geels (2007, p. 406-413) proposed six different transition pathways:

- ***P0 Reproduction process (p. 406):*** *If no external landscape pressure ('regular change') exists, the regime remains dynamically stable and will reproduce itself.*
- ***P1 Transformation path (p. 406):*** *If there is moderate landscape pressure ('disruptive change') when niche innovations have not yet been sufficiently developed, regime actors will respond by modifying the direction of development paths and innovation activities.*

- ***P2. De-alignment and re-alignment path (p. 408):*** *If landscape change is divergent, large, and sudden ('avalanche change'), increasing regime problems may cause regime actors to lose faith. This leads to de-alignment and erosion of the regime. If niche innovations are not sufficiently developed, there is no clear substitute. This creates space for the emergence of multiple niche innovations that co-exist and compete for attention and resources. Eventually, one niche innovation becomes dominant, forming the core for re-aligning a new regime.*
- ***P3 Technological substitution (p. 409):*** *If there is much landscape pressure ('specific shock,' 'avalanche change,' 'disruptive change') when niche innovations have developed sufficiently, the latter will break through and replace the existing regime.*
- ***P4 Reconfiguration pathway (p. 410):*** *Symbiotic innovations developed in niches are initially adopted in the regime to solve local problems. They subsequently trigger further adjustments in the basic architecture of the regime.*
- ***P5 (p. 413)*** *If landscape pressure takes the form of 'disruptive change,' a sequence of transition pathways is likely, beginning with transformation, then leading to reconfiguration, and possibly followed by substitution or de-alignment and re-alignment.*

The researchers distinguish paths 1 to 4 from paths 0 and 5, whereas the formers are the main and the latter are additional paths. Geels (2019) pointed out that transitions could vary. However, the general multi-level perspective dynamic is similar to the transformation pathway (P1).

These different transition pathway types will be used to inform a reflection (in the concluding chapter) on what green transition pathway the Dutch IT system seems to be following, based on the results of the case study.

2.6. Transition phases of MLP

Some transition studies discern between transition phases, based on the MLP's transformation pathway. Almost all transition studies that make use of phases use either three or four phases. For this research, I use four phases, as it gives more granularity for the analysis and is in line with the phases of Geels (2019), which is the MLP specification from which I draw. In this section I delve deeper into these phases. A study using these four phases in Green IT has yet to be executed. Based on this absence, I translate the existing knowledge of these phases in comparable studies into a blueprint sketching how phases are likely to look for Green IT. This conceptual blueprint represents my analytical framework and is a contribution of this thesis, providing an answer to sub-question 1.

2.6.1. MLP transition phases

Transition typically takes several decades and can be divided into four phases. In each of the phases, there are different activities and struggles. The phases are described as follows (Geels, 2019):

- **Phase 1 (experimentation)** is characterized by experimentation and trial-and-error learning at the niche level. This phase is highly uncertain, contains number of failures

and competing claims and promises. During this phase, niche innovations face several challenges that hinder their development. These involve being more expensive than expected; uncertainties about users and their specific preferences; and 'new' innovations perceived as unfamiliar, which reduces their cultural legitimacy, social acceptance, and access to financial resources.

- **Phase 2 (stabilization)** starts when one of the innovations in the niche level forms a dominant design (a *de facto* technical standard). The innovation stabilizes with the help of best practices, design guidelines, and standardization, drawing in more financial resources and increasing its cultural legitimacy.
- **Phase 3 (diffusion, disruption)** starts when radical innovation diffuses into mainstream markets. This mostly happens because of niche-internal drivers (such as technological features) and taking advantage of a window of opportunity because of landscape developments that put pressure on the regime level. During this phase, struggles appear between the existing regime and the niche innovations. These are economic competition, political conflicts, and cultural struggles.
- **Phase 4 (institutionalization, anchoring)** is where the old socio-technical system (partly) is replaced by the new one. The new socio-technical system becomes the new norm, considering the new user habits, technical capabilities, and standards.

A visualization of these phases and the transition path is shown in Figure 2.1.

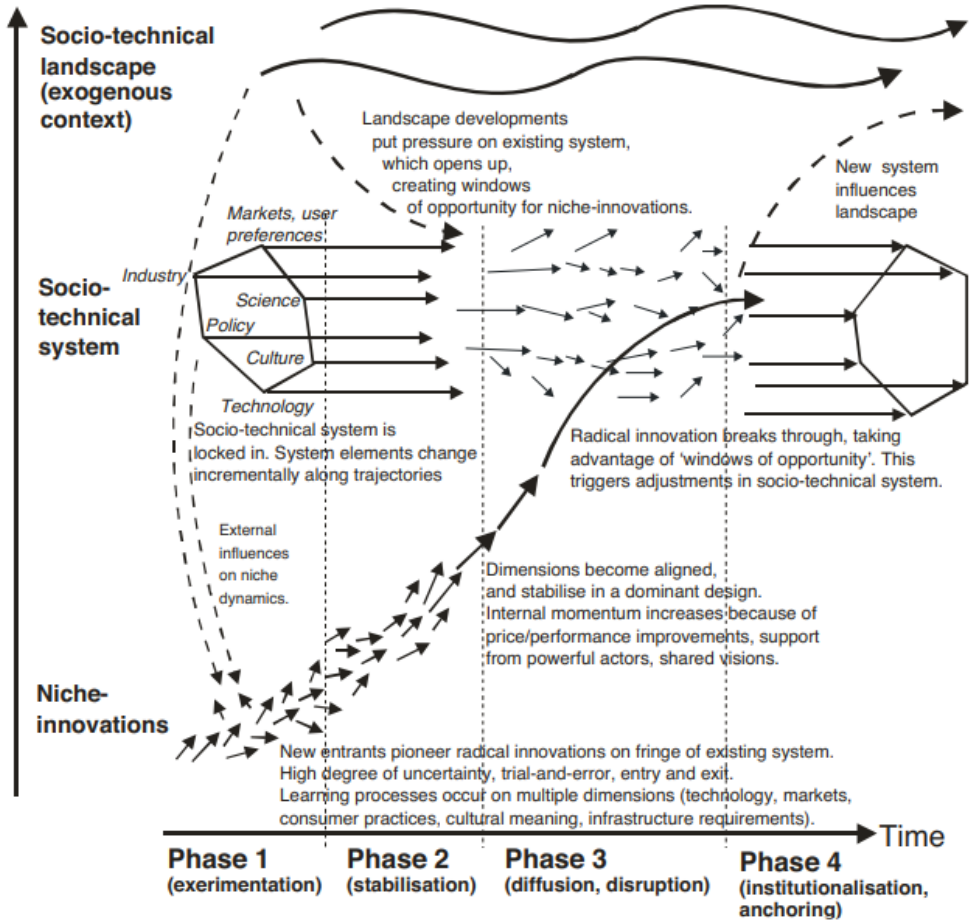

Figure 2.1: Transition phases in multi-level perspective (Geels, 2019)

In addition to the description of the phases in general I add a more detailed overview of how each dimension looks in the phases of transition. As stated earlier, Green IT transition has yet to be researched using the MLP, or a phase-based framework. To sketch a blueprint of how each dimension of the socio-technical system could look like, I used a variety of related papers. I executed a desk study for these phases. Included in this desk study are papers explaining the interactions of other low-carbon or sustainable transitions. These papers were found using google scholar using multiple search strings such as “multi-level perspective phases”. Papers that came out were scanned and used if the papers addressed phases in the research. This phase distribution is not necessarily common when researchers use the MLP framework. From this starting point in google scholar I used the backwards snowballing method to find more papers. Within the used papers I found a consensus on the dimensions in each phase. The papers referred to the same papers and did not show any contradictions. I neither found contradictions in alternative articles that I retrieved. After the papers were collected, I conducted extra research using “Web of Science”, testing multiple search strings relating to phases, MLP and transitions. Again, articles were scanned for contradictions or new insights. Neither this check-up for other papers led to new insights, based on this I conclude that there was saturation in this review. Based on the papers Daniel, 2022; Geels, 2006; Geels, 2020; Geels and Turnheim, 2022 Geels et al., 2017; Hundscheid, 2022, I propose the dimensions for each transition phase of Green IT as below. Table 2.1 briefly summarizes these dimensions and phases.

Phase 1 (Experimentation)

Markets, user preferences (Demand side): There is uncertainty about who the users are and what their preferences are. In this phase the market in general could not be ready for the radical innovations, companies prefer their current IT execution over new innovative options. In this phase the system mostly changes because of small incremental improvements, done by the actors in the existing market. Some end users are building social networks and transformative coalitions of actors who are willing to develop, nurture and protect the innovation. Actors are supporting these niches, hoping that novelties will eventually be used in the regime or even replace it. However, not all actors are helping, some others may lobby the government to hinder the innovation.

Industry (Supply side): Different initiatives for executing Green IT pop up from different actors, however these initiatives are fragmentated. Feedback of positive visions, such as proven reductions of emissions in datacenters provide directions for innovation processes and attract wider attention. Performance tends to be low and costs high. Innovations struggle to survive economically, and often depend on financial support from policymakers (e.g., subsidies for R&D or demonstration projects) or specialized investors (e.g., venture capital, business angels). To attract more partners and investors the industry is demonstrating their projects, showing the improvements and potential benefits of Green IT.

Policy: There is no certain policy on promoting Green IT or hindering the current IT emissions. There are no stable design rules, guidelines, standards, policies, or governance structures in this early phase, given that radical innovations do not initially ‘fit’ with prevailing regulatory and selection environments. If there is policy support, this tends to be small and relatively

uncommitting, often in the form of seed money for demonstration projects or subsidies for R&D.

Technology: Performance of technology is low; innovations do not cause significant reductions in IT emissions. R&D laboratories are widely experimenting and learning by trial and error. Different technical forms (standards) may be competing with each other, it is unclear which functionalities will be useful for the greening of IT. Even though the technicalities are still emerging, some small improvements are implemented. Technology delivers small changes in IT handling, already leading to minor reductions in IT emissions.

Culture: The awareness of the IT sector and its consequences starts to increase; the current system is criticized by society. System changes incrementally due to small improvements in cultural meanings.

Science: Rather experimental, aiming to answer the uncertainty of the technology and innovations.

Phase 2 (Stabilization)

Markets, user preferences (Demand side): The novelty is used in small market niches, for example data centers or companies aiming for a green reputation. Green IT is adapted by a slightly wider group of actors. These users provide resources for technical specialization. The interaction with these first users builds user experiences. Real world practices of the benefits and problems are resulting from these user experiences. Users are getting involved and social networks and alliances become bigger in the second phase as a dedicated community (of firms, engineers, datacenters, policymakers, users) emerges. The involving of more actors, including powerful incumbents brings more resources into niches. Consumers 'domesticate' radical innovations and transform them from unfamiliar things to familiar objects embedded in the routines and practices of everyday life. However, innovations may remain stuck in market niches for a long time, especially when they face a mismatch with the existing system (e.g., infrastructure, user preferences, institutional barriers). Dedicated professional groups such as branch organizations are trying to overcome this by lobbying for more support and bundling knowledge on Green IT practices.

Industry (Supply side): Different practices of Green IT execution stabilize; Green IT gains more understanding, and it gets more attractive for a wider group of actors. Learning processes focus on improving functionality (e.g., more reductions) rather than costs. The improving of the functionality is helped by users, delivering feedback and other resources.

Policy: Governments start acting, policy around IT emissions in on the agenda. Policy support often becomes stronger in this phase and may take the form of investment subsidies for firms, purchase subsidies for consumers, public procurement, which help to create and expand Green IT execution. The focus is mostly on legislations, however the first debates on (emission) standards arise. Niche advocates may try to alter wider contexts through political lobbying and institutional entrepreneurship by showing how important Green IT is, and what

could be achieved. On the other side, incumbent regime actors may actively resist these changes.

Technology: It becomes more clear what Green IT is exactly, how it is executed and what we can achieve by implementing. A dominant design stabilize, knowledge on this topic grows. Industry associations and engineering communities supply knowledge circulation and aggregation.

Culture: Problem agendas and promising findings are discussed, resulting in stabilization of new norms. These new norms are mainly shaped by further increasing awareness of emissions of IT and global warming in general. Social networks and alliances become bigger in this phase. Society shapes future by socially accepting Green IT and start interacting with it, Green IT gets socially accepted and promoted. Society stabilizes the economic opportunities by creating generating support.

Science: A rising number of articles are published, generally with a negative overall tone about IT emissions.

Phase 3:

Markets, user preferences (Demand side): Economic competition and strategic games between firms rise, this creates opportunities for green technologies to break through. Markets change and user preferences shift towards greener IT execution. The number of actors implementing Green IT increases rapidly. As the number of actors is growing, there is more interaction and positive feedback. Actors are realizing what Green IT could bring to their companies as practical examples rapidly arise and emission reductions improve.

Industry (Supply side): Business struggles between entrants and incumbents, entrants demonstrate that Green IT is possible, putting pressure on incumbents. Industry is improving in costs and performance caused by several factors. Supply side has more interaction with end users, resulting in improvements in IT reductions because of learning-by-using. Supply side benefits from increasing information by the shared information among users. Benefits become clearer for the end users.

Policy: Regulatory framework for Green IT is proposed. Political struggles over adjustments in regulations, standards, subsidies, and taxes. It is not clear how they will be framed, and what degree of stringency will be attached to them. The debate on (emission) standards becomes more prominent. There may be conflicts and power struggles about the settings of policy instruments (e.g., adjustments in subsidies, taxes, and regulations) and the kinds of instruments (e.g., market-based, regulatory, informational). Eventually, changes occur in policy agendas. These changes are twofold. These changes result in the introduction of stricter regulations for the existing way of IT. Besides, adjustments in regulations and policies become more supportive of radical innovations. Examples of these policies are capital grants or interest-free loans that stimulate investments and uptake by firms or regulations that drive company engagement such as strengthening change coalitions.

Technology: Technology improves significantly in this phase. Resulting from the interactions with the demand side more knowledge is gained for reductions. It becomes visible which executions improve emissions significantly. Technology becomes more attractive to the market.

Culture: Cultural changes towards Green IT as a standard, influencing changes in markets and user preferences. Society expects changes from the market, as the new way of Green IT is socially accepted. Although the new innovations slowly become the norm, there are still some cultural and discursive struggles about the framing of problems and solutions, as social groups have different views and interpretations. These struggles are expressed in public debates.

Science: Green IT performances and developments are researched; complementary technologies are researched.

Phase 4:

Markets, user preferences (Demand side): The new socio-technical system replaces (parts of) the old one. The majority of users switch to Green IT, it becomes in institutionalized and anchored in regulatory programs, user habits, views of normality, professional standards, and technical capabilities. Knowledge and staff training are normalized to help staff in executing Green IT.

Industry (Supply side): In the industry the new system of Green IT becomes the norm. The technology is mature and became part of the daily IT executions.

Policy: The new system becomes anchored in safety regulations, (technological) performance requirements, tax and subsidy rules, and professional standards including emission standards for IT.

Technology: New, more sustainable, technologies replaced the existing technologies. 'New' technological measures are the new norm. Within this new norm incremental changes take place from this phase on.

Culture: The majority of users switch to new technologies and social practices, which stabilizes new habits of use and views of normality.

Science: Green IT becomes a market standard in this phase. For science this means that Green IT becomes a regular topic of research, not necessarily for change or transitions anymore, for a wide variety of research.

Bundling all this information, table 2.1 provides an answer to sub-question 1: "*How could the transition phases for Green IT look like?".*

Table 2.1: Indicators of Green IT transition phases

	Phase 1 (experimentation)	**Phase 2 (stabilization)**	**Phase 3 (diffusion, disruption)**	**Phase 4 (institutionalization, anchoring)**
Market, user preferences (demand side)	- Uncertainty about the users and their preferences - Incremental innovations from users - Some networks are built	- Novelty is used in small market niches - Increasing interactions (e.g., alliances, feedback) - Bundling knowledge - No clear match to technology	- User preferences shift towards greener IT execution - Number of actors using Green IT is growing - Actors realize the benefits of Green IT	- The majority of users switch to Green IT - Green IT is normalized and anchored in business practices
Industry (supply side)	- Different initiatives of Green IT pop-up - industry trying to get more attention	- Green IT practices start to standardize - Better functionality and more attraction	- Increasing information/ feedback due to interaction with market	- Green IT is normalized
Policy	- No certain policy on Green IT - No standards	- IT emissions policy is on the agenda - Market and industry lobbying	- Green IT policy is created - Standardization becomes more prominent - Adjustments in policy are on the agenda	- Clear regulations (e.g., performance requirements, professional standards) - Clear emission standards
Technology	- Low performance - Uncertainty and competition	- Green IT becomes more clear - Practices stabilize	- Technology improves significantly - Technology becomes more attractive to the market.	- New, more sustainable, technologies replaced the existing technologies - Incremental improvements in new technologies
Culture	- Low awareness, starting to increase	- New norms arise - Green IT gets accepted and promoted	- Cultural changes towards Green IT as a standard -	- Culture stabilizes new user habits and views of normality.
Science	- Rather experimental, researching uncertainties of Green IT	- Number of articles rise, mostly negative	- Green IT performances and developments are researched	- Green IT becomes a standard research topic

2.7. Drivers and barriers of transition

In the previous section, the theory of each of the phases is described. In practice, several factors influence the transitions, either barriers that hamper the innovations or drivers that push the system toward a new phase. These drivers and barriers could be phase-specific and constant throughout the transition. In general, the factors influencing de adoption of Green IT could be sorted into three different sources (Molla et al., 2009, p.6):

- **Economic forces** refer to the need to pursue internal efficiency and market performance and could be significant motivators of Green IT adoption. The expansion of global business and the need to keep copies of the same data to comply with regulations and meet business continuity strategies are leading to a meteoric rise in stored data.
- **Regulatory forces** are critical in demanding adherence to green or environmentally responsible behaviors or initiatives. Governments and other inter-governmental organizations could influence the adoption of Green IT by rules and laws that allow or prohibit certain practices. Some of these include caps on greenhouse gas emissions, institutionalizing emissions trading, banning the use of hazardous materials, and imposing restrictions on e-waste disposal.
- **Normative forces** refer to the pursuit of legitimacy within the broader social context. The need to meet social obligations and enforce moral governance can induce certain Green IT practices. Several national, professional, and intergovernmental institutions are producing guidelines related to Green IT.

This distinction is retained by Bohas and Poussing (2016). Based on an extensive literature review, Yang et al. (2020) concluded a likewise division in motivations, calling them economic factors, authority factors, and moral drivers.

Projecting these factors to the MLP framework, I conclude that not all relevant elements (system dimensions) of a socio-technical system are covered. Considering the six socio-technical system dimensions (Geels, 2006) – Culture, policy, industry, science, technology, and user preferences – I conclude that four out of the six elements are covered in the stated factors by Molla et al. (209). User preferences and industry are both covered in the economic forces, based on that the industry which must adopt Green IT partly based on economic decisions such as reputation and costs, and their preferences must be met. Policy is covered in the regulatory force. Regulations are the direct result of policy, and these rules and laws influence the adoption of Green IT. Finally, culture and normative forces are linked, being the social context. It is striking that it leaves aside the elements science and technology. Therefore, in this dissertation, I will expand on Molla to look at barriers and drivers across all relevant dimensions of an ST system. I add a fourth factor to this division:

- **Knowledge forces** refer to the technological and academic knowledge on Green IT. It captures how absence or presence of technological opportunities drive the transition. This technological knowledge is supported by scientific knowledge.

2.7.1. Drivers and barriers on the landscape level

Based on the knowledge captured in the MLP framework, landscape developments could be a significant driver for transitions. Pressures on the existing regime could result from these developments and external shocks on the landscape level (Geels, 2019). Examples of these are demographics, cultural repertoires (developments), wars and financial crises (shocks) (Geels, 2019). This level is threated as secondary in this research. The landscape does have an influence on transitions. However, it cannot be controlled and thus analyzing it explicitly do not yield substantive insights considering the objective and main research question of this research (how to accelerate a transition). Nevertheless, I will consider landscape

developments when reflecting, in the conclusion, on what type of transition pathway the Dutch Green IT transition seems to be following.

2.7.2. Drivers and barriers on the socio-technical regime level

Most drivers and barriers mentioned in current literature are within the socio-technical regime level, where organizations interconnect with other organizations. Molla et al. (2009) identified the main reasons for pursuing Green IT in their case study; an overview of this is visible in Figure 2.4. This case study compared three countries, and there were no significant differences in motivations for each country. I would argue that 10 out of 12 motivations could be explained as interactions in the socio-technical regime, as they all could be linked to industry, culture, policy, technology, and market and user preferences. Only environmental considerations could be placed at the landscape level as this is an external pressure on the regime. Sorting these motivations along the four forces, I conclude that CIOs are mostly motivated by economic factors, as I place seven of the twelve under this category (reducing costs, corporate strategy, client pressures, industry associations, competitor actions, and IT vendors pressure). None of the factors is left out in this research. Regulatory factors are presented by governmental regulations and incentives. Environmental considerations, social acceptance and Green IT uptake by more organizations are included in normative factors. Finally, maturity of Green IT industry refers to knowledge. This last factor could arguably be the 11th motivation in regime level or could be in niche level. The maturity of Green IT is both dependent on technologies from niche innovators as well as from the current industry. Looking into the MLP system dimensions all elements are covered, including the industry dimension as this is partly covered by the maturity motivation.

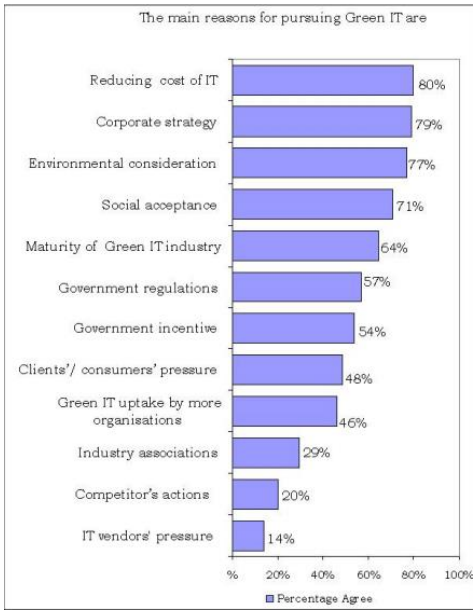

Figure 2.2: Motivations for implementing Green IT in international case study (Molla et al., 2009)

When analyzing the inhibitors of Green IT, which are visible in Figure 2.3. I draw a similar conclusion. Here 5 out of 8 of the most mentioned barriers lay within the regime level. Next to these remarks, there must be mentioned that this is an outcome of interviews with Chief

Information Officers (CIOs). These CIOs operate within the socio-technical regime, so it is more likely to have motivations and barriers within this level. However, they could still feel pressures from the landscape level or could mention more problems from upcoming innovations.

Subdividing the inhibitors to the categories I draw the same conclusion that economic factors are the most valuable to the CIOs. However, 3 of the 4 barriers (costs, business value and adoption) are associated with the niche level. Lack of leadership is the only economic barrier in this level. Knowledge is relatively and absolutely more mentioned as an inhibitor compared to a motivator. Lack of sophistication and inadequate skills and training are knowledge factors. Lack of governmental incentives is the only regulatory force. Finally, it is striking that none of the mentioned inhibitors is a normative factor. I conclude from this that the dimension culture is likely to primarily pushes a transition. I find this explainable as expected as Green IT is 'doing good' environmentally seen so normative factors are likely to support this.

Remarkable is the number of reasons mentioned both as a motivation and as an inhibitor: costs, (lack of) government incentives, and (lack of) governmental regulations. I conclude that these are essential factors, as they can influence the system's transition negatively and positively. Additionally, a relatively large number of the CIOs agreed on these three reasons.

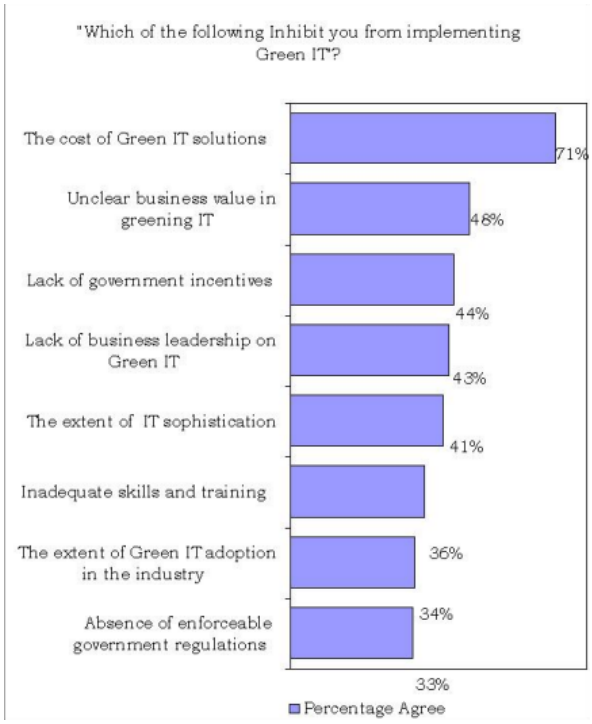

Figure 2.3: Inhibitors for implementing Green IT in international case study (Molla et al., 2009)

2.7.3. Drivers and barriers on niche-innovations level

Geels (2018) suggests that there are internal and external drivers for niche-innovations. External factors are captured in the framework. These are landscape shocks or developments, such as environmental pressure. Concerning the internal drivers for niches Geels (2018) states

that drivers are: “price/performance improvements, scale and learning economies, the development of complementary technologies and infrastructures, positive cultural discourses, and support from powerful actors.” I want to highlight the amount of knowledge factors in this level. Complementary technologies is a pure knowledge factor, whereas price and performance improvements, scale and learning economies and support from powerful actors could all be divided into economic forces and knowledge factors. Price and performance and scale and learning economies could both be the result of economic factors as well as technological improvements. For support from powerful actors the support could be financial or by knowledge support. This amount of knowledge factors in this level is high compared to the regime level. The maturity of the technology as proposed by Molla et al. (2009) as well is one of the driving knowledge factors. Positive cultural discourses is the only normative factor. Notable is that Geels does not mention one regulatory factor.

Barriers for niche level innovations are captured in the MLP framework as well. Geels (2019) mentions “much uncertainty, competing claims and promises, and high rates of failure and pioneer burn-out, costs, time” (p. 190) as problems at niche-level. These are all related to knowledge and economic factors. Examples of economic factors are given by Molla et al. (2009); costs of Green IT solutions, unclear business value, the extend of Green IT adoption in the industry are all barriers that hamper niches to be developed. Just as in the regime level, normative factors are not mentioned for a barrier. Neither regulatory factors are mentioned specifically for the niche level.

2.8. Accelerating transitions

Drivers must be exploited to accelerate the Green IT transition, whereas barriers must be overcome. How this is done in the Netherlands has yet to be researched. Still, we can learn from Green IT studies in other regions and comparable sustainable transitions.

Although the landscape level is essential for change, the developments in this level cannot be influenced by actors in the short term (European Environment Agency, 2018). The developments depend on various actors that are primarily beyond human power; they form an external context (Geels, 2004). It thus is not advisable to try to adapt this external context in the socio-technical regime level and the niche innovations level, there exists some useful literature that could lead to acceleration.

2.8.1. Acceleration in phases 1 and 2

Rosenbloom and Meadowcroft (2022) claim that the primary strategy should be to support niches in the early phases of transition. Translating this claim to the MLP, I place this in the first phase. Niches are crucial to support technical improvements. They also nurture social processes such as vision building (Rosenbloom & Meadowcroft, 2022). Supporting these niches leads to creating a learn-full environment that delivers new insights, such as new visions of potential transition pathways, carrying out transition experiments, and monitoring and evaluating to derive lessons (Rosenbloom & Meadowcroft, 2022). This environment brings diverse innovators together. Geels et al. (2017) mention something likewise as one of their four lessons to accelerate low-carbon transitions. Their article mentions the importance of aligning multiple innovations and systems and claims that this could gain momentum. In

the same article, societal and business support is mentioned as an essential driver in the first and second phases of MLP. According to the researchers, "business support is essential because the development and deployment of low-carbon innovations depend upon the technical skills, organizational capabilities and financial resources of the private sector." Rosenbloom and Meadowcroft (2022) suggest bottom-up learning processes, participatory governance, and polycentric stakeholder engagement. In addition, policies (subsidies, tax credits, standards) or changing consumer preferences are offered as business support. Public support is critical for transitions as transitions ask for modifications of citizens, information about climate threats, and financial incentives are deemed essential.

2.8.2. Acceleration in phases 2 and 3

Socio-technical transitions could be accelerated by actively phasing out the current technologies or systems (Geels, 2017). Phasing out creates space for niche innovations and removes barriers to the diffusion of the new technology or system (Geels, 2017). This way of accelerating should take place in phases 2 and 3 to destabilize the current system when the new system is mature enough to replace (parts of) it. Geels (2017) states that policies that lead to phasing-out could take several forms: "bans or regulations that stipulate emission reductions from specific technologies or sectors; targeted financial incentives to encourage decarbonization; or removal of implicit or explicit subsidies for high-carbon systems." Rosenbloom and Meadowcroft (2022) likewise claim these policies mid-transition. However, they separate diffusing innovations from phasing out the old system. For diffusing innovations, they highlight that promising innovations face more political tension due to the threat to the market share of established interests, and despite their momentum, there will be harsh competitive pressures. One example the researchers gave to help is feed-in tariffs for new renewables. Concerning phasing out, Rosenbloom and Meadowcroft (2022) state that delegitimization, divestment, phase-outs, and associated measures are crucial for transitions, as scholars have proved that diffusion of innovation alone tends to be insufficient for rapid change.

2.9. Concluding chapter 2

In this chapter I introduced all important concepts for this research. The MLP is motivated and described and the (accelerating) transitions literature is presented. The MLP is the leading framework for this research, it helps understanding and analyzing the Green IT transition. Furthermore, the knowledge gathered in this chapter is used throughout the research, an overview of this is visible in table 2.2. The most important contribution of this chapter is the answer to the first sub-question "*How could the transition phases for Green IT look like?"*, which is answered in section 2.6.1. The indicators following from sub-question 1 are used to answer the third sub-question. The system dynamics that are observed are compared to these theoretical phases. The identified factor categories are the basis of the interviews. Interviewees are asked to respond to these factors, to share their perspectives. Finally, this chapter is retrieved to answer the main research question, indirectly by answering the sub-questions and directly by using the framework and the accelerating knowledge of section 2.8.

Table 2.2: Contributions of chapter 2 to the remainder of this research

Elements in chapter 2	Contribution to this research
Section 2.1, 2.2 and 2.3	Background information and elaborating on concepts fundamental to the conceptual framework and this research.
Section 2.4, 2.5 and 2.6	Explaining the framework used in this research, this framework is used to analyze the system and eventually answer the main research question.
Dimensions explained in 2.4	These dimensions serve as input for the interviews, interview questions are drawn up in such a way that these dimensions are discussed. These questions help to answer sub-question 2.
Section 2.6.1 (phases)	In this section I provide an answer to the first sub-question, creating a blueprint of theoretical transition phases. The table answering this sub-question is as well used to answer sub-question 3 in chapter 5.
Section 2.7 (drivers and barriers)	Fundamental for the interview questions. The categories from this section are discussed in the interviews, with the aim to answer sub-question 2.
Section 2.8	Background information on accelerating transitions, helping to answer the main research question.

3. Methodology

In this chapter, the methodology is presented. It includes the research approach (case study), the data collection, and the data analysis.

3.1. Research approach

After retrieving Cohen et al (2017) and comparing several research designs I concluded that a case study is most suitable for this research. In this research the Green IT in the Netherlands is the case, the goal to investigate this case is to accelerate the transition. One of the main motivations of this is Cohen's claim about case studies: "Case studies are a step to action. They begin in a world of action and contribute to it. Their insights may be directly interpreted and put to use" (p. 184). This statement perfectly aligns with the aim of this research, aiming for acceleration, requiring action. Based on the limited knowledge and awareness in society of Green IT, I was motivated by Nisbet & Watt (1984), stating that case study data is strong in reality, a wider audience relatively easily understands the results, and that unique features are captured that could be lost in other types of research. All of these features contribute to the aim of this research, as the outcome must be implemented in the real world and thus has to be understood by the wider audience. Finally, the decision for a case study was confirmed after retrieving Yin (2009) stating that the more questions seek to explain how or why social phenomenon's work, the more a case study is relevant. As explained in the theory socio-technical transitions are socially influenced, and the research question aims to find out *how* to influence this.

Based on the need for more knowledge of how to accelerate the transition, in-depth knowledge is needed for this research. According to Denscombe (2014), a case study works best when the issue is investigated in depth. These in-depth insights are necessary for this research. The research is analyzed based on qualitative data. According to Hammarberg et al. (2016), qualitative methods can reveal potential problems, as is needed in this research. Within a case study, there are six types of usage, according to Denscombe (2014). For this research I have chosen an explorative case study with elements of the descriptive case study. Describing what is happening in the case study setting to explore the problems and opportunities align with the accelerating aim of this research.

The reason for analyzing the Netherlands for this case study is because the Netherlands is an emerged country with a robust information infrastructure and thus could be a leader which other countries could learn from. In terms of reducing emissions, the Netherlands is more ambitious than other European countries (Rijksoverheid, 2020), and, likely, the Netherlands is further in this transition than other countries. Due to the explorative character of this research, it could be helpful for researchers investigating other countries or regions to retrieve this research later in time. The case itself will be elaborated on in chapter 4.

3.2. Data collection

In this research, data is collected using two different methods, desk research, and interviews. One of the strengths of a case study approach is that different types of data can be used

(Denscombe, 2014). The two methods are complementary to each other. The interview questions include the insights gained from the desk research, such as the categories from drivers and barriers. This inclusion can either be to elaborate or check on something from an actor or to gain more insights from underexposed topics. Later in the research, findings from the interviews are an input for the desk research. Again, this input is twofold. In the first place the findings from the interviews are triangulated with other sources from desk research. Data triangulation is conducted by researching statements of the interviewees, either to validate or invalidate the data. An example of this is searching for a report that deals with a driver that arises from the interviews. Beside triangulation, interviews provided interesting new insights that I was not aware of, or interviewees pointed towards interesting research. Examples of this are exploring organizations and their studies, based on the advice of an interviewee. In some cases, these new insights were brought up in interviews that were later in time. Both data collection methods are used for answering SQ2 and SQ3. SQ1 is not specified to this case study is already answered in section 2. An overview of the data collection methods is visible in figure 3.1.

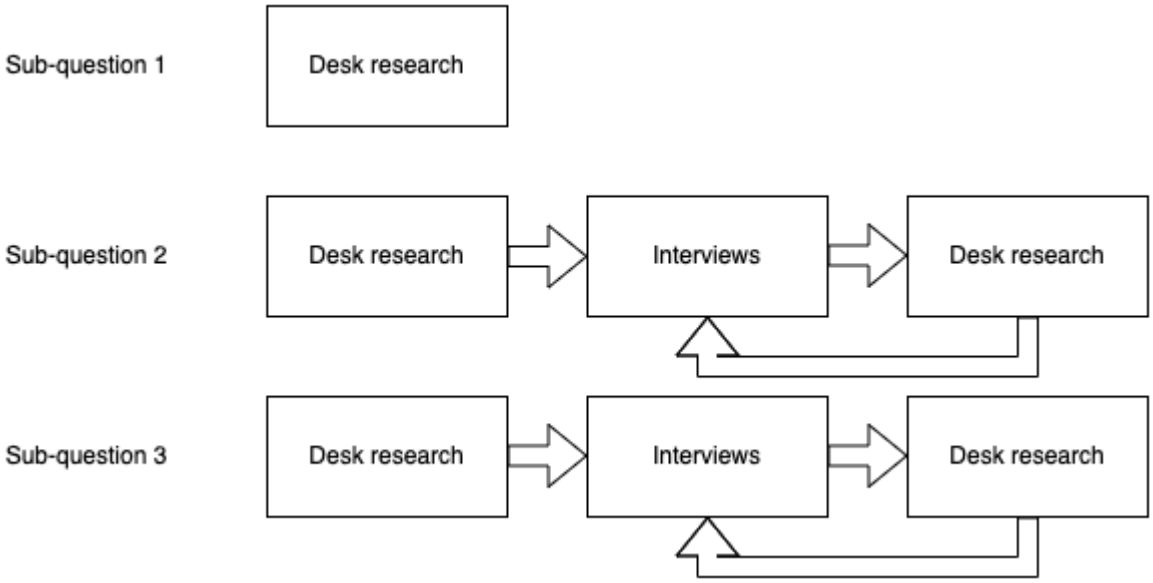

Figure 3.1: Data collection

3.2.1. Desk research

In the desk research, secondary documents are analyzed to answer the last two sub-questions. A wide variety of documents is used in this desk research. It includes documents from companies (such as annual reports or websites), reports from NGO's or research organizations, academic papers, market research reports, technology journals, and influential group publications. Data from these documents is used for the interview questions as well as for triangulating the outcomes of the interviews.

3.2.2. Interviews

There are three general common interview types used in qualitative research; structured, semi-structured, and unstructured interviews. (Adhabi & Anozie, 2017). For this research I

chose semi-structured interviews. This type of interview outlines the questions and topics that are prepared (Stuckey, 2013). However, this type of interviewing allowed me to change questions or topics during the interview based on the interviewees' responses. It allowed me to ask extra or more profound questions on interesting topics than he/she initially prepared (Adhabi & Anozie, 2017).

I asked the interviewees targeted questions based the literature review and the desk research. An overview of the standard questions is visible in appendix A. In this appendix, one can see that there are questions relating to the driver/barrier categories as identified in section 2.7. In a similar way, the questions about phases are drawn up to subtract knowledge from the interviewees about the phases of the MLP framework as presented section in 2.6. The standard template was adjusted after a dummy interview, as well in-between the interviews the questions were revised. These revisions are made based on different profiles and backgrounds of the interviewee. Besides, I revised the interviews to gather better insights, for example taking out a question that interviewees did not fully understand or including new questions based on new insights.

To be allowed to conduct interviews I requested a Human Research Ethics Committee (HREC) approval. The aim of this approval is to protect the collected data and more important, the interview respondents. This contained an application with a HREC checklist, informed consent materials and a data management plan. The HREC checklist addresses all risks of research involving data obtained from Human Research Subjects. For each of the identified risks, a mitigation plan was formulated. The informed consent materials supplied the interviewees with information what data is collected, how it is stored (where, who has access and when it is deleted) and how the data is used. Finally, the data management plan describes how the data is collected, managed, stored, and made available during the research, and how it is shared after the research. The request is approved by the HREC, and all interviewees provided a written consent after reading the informed consent statement. This statement is visible in appendix B.

3.2.2.1. Interview respondents

The interviewees in this research are a heterogeneous group. Different actors provide different insights. In this case study of a socio-technical system, at least two persons presenting each of the relevant actor groups are interviewed. On top of that, IT experts are relevant to be interviewed, as they are in the middle of developments. They could be aware of promising innovations challenging the regime or upcoming pressures from society, suppliers, or regulations. The most essential actors are the IT decision-makers at organizations, as they have the best insights on what is happening in the market concerning Green IT. In table 3.1 the profiles are elaborated. An overview of the actual respondents is visible in table 3.2.

Table 3.1: Interview profiles

Interviewee profile	Relevance
IT Experts	Ideally, several IT experts are interviewed. Even though they are not one of the relevant actors, they do have an excellent view of the regime as they are in the middle of it. IT experts could be beneficial to fill the gaps that remained after the desk research because of their broad knowledge of the field.
IT decision-makers at organizations (CIOs)	The most central actor in the case study. Interacting with suppliers, data centers/cloud providers, governments, small innovation companies and other organizations. They could tell how the market responds to several developments and what their problems and opportunities are for Green IT. In addition to company documents, they could tell their environmental targets (and of their suppliers/competitors) and to what extend Green IT is involved in this.
Datacenter/ cloud executives	The contribution of this actor group is twofold, in the first place to gain knowledge about how and if Green IT is practiced in data centers, and as well to inform what other organizations demand from them. Ideally it is someone in a higher-level function as they might know more about
IT disposal company	Same as data centers
NGOs with focus on Green IT	NGO's working on greening of IT are knowledgeable on the problems companies and innovators face, as well as on the developments within the regime.

Table 3.2: Interview respondents

Organisation	Role/position	Dimension
Network organization	Digital	Overall, technology
Consultancy	Cloud consultant	Industry, market
Media organization	Director	Overall, culture
Consultancy	Sustainability IT consultant	Overall
Financial institution	Business analyst	Overal
ESG advisory	ESG Specialist	Policy
Datacenters	Director	Industry
Datacenter	Director	Industry
NGO	Director	Overall, technology
Reseller	Manager	Industry
Disposal	Sales	Industry
Disposal	Partner	Industry
Corporate	CIO	Market
Financial institution	Manager	Market
Corporate	Sustainable IT lead	Market
Consultancy	IT consultant	Overall
Financial institution	Sustainable IT consultant	Overall
Financial institution	CIO	Market

Elaborating on table 3.2 I conclude that there is a wide variety of interviewees included in this research, all five profiles as drawn in table 3.1 are included. Addressing the six dimensions it stands out that one of the six dimensions (science) is not included. This could address a respondent selection bias. Moreover, nobody within the science dimension is included and thus statements about this dimension and its influence on the wider system are more likely

to not be correct. The underlying factor for this absence is the current prominence of science in the Dutch system. I tried to overcome this bias by asking other respondents (such as the business analyst, having an overview of the system) about science. In chapter 4 I elaborate more on science' presence in the system. In contrast, the industry and market dimensions are significantly presented by the interviewees. This is the consequence from not randomly selecting the interviewees. These dimensions are over included on purpose as data about these dimensions is harder to obtain, for example (governments') policy interventions are mostly published whereas companies' actions are not. Again, there might exist a selection bias, these two dimensions could influence the conclusions of this research more prominently.

3.3.2.2. Interview data processing

The data from the interviews are analyzed based on the thematic analysis by Braun and Clarke (2006). This method is widely used in qualitative research (Braun & Clarke, 2006). Using this method, the researcher goes through six phases. These phases are described in the table below.

Table 3.3: Phases of thematic analysis (Braun & Clarke, 2006, p. 87)

Phase	**Theoretical description of the process**
1. Familiarizing yourself with your data	Transcribing data (if necessary), reading and re-reading the data, noting down initial ideas
2. Generating initial codes	Coding interesting features of the data in a systematic fashion across the entire data set, collating data relevant to each code
3. Searching for themes	Collating codes into potential themes, gathering all data relevant to each potential theme
4. Reviewing themes	Checking if the themes work in relation to the coded extracts (Level 1) and the entire data set (Level 2), generating a thematic 'map' of the analysis
5. Defining and naming themes	Ongoing analysis to refine the specifics of each theme, and the overall story the analysis tells, generating clear definitions and names for each theme.
6. Producing the report	The final opportunity for analysis. Selection of vivid, compelling extract examples, final analysis of selected extracts, relating back of the analysis to the research question and literature, producing a scholarly report of the analysis.

In practice I used the method as a guideline. In the first phase I transcribed the data, with the help of Microsoft teams. The first transcript was drafted by the program, after which I watched the interview one or two times to improve it. In addition to this first phase I wrote a document containing my wider view of the interviews. This document prevented me from getting lost in the details when coding in later steps.

The second phase contained out of identifying interesting quotes and insights from the interviews. All these insights were sorted in a document, including the interviewee who produced mentioned it.

The third, fourth and fifth phase were in practice less structured than Braun & Clarke drafted. These steps contained the most time-consuming action, coding. The most used themes for

the coding followed from the literature, about the drivers/barriers and the phases. Concerning the drivers and barriers the codes contained out of the five categories (Economic, regulatory, normative, knowledge and additional). An example of this code is "*Barrier, economic".* These categories are used for sub-question 2. For the phases the quotes are coded based on the six dimensions of the MLP system (market, industry, policy, technology, culture, science), there was no distinction to which phase quote the relates. An example code within these categories is: *"Phase, market",* these were used for answering sub-question 3. Beside these some other coded are included based on the quotes, examples of these are *"transition"* or *"responsibility",* quotes with these codes could be used for either of the sub-questions or the main research question. After all quotes were coded, they were checked once again. After these phases all quotes were reorganized, sorting them on code, laying down the previous sorting based on interviewees.

In the sixth phase the quotes are used for the report. Before writing a sub-section, I reread all quotes concerning one topic (e.g., *"barrier, economic"*) and started writing. When a quote is used in the text this was marked to prevent multiplications. Not all quotes that are coded are used because of several reasons. Examples of this are quotes that are too specific to a company, quotes that later turned out to be irrelevant, quotes that could be redirected to an interviewee, and many more.

4. Case study

In this chapter I analyze the case study and the results. In the first section, I provide an overview of the case; the socio-technical system of Green IT in the Netherlands. In this overview the institutions within the system are introduced and elaborated on. These institutions together form the socio-technical regime, the middle layer of the MLP framework. In section 4.2 the drivers and barriers for Green IT transitions are analyzed based on the interviews and the desk research. The section is structured based on the categories identified in section 2.7. In section 4.3 I elaborate on current system dynamics, structured by the six dimensions as identified in section 2.4.

Together, the results of these sections form the analysis of this research as follows.

- In section 4.1 I analyze which actors are involved in the system, based on the six dimensions following from the MLP framework.
- In section 4.2 I analyze the drivers and the barriers within the system as drawn up in section 4.1. This section provides an answer to sub-question 2.
- Finally, in section 4.3 the system dynamics are analyzed based on the six dimensions following from the MLP framework. This analysis is used to answer sub-question 3 in chapter 5.

4.1 Introducing the socio-technical system

The case study is visualized as a socio-technical system such as in a MLP in figure 4.1. For clarity the interactions between dimensions are not plotted in this figure. This visualization is based on desk research and the interviews. Bearing in mind what are typical actors in each of the dimensions based on literature using the MLP (e.g., governments for policy) I analyzed multiple sources to draw up this socio-technical system. These contain multiple sources in the desk research prior to the interviews, such as reading trend reports about Green IT, finding out which actors were involved. The interviews itself revealed a lot of actors as well, such as interesting NGOs and network organizations, these were researched after the interviews to become more knowledgeable about their role in the system (on which I further elaborate in section 4.3).

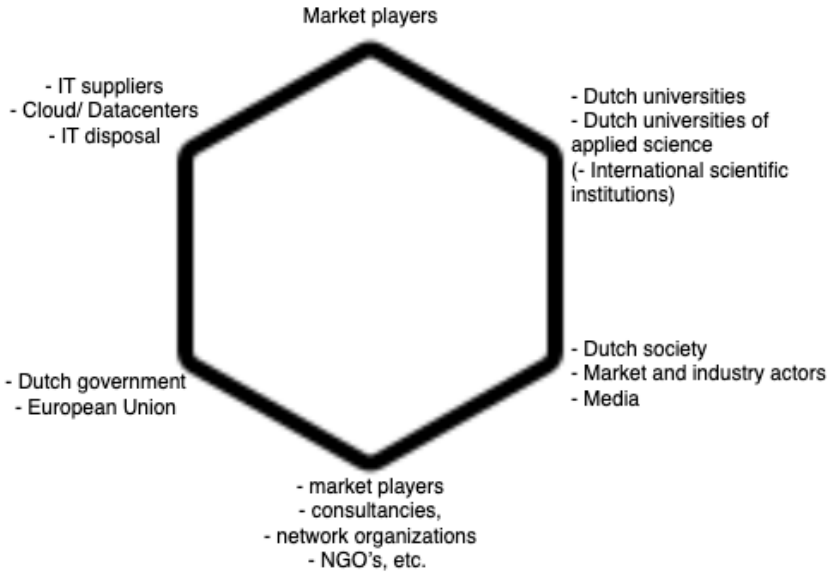

Figure 4.1: Visualization of Green IT as a socio-technical system

Market, user preferences: The market contains all companies that are using IT in the Netherlands. These are defined as end users and range from large multinationals to smaller family companies. The aggregation of all these companies set the user preferences and determine how the market looks like. Examples of organizations within this are: Financial institutions, hospitals, and transport companies. The only two requirements are that they are using IT and that they operate in the Netherlands, interacting with other Dutch companies in the Dutch IT system.

Industry: The industry could be simply explained as the suppliers of IT. Forming an infrastructure of both IT hardware and software components. Actors in this dimension are IT manufacturers/software suppliers, datacenters/cloud providers and IT disposal companies. The industry interacts with the market based on its preferences. These interactions include the industry adjusting to the market and the market adapting to new industry offerings. Disposal companies in the market are mostly located in the Netherlands, they are responsible for the end-of-life management of IT hardware. The IT suppliers have a more international character, examples of these are HP, Lenovo and Dell as manufacturers and windows as a software supplier. Datacenters/ cloud providers are both Dutch and international, the Dutch market is in business with large international companies such as Google and AWS, but as well with local datacenters.

Policy: Concerning policy there are two important actors in this system, the Dutch government, and the European Union. These two political bodies are capable of setting legislation, maintaining rules and regulations, and giving out certifications. These bodies could be advised by external parties, however, they are sovereign in decision-making.

Technology: Technology, more important, technological knowledge comes from a variety of actors. These actors are companies within the market, consultancies, network organizations, NGO's, new innovative companies (niche innovators), universities and governmental organizations. All of these actors could provide technological knowledge, however with

different interests. A market player could want to improve their own IT operations, knowledge is a resource for consultancies to make profit and for governmental organizations sustainable improvements could be the goal.

Culture: The culture within the Dutch system is determined by the Dutch society, the market, and the media. Dutch society sets the 'rules of the game', what we in the Netherlands deem normal and acceptable. Media plays an important role in this. Companies within the market interact with these rules in many ways, such as setting corporate strategies and creating brand reputation.

Science: Science is not necessarily constrained to the Netherlands. The Dutch market could interact and benefit from publications all over the world. However, Dutch universities and universities of applied science are more intensely interacting in the Netherlands. These interactions consist out of educating new talent, creating, and testing new knowledge and researching older executions of IT usage.

4.2. Drivers and barriers for Green IT

In this section I categorize the findings that came out of the interview concerning drivers and barriers in the system. Based on the literature review I asked the interviewees about economic, regulatory, normative, knowledge-related, and additional drivers and barriers. Below, in table 4.1 the drivers and barriers are visualized. In the remainder of this section, I elaborate the drivers and barriers based on the interviews. After the elaboration of each driver or barrier from the interviews I triangulate it with other documents/sources (academic, reports, data, etc.).

Table 4.1: Overview of drivers and barriers from the interviews

Category	Drivers	Barriers
Economic	- Efficiency and cost reductions - Efficiency and space constraint (Datacenters) - Brand reputation	- Internal investment conflicts - External conflicts
Regulatory	- Corporate Sustainability Reporting Directive (CSRD) - ISO certifications	- CSRD only affecting large companies - CSRD only applies to European companies - Feasibility of CSRD
Normative	- War on talent - Societal pressure on industry	- Insufficient societal pressure - Invisibility to society - Magnitude of societal pressure - IT is seen as a necessity
Knowledge	- Network organizations and alliances - Scientific institutions - Market knowledge sharing - Consultancies	- Lack of knowledge - Unawareness of employees - Knowledge fragmentation
Additional	- Intrinsic motivation/ environment	- Significance of IT for organizations - IT is a conservative sector - Chain responsibility

4.2.1. Economic drivers and barriers

From literature I concluded that Economic forces refer to the need to pursue internal efficiency and market performance. The interviews allowed me to identify three drivers and two barriers within this category.

4.2.1.1. Economic drivers

Efficiency and cost reductions: For the industry, efficiency is one of the major goals. Especially for datacenters, where energy usage is one of the main matters of expense. From the interviews with datacenters experts, it became clear that efficiency in the energy usage is a continuous topic for more than a decade. One of the datacenter experts stated that *"sustainability is a clear business necessity, as being more sustainable is more efficient".* This could lead to a competitive advantage, as well as more margins. Efficiency (and thus sustainability) and costs go hand in hand in the industry. For disposal companies, the old hardware that is delivered to them represents value. Handling this hardware in a more efficient way leads to more profit.

Beside the industry, the interviewees mentioned the efficiency benefits for end users numerous times as well (e.g., "*efficiency is cheaper, the current prices of energy cause an increase in importance"*). Reducing the energy usage leads to cost reduction, CIOs are very delighted when their IT infrastructures deliver cost reductions. The interviewees pointed out that the economic benefits of being more sustainable are clear and claim that it is "astonishing" that almost all sustainable measures save costs.

The connection between costs and efficiency is confirmed by the Dutch Datacenter Association. On their website is stated that efficiency is a natural driver, as less usage of resources leads to lower costs and a stronger competitive position (Dutch Data Center Association, 2023). Besides, in other studies the topics and efficiency and costs are linked to each other. Capgemini (2021) reported about 24 sustainable IT use cases, mentioning which measures cause what cost savings. An example of this is the simple measure of auto switch-off in devices, saving 14% of costs on average.

Efficiency and space constraint: Datacenters are restricted by space; more efficiency could prevent a datacenter from expanding or moving. One datacenter interviewee explained that this space restriction is a problem that is present for years, so sustainability is already considered in the physical building of datacenters. Another datacenter interviewee mentioned that datacenters are able to make more significant contributions to sustainability because or at least less harming data execution, because companies outsource their data to these datacenters. Being centralized the cooling and general power usage are more efficient compared to if every individual company had to this themselves, with less expertise and resources.

On the website of the Dutch Datacenter Association is claimed that IT could be more efficiently facilitated because of economies of scale, despite the increase in data, the energy usage is stable in the last 10 years (Dutch Data Center Association, 2023). Microsoft even

reported in their own research that their cloud could improve energy efficiency by 93 compared to traditional enterprise datacenters (Microsoft, 2020). The claim of space constraint is confirmed Finnegan (2017), stating that *"It's imperative to make efficient use of the available space"*. Datacenter managers must make do with existing space, at an extreme, Google even spent 3000 dollar per square meter to do so.

Brand reputation: Brand reputation is driving sustainability. Sustainability is increasingly becoming an important topic to organizations. This is beneficial for clients, partners, potential employees, and other relations. An example of this is pointed out by an IT disposal interviewee, mentioning that sustainability became a more important topic for their clients, certifications are actively present in tenders.

Cowan and Guzman (2020) conducted research on the influence of CSR and sustainability on brand reputation, they state as well that organizations invested exponentially in their reputations through sustainability. As well Capgemini (2021) concluded that in brand image is improved for 61% of the high maturity companies because of sustainability in IT.

4.2.1.2. Economic barriers

Internal investment conflicts: Greening is mostly associated with investments. Even though (some of these) investments could have a return rate, shareholders could be against these investments and rather continue as it goes. Interviewees indicate that the profit is still the most important factor in decision making, from the perspective of shareholders. Green IT is not approved enough to see the benefits for all organizations, some are afraid that it will only cost them money. Companies facing multiple challenges at the same time, with a limited amount of money and other resources. The consequence of this is that greening is not always on top of the list of challenges and thus does not it thus not always make it into practice. One given example for this is knowing that there are more sustainable IT hardware options (e.g., because of life cycle or less energy consumption), a cheaper, more environmentally harming option, is preferred.

Both other priorities (33%) and companies thinking benefits would not exceed the costs of Green IT (32%) were named in research by ABN AMRO (2021) including 588 IT decisionmakers. Profit being the most important factor in decision making is approved by Muguresan (2012), stating that "the costs associated with green transformations and the return on those costs are the first ones to appear in the minds of leaders and those in charge of the green transformation".

External conflicts: Collaborating organizations mismatch in their wants and needs. Two examples of this raised in the interviews are:

- IT producers would like to sell new hardware every 3 years, whereas the more sustainable option is extending the lifespan, which is the preference of the end users. Still, end users are pushed to buy new hardware as manufacturers only ensure safety for a limited number of years.

- Datacenters state that lower energy usage causes a cost reduction, one of the other interviewees noted that Datacenter co-locations earn money by making a margin on the energy used. As well datacenters make a profit of services that are not used by the end users, making datacenters striving more services, even though this is not efficient and thus harming the environment.

For the specific examples there are no studies investigating this. However, ABN AMRO (2021) found that just 41% percent of the companies select their vendors based on sustainability, relating to the first example. Reflecting on this barrier more in general, it seems logical that companies doing business have conflicting wants and needs. In the end one must pay for another's profit. It as well may be feasible that one companies' intension are profit related and that may not be the most sustainable way of doing business.

4.2.2. Regulatory drivers and barriers

Regulatory forces refer to the influence of governments and inter-governmental organizations on Green IT. These organizations could influence Green IT by setting legislation that allow or prohibit certain practices. Based on the interviews I identified two drivers and three barriers.

4.2.2.1. Regulatory drivers

Corporate Sustainability Reporting Directive (CSRD): The CSRD is brought up by almost every interviewee when discussing regulatory factors. The interviewees are predominantly positive about the upcoming directive. Some mentioned the fact that companies are significantly more sustainable in their communication compared to what they execute in terms of sustainability. With the new directive, companies must be more transparent on their actual deeds. Some interviewees even brought up "greenwashing". According to one interviewee working at an NGO, legislation is the way to force transparency, as it is not a company's own interest to be transparent. Even though this transparency is coming up leisurely, consultants see that companies start to be more transparent. As well it forces companies to think about their (IT) emissions, even if they are not intrinsically motivated to do so, argues an IT business analyst in the interview. This is confirmed by an interviewee that works at an end-user, which states that the CSRD was an impulse for their company to start investigating Green IT. *"Intrinsic motivation is not enough"* according to an IT sustainability expert, there could be a movement within a company, but legislation is needed to catalyze this movement. The ESG specialist agrees on the importance of the CSRD, stating that *"now that there is an obligation, companies will now request this and ultimately this will result in market forces and the smartest solution will emerge".* A consultant even adds that beside the assigned self-reflection, the transparency is going to be a topic of conversation more. Just one interviewee did not really see the benefit of regulations, mentioning that in his/her sector, the datacenters, they are ahead of most regulations.

Consulting other sources on the CSRD, it clarifies that the CSRD is a directive from the European Union, that obliges large companies to report about their environmental, social and governance actions. This directive affects all stock market listed companies, as well as

companies that meet two out of these three requirements: over 250 employees, over 40 million euros in revenue, and over 20 million euros on balance sheets (Grant Thronton Netherlands, 2021). For many companies, this means that they will have to draw up or update a sustainability strategy and based on this, set up the processes and systems to achieve the sustainability objectives. Since it must be in the annual report, this also means that the company will have to collect the right data for this and guarantee the quality of that data (Koninklijke Nederlandse beroepsorganisatie van accountants, 2023).

ISO certifications: For the industry, there are some ISO certifications that demonstrate the activities of a datacenter or IT disposal companies. Interviewees mention that this is a driver to meet the (green) requirements of this certification to be able to show this to their clients.

After researching the ISO certifications, I have found that are some relevant ISO certifications. An example, of the most important one, is the ISO 50001. It states a standard for energy management (ISO, 2023). This certification obligates companies to measure and report their energy emissions. I indeed see this as a driver as companies become more aware of their energy usage and must improve this for the certification.

4.2.2.2. Regulatory barriers

CSRD only affecting large companies: Some interviewees raised their questions by the number of companies that are affected by the CSRD. According to the ESG expert and other interviewees, smaller companies are not included. A CIO concluded the same for governmental organizations, despite their significant IT usage, others stated that the government is not leading by example or that they should create a transition roadmap.

The three requirements CSRD requirements imply that almost all SME's are not included, as they are by definition under 250 employees, with a profit of less than 50 million euros and have less than 43 million euros on balance sheets (SNN, 2023). This group of SME's consists out of almost 450.000 companies (Bos, 2023). To cause a transition all companies should be included, according to PWC (n.d.) currently more than thousand companies in the Netherlands are affected by this directive. SME's not being included in this legislation, does not hinder them individually to become more sustainable. However, to cause a transition as a system, this directive may not suffice.

CSRD only applies to European companies: a large share of datacenters in the Netherlands are hyperscale datacenters, owned by large non-European companies such as Google. A business analyst mentioned that these companies are not affected by CSRD. Some interviewees from the industry pointed out that the costs of reporting and certifications is high. Having non-European with different rules gives them a cost advantage and they could become even more dominant.

Currently, sustainability reporting is not required for non-European companies, this is not until 2028 (IBM Envizi, 2023). From this I conclude that the concerns of the interviewees are valid.

Feasibility of CSRD: The ESG specialist speaks out about the feasibility of the CSRD in the interview. The legislation is not complete, and is yet to be announced, giving the companies a short timeframe to prepare for the reporting. Besides, he/she states that the ESG is going to cause a significant change which is affecting the entire company, making it challenging to implement certain things.

PwC (n.d.) states that the current version of June 2023 is currently under review for feedback. The aim is to finalize the legislation in the end of august 2023. The problem of four months for each company to collect all important data indeed seems ambitious. Still, companies could already be collecting this data based on former versions.

4.2.3. Normative drivers and barriers

Normative forces refer to the pursuit of legitimacy within the broader social context. The need to meet social obligations and enforce moral governance can induce certain Green IT practices. Several national, professional, and intergovernmental institutions are producing guidelines related to Green IT.

4.2.3.1. Normative drivers

War on talent: Multiple interviewees pointed out that sustainability (as an organization) is significantly driven by their intentions to attract talent, mostly starters. A business analyst stated: *"the war on talent is a huge topic with the shortage on the IT market".* Both attracting new employees as pleasing current employees were mentioned on this topic. There is a significant bottom-up force by young employees striving sustainability, both in interviewees' companies (stated by IT decision makers) and in general in the market (business analyst).

When searching for sustainability importance for young employees, a lot of results come up. Yet, many of them triangulate with or refer to research of the European Investment Bank (2023). In this research it is stated that: "69% of Dutch people aged 20-29 say the climate impact of prospective employers is an important factor when job hunting, and 13% even say it is a top priority."

Societal pressure on industry: Datacenters receive significant pressure from society. Datacenter interviewees claim that this is unjustly. One of the interviewees claimed that: *"datacenters centralize usage, because of this we are more efficient, however this makes it more visible as well, causing a more negative image than they should have".* For datacenters this is a driver to make their aggregated consumption more sustainable themselves, and even more to collaborate with their partners. As well IT disposal companies pointed out that it is very important to propagate sustainability in the industry, in cooperation with their clients.

RTL Nieuws (2023) indeed stated that datacenters increasingly becoming a subject of critique in the last years. As response datacenters are actively improving their energy usage and publishing reports to prove this and tackle the critical notes from society or media. An example of this is the Dutch Datacenter Association (2023) posting on several research about energy usage and other sustainability related topics.

4.2.3.2. Normative barriers

Insufficient societal pressure: The interviewees brought up that the societal pressure is not yet at the point to enforce transparency in (Green) IT. One of the interviewees even mentioned that there is societal pressure to not report, as the fear of negative commotion motivates CIOs to leave it as it currently as. There was an overall consensus in the interviews that CIOs of end users must be forced to become more active in terms of sustainability.

Researching the societal pressure there are several (scientific) publications about the consequences of IT. However, this does not directly lead to naming specific companies or sectors, increasing the pressure. This societal or media pressure is only experienced in datacenters.

Invisibility to society: IT usage is a black box for most people, they are unaware of how much is used at a company, and more important, what the consequences are. In line of this unawareness companies can claim to be green as there are no standardized measurements. 'Reporting' to be green does not have to be green in practice. An example of this is reporting about IT for green, leaving out the IT footprint of the company itself.

Toet (2022) starts his article with stating that ICT is a blind spot, as many companies and end users have no idea how much CO2 emissions their automation causes. There is a handful of non-scientific articles aiming to provide more insights in IT usage. However, mostly they start with confirming this claim that people normally not consider emissions when using computers/IT, for example in the article from BBC Science focus magazine (2020) comparing sending emails to car usage.

Magnitude of societal pressure: Beside the fact that societal pressure is limited in general. An existing problem concerning societal pressure is that this pressure is experienced to a lesser extent by large multinationals. A given example of this is that Microsoft (azure), Amazon (AWS) and Google are not that impressed neither by Dutch society nor by Dutch companies when their hyperscale datacenters are criticized.

There is no research conducted on the amount of societal pressure on multinationals. However, it seems logical that the Netherlands have limited influence on large multinationals as it probably contains a small share of their businesses.

IT is seen as a necessity: Because of (part of) society's view that IT is a necessity and may even be a solution, companies benefit from less societal pressure. Two business analysts pointed out that the IT sector sometimes even hides behind the environmental advantages of IT, fading the disadvantages. The term "green washing" is frequently used in this discussion. A consultant pointed towards this as a growing problem, as companies are not focusing on the exact problem because of this. I experienced this phenomenon in other interviews as well, in which interviewees brought up good actions that I subscribe as IT for Green, even I elaborated that this is out of scope in the beginning of the interview.

Watching around in daily life in the Netherlands we see IT usage everywhere. Entire businesses would stop without phones and computers, and IT became part of our social life. Some researchers even investigated where ICT should be located in the Maslow theory, for some countries ICT is more important to citizens than money (Arellano & Cámara, 2017). Concerning the IT for Green voice over the Green IT I validated this by scrolling tech websites. The majority of articles on these websites are about IT for green, confirming the sector focuses more on IT for Green, or at least speaks more about it. An example of this is Datacenters publishing about how reusing their residual heat could be used in other sectors.

4.2.4. Knowledge drivers and barriers

In addition to the previous three forces, supported by literature, I identified one extra force in the theory. The knowledge forces contain all mentions from the interviews that relate to the presence or absence of scientific and technological knowledge. From the interviews it turned out that knowledge is provided by a wide variety of actors. Based on the interviews I identified four drivers and three barriers, stated in the following sections.

4.2.4.1. Knowledge drivers

Network organizations and alliances: knowledge sharing trough organizations have been an extensive topic during the interviews. One of the interviewees claimed that organizations are willing to share knowledge as Green IT is a relatively new topic with high societal value. Out of the interviews some (network) organizations and alliances came up as important actors in the Netherlands: Nationale Coalitie Duurzame Digitalisering (NCDD), Sustainable Digital Infrastructure Alliance (SDIA), platform voor de InformatieSamenleving (ECP), and CIO Platform Nederland. In the Netherlands the (Digital Sustainability Center (DISC) is one of the academic facilitators of Green IT knowledge.

Consulting the websites of these organizations it becomes clear that they are indeed sharing knowledge about Green IT. By publishing articles and bringing actors together.

The NCDD aims to overcome the most important bottlenecks for sustainable digitalization, it is a public-private partnership between the government, the business community, educational and research institutions, and civil society organizations (Nationale Coalitie Duurzame Digitalisering, 2023). Their knowledge contribution is twofold, on the first hand by sharing knowledge with their partners, this includes scientific knowledge, practices from companies and their own research. On the other hand, the coalition as well advices the government by clarifying what the current bottlenecks are and how the government should proceed to overcome these bottlenecks.

The SDIA, a European platform for the creation of a sustainable digital company. The is a merger from the former Dutch organization called “GreenIT Amsterdam” and the German organization SDIA. The SDIA is an independent alliance of all stakeholders working across the digital sector, their goal is achieving a sustainable digital economy by 2030 (Sustainable Digital Infrastructure Alliance, 2023). The SDIA created a roadmap to achieve this goal. The SDIA

contributes knowledge by sharing an extensive knowledge hub on a wide range of sustainable and digital topics. Besides, this organization is consulted by companies to achieve their personal sustainability goals. Finally, the SDIA hosts multiple events, sharing knowledge, delivering policy advisory and other activities. All together the SDIA drives Green IT by producing and sharing knowledge.

Platform voor de InformatieSamenleving (ECP) is an independent platform, it fungates as a neutral terrain bringing together knowledge and experience from science, government, businesses, and NGO's (Platform voor de InformatieSamenleving, 2021).

CIO Platform is another organization that brings together actors out of the system. It is the association for CIO/CDO's of large users of digital technology in the Netherlands (CIO Platform Nederland, 2023). The platform is active in multiple topics, these are chosen by their members. The CIO platform shares knowledge on sustainability in IT to their members, the end users in this thesis.

Scientific institutions: The interviewees mentioned educational organizations such as universities as a knowledge generator. They both work with the previous mentioned organizations as individually. According to some of the interviewees, sustainability is a growing topic in academic curricula in the Netherlands.

On several websites of alliances, the Digital Sustainability Center (DISC) of the Vrije Universiteit Amsterdam can be found. This research group did not publish many articles about Green IT yet.

Market knowledge sharing: organizations could learn from other market players. According to a business analyst companies are inspiring each other by showing best practices. Some of the interview respondents argued that there is sufficient knowledge on Green IT, some others did not. However, there is a consensus that at larger companies there is more knowledge available and there are more resources to make their IT usage more sustainable. Corporates sometimes even have a separate department working on Green IT, these organizations produce a lot of knowledge by bringing Green IT into practice. In the best-case scenario, these pioneering companies share their knowledge with other organizations.

For the latter, Schiphol sharing their twin transition playbook publicly is a good example (PA Consulting & Royal Schiphol Group, 2023). In this example, other organizations are supplied with guidance of a roadmap to become more sustainable in IT. Furthermore, there is visible that certain players present at organizations such as the CIO platform. How much knowledge a certain actor has is hard to retrieve.

Consultancies: In line with the attention that Green IT and its reporting receives, it becomes more interesting to consultancies according to some interviewees (including consultants). Now that there is a specific urge to organizations to report and thus improve sustainability there arises a market for consulting companies. This business opportunity attracts consultants to gain knowledge on this topic and makes Green IT more available to companies. Multiple interviewees brought up that Green IT becomes attractive to consultancies.

Confirming this on consultancy websites, ESG advisory is one of the services that is almost standardly offered. I could not conclude from this that these consultancies create their own knowledge, however, they will share their knowledge to help clients.

4.2.4.2. Knowledge barriers

Lack of knowledge: Multiple employees pointed out that there is a shortage in IT employees in the market. This may hinder Green IT implementations. IT departments face many different challenges, such as operations and cyber security. Not all challenges could be addressed because of the shortage of IT employees, this affects Green IT implementation on company level. Several interviewees mentioned that especially the SME's struggle with attracting the required knowledge to tackle all IT challenges, including Green IT. Smaller companies have less resources for this and thus Green IT is less within sight.

Specifically for Green IT this is not confirmed. However, Rijksoverheid (2023) confirms the shortage in IT employees and mentions that this could hinder digitalization and sustainability in the Netherlands. Furthermore, how organizations allocate their IT employees remains unclear. This shortage on the labor market is as well included in the manifest of the NCDD, in which they aim to overcome this barrier and five others (Nationale Coalitie Duurzame Digitalisering, 2022).

Unawareness of employees: This barrier covers both awareness/knowledge of IT and non-IT employees. A non-IT employee is almost always still using IT, by emailing, using a phone, attending online meetings, and tons of other things. However, the average employee turns out to be completely unaware of the footprint caused by their individual business-related actions. Interviewees pointed out that as well IT employees most often do not have knowledge about sustainability. An example of this from the interviews is that it is not clear to a coder what would be the environmental benefit of writing a code with 400 instead of 500 parameters. For a long time, sustainability has not been a prominent topic in IT so there are a lot of questions concerning sustainability that may have never been asked. IT departments are probably not yet aware of their electronic waste.

The lack of awareness for non-IT employees refers to the articles I stated in the invisibility to society. ABN AMRO (2021) stated that in fact for 26% of the companies because there is not enough knowledge within the company. Capgemini (2021) researched that just 43% of executives is aware of their IT sustainability and just 23% of IT has high awareness.

Knowledge fragmentation: Some interviewees even questioned if the knowledge is available in the entire system. However, even if companies have the required knowledge in house, this does not have to be a benefit for the system as knowledge is still highly fragmentated, and unstandardized. Companies are testing and executing their own visions to Green IT. In some cases, these companies are not willing to share their executing because of competitive advantage or aiming to keep their partners' knowledge limited. For example, cloud providers not sharing their workloads, being afraid their end-users scale down.

This fragmentation of knowledge is as well included in the manifest of the NCDD, in which they aim to overcome this barrier and five others (Nationale Coalitie Duurzame Digitalisering,

2022). ABN AMRO (2021) remarks this fragmentation, and the lack of transparency in their research as well, forming two of the five identified challenges.

4.2.5. Additional drivers and barriers

Beside the four categories of drivers and barriers that I have identified after consulting the literature, the interviews delivered some insights that do not (completely) relate to one of these four. Some of them could be connected to the factors, however, to be strengthen the clarity these are displayed in this section. After the interviews I identified one additional driver and three additional barriers.

4.2.5.1. Additional drivers

Intrinsic/environmental motivations: Several interviewees mentioned that becoming more sustainable is the consequence if intrinsic motivations, such as the environment or aiming to help next generations.

This intrinsic motivation could be linked to other factors, such as creating a sustainable brand image with the associated advantages of it (normative factors associated with economic factors). However, it could still be an autonomous factor to some companies, as other interviewees brought this up as such. Virtue could be a motivation that is present in several companies. Leaving in the middle if there are other underlaying motivations playing a role in this.

4.2.5.2. Additional barriers

Significance of IT for organizations: Even if organizations are aware of their IT footprint, they must report it, and a company is willing to become more sustainable, IT is mostly not the top priority. The ESG specialist pointed out that this is the case because for most of the companies, IT causes relatively few emissions compared to other factors. A consultant describes that companies tend to challenge factors that cause more emissions, such as their car fleet, IT fades bigger sustainability challenges. Another consultant interviewee added to this that companies are worried about CSRD regulations, but not in particular on IT as this is relatively small. One of the CIO's even mentioned that CIOs are not even questioned about sustainability sometimes. An interviewee working at an NGO mentioned, in contrast to this, that the discussion on sustainability in IT is significantly growing. However, he concludes the same as the others; sustainability is challenged as a whole within companies. Finally, a business analyst agrees by stating that IT is just a drop in the ocean to most companies, and therefore it is often not challenged.

This could not be confirmed on company level. However, according to Freitag et al. (2021), the usage of IT is responsible for 1,8 to 2,8% of worldwide greenhouse gas emissions. Other sources show us that for example mobility is responsible for 18% of greenhouse emissions (CBS, n.d.). Additional to this, part of the emissions is outside of the companies.

IT is a conservative sector: this sector is known to be a conservative sector, according to a business analyst. Beside sustainable transformations, the sector is mostly not very open to

new innovations. Performance is the most important factor in IT, with changes there is a lot that could go wrong and thus IT decision makers do not prefer change, according to a consultant. In addition to this, another business analyst stated that in IT, unknown is mostly seen as unreliable.

ABN AMRO (2021) concluded the same after research, calling it a traditional attitude in the IT sector.

Chain responsibility: I already stated that because of economic motivations different actors are not on the same page. From the interviews it became clear to me that there is not a consensus on what the way to go should be in greening of IT. Datacenters try to become more sustainable by using their residual heat, whereas manufacturers try to generate chips that become less warm. Datacenters point towards CIOs to make more sustainable decisions, whereas some CIOs say that the government should intervene. NGOs direct on creating a standardization. A business analyst summarized this as that the market is fragmentated and different organizations are looking for solutions, all with good intentions but without major steps as most of them are working individually. In this discussion, transparency within the system is a major topic. As well, there is a consensus that it is important to look at the entire system to create a transition, which is currently not done sufficiently.

As stated, the NCDD confirmed this fragmentation. Additionally, ABN AMRO (2021) raises the importance of collaboration for Green IT.

4.2.6. Conclusion drivers and barriers

In this section I elaborated on the most important and most mentioned drivers and barriers.

Answering sub-question 2: "*What are the drivers and barriers for implementing Green IT in the Netherlands?*" I conclude that the lack of standardization and transparency are the two most important barriers, and the CSRD and the alliances are the most important drivers.

Almost all barriers are tackled when standardization is created, and transparency is forced. Green IT could require significant investments from companies. Currently, competing to other investments Green IT sometimes does not make it to the agenda. With clear costs, and benefits, provided by standardization, shareholders could make a more well considered decision on these investments. It is highly likely that this will lead to more implementations as in the long-term Green IT should return on its investments. Not even mentioning the easier practices, requiring less investments, such as eco modus.

Standardizing and transparency are likely to reduce external conflicts as well. If for every computer or software service there would be a fair comparison, companies could consider sustainability more compared to price. With transparency, end users could force manufacturers or other partners to become more sustainable by choosing other options now that their decisions are more well-argued. Sustainability could deliver specific companies a competitive advantage.

Beside companies forcing their partners to become more sustainable, society could do the same. With standardized measurements awareness will increase. IT usage will become less invisible to society and societal pressure will rise against companies who are either not transparent or harming in their IT usage. This could make the barrier of insufficient societal pressure a driver, forcing companies to become more sustainable now that in this scenario sustainability became a competition element. To a lower extend the increasing awareness can lead as well to a relativizing of IT being a necessity. If society becomes more aware of what the consequences are of buying IT hardware and IT usage, they may become more critical and adjust their habits and perceptions.

The barrier of knowledge fragmentation partly lays within transparency as well. Competition, and companies not willing to share knowledge with competitors are insurmountable. However, if there would be one measurement tool it would become clearer to bundle knowledge at alliances, or between partners. Knowledge sharing and bundling becomes more convenient, and knowledge gets more available. This knowledge could be used to skill employees. As well partner companies could have more insights. Making them able to take responsibilities in the chain.

The barrier that IT is 'a drop in the ocean' in terms of sustainability is hard to challenge. Limiting this barrier would only enlarge the problem, as IT could be responsible for a larger share of companies' emissions. As well IT being a conservative sector is hard to tackle, all that could be done is presenting the benefits of Green IT to attract change in this conservative sector. Concerning the shortcomings in legislations, this must be, and will be tackled by the European Union. From 2024 onwards every year new groups of companies, such as SMEs are included.

Zooming in to the drivers, I foresee the CSRD and the forming of alliances as the most important transition drivers. As stated above, most of the barriers are tackled by standardization and transparency. The CSRD forces transparency, and the alliances bring actors, both public and private, together to get closer to a standardization.

By creating a fair playing field with the new legislation, and later a standardization we exploit all economic drivers. As Green IT will be brought in practice more, knowledge will grow, and we are able to learn. Resulting in efficiency and cost reductions. As all competitors are doing this competition will drive sustainability. Companies must be transparent when aiming a sustainable brand reputation, being another driver. If not, societal pressure could increase, or market share could decrease. For the industry we already identified this as a driver.

This transparency is the same for exploiting the war on talent driver. Currently companies could claim sustainability, with more transparency and the need to prove this in audited reports (potential) employees can make a fair comparison.

To achieve the standardization, it is important to exploit alliances and other forms of knowledge generation. This includes network organizations, market players, scientific institutions, consultancies, and other organizations aiming to bundle knowledge. They should be funded and should be in close contact to the government to bring standards not just to the market, as well into rules and regulations.

Finally, intrinsic motivation, is hard to exploit as this must come from the inside of companies.

4.3. System dynamics

In this section visualize the dynamics within the socio-technical system. It includes ongoing events in each of the dimensions, based on the findings of the interviews. In the interviews I interrogated the experience of the interviewees with Green IT from their point of view. As explained, different interviewees were asked some similar questions, but also different questions based on their expertise and on their own responses. An overview of the standard questions is visible in appendix A. By asking what their interaction and view on Green IT is and which shifting they experience I sketched the state-of-the-art of each dimension in this section. A standard format of the interviews can be found in the appendix. From subsection 4.3.1 onwards all dimensions are elaborated, a table summarizing each of the dimensions is visible below in table 4.2.

Table 4.2: Summary of system dynamics per dimension from the interviews

MLP dimension	**Summary of interview insights**
Markets, user preferences (Demand side)	Green IT is a rapidly growing topic in the market since the last 2 to 4 years, both in frequency and in importance. Despite the growing attention, Green IT is still mostly executed by pioneers. These pioneers are actively inspiring other companies, causing a small shift in user preferences and making more market players implement Green IT.
Industry (Supply side)	Datacenters/cloud providers and IT disposal companies are ahead of the market. Incrementally these actors are executing several practices of Green IT, starting years before this was a topic in the market. The sustainability measures do not necessarily match the market preferences, in some cases the industry are even constrained by the market. IT suppliers have limited interaction with the Dutch market, however, this industry does make steps towards sustainability.
Policy	The European Union is creating the Corporate Sustainability Reporting Directive (CSRD). This will affect the large companies in the Dutch market, some of them are lobbying to steer this directive.
Technology	Technologies are developed by a lot of different actors. However, knowledge remains fragmentated. Measurements and standardization becomes more important, some actors strive to bring knowledge together and create this standardization.
Culture	Green IT is an emerging topic. Alliances are forming and there are small shifts in the culture, however, culture is not changing significantly.
Science	Green IT slowly gains ground in the Academic world, universities collaborate in network organizations. However, research on Green IT remains limited.

4.3.1. Market, user preferences (demand side)

According to a handful of interviewees, Green IT is something that became a topic of discussion in the market over the last couple of years. Although there is not a unanimous start year for this, there is a consensus to a certain extent. An IT decision maker mentioned that

Green IT was not a significant topic three or four years ago. Likewise claims that affirm this are a CIO stating that in 2020 sustainability was not a concern for CIOs and a business analyst stating that in 2021 the majority of IT decision makers was not working on sustainability in IT. Three other interviewees elaborated more on when this topic arose. A cloud consultant mentioned that Green IT is growing in his/her circles since two or three years. A supplier mentioned that it became serious in the last four years and a business analyst mentioned that Green IT is a topic of conversation at business conferences.

Beside the consensus that Green IT is an upcoming topic since the last two to four years, several interviewees mentioned that this topic is rapidly growing in the last years. Two IT decision makers claim IT is a growing topic on the agenda and that IT sustainability is a standard topic when discussing IT. An NGO employee affirmed this as he/she sees a rapidly growing topic as well. One of the IT disposal interviewees mentioned that preferences from end users are shifting as well, as they are expecting more in terms of sustainability. This growing attention could be a consequence of the fact that IT is growing within every company, becoming an undeniable part of organizations.

Still, despite the growing attention, Green IT stays small in the market. One IT decision maker explained this as growing awareness about Green IT, however, not enough to make it up to the top management. A business analyst claimed likewise that the topic is growing but is yet to become a top priority, apart from some exceptions. An NGO interviewee mentioned as well that the few companies that have implemented Green IT are outliers. Green IT is still not on the radar for the majority of the companies. Across the entire market, application of Green IT occurs sporadic, other IT topics are more popular, conferences about Green IT do not receive wide attention.

It is remarkable that the so-called regime outliers and outsiders are actively promoting Green IT. Leading companies are expecting more from their partners. Companies arrange lectures, such as Schiphol presenting their twin transition roadmap to other companies at the CIO platform. Furthermore, these leaders are transparent in their IT sustainability, reporting about this in year reports, setting examples for other companies. NGOs play an important role in this as well. An example of this is the NCDD, which is collaborating with leading 40 organizations. These organizations strive an integrated approach with standardization on sustainability in IT. Currently this standardization, or certifications are not existing. However, it is the goal of several groups of organizations to create this. The small shift in user preferences is also visible at consultancies, which are creating sustainable IT capabilities and bringing new initiatives to the market. A business analyst points out that the IT market is becoming greener, even though this is originally one of the markets where sustainability is the least on the radar, companies are inspiring each other by showing their best practices.

4.3.2 Industry (industry side)

4.3.2.1. Datacenters/cloud providers

Within the datacenter industry sustainability is a topic of discussion for a longer period compared to the end-users. According to a datacenter interviewee sustainability was a consideration in 2008 already. Since then, CO2-neutral buildings, efficient cooling and

collaborations with energy companies were standard topics. However, another interviewee mentioned that these were incremental steps, and explained that sustainability is more predominating in the last five years. The Cloud consultant explained in the interview that the majority of the companies is using cloud nowadays, this is a big step in sustainability as this centralization of datacenters leads to more efficiency and thus less emissions. An IT decision maker confirmed this; cloud is more efficient than operating IT in-house. Cloud as well has more opportunities to up- or downscale efficiently. Sustainable innovations in datacenters are not directly a consequence of market expectations. There are important ISO certifications for datacenters. However, the ones concerning energy-management (ISO 50001) is not frequently asked for in the market. Green IT implementations in the market such as efficient cooling is an intrinsic project rather than a requirement from the market. This becomes visible as well from the datacenters doing this since 2008, when the market did not really recognize sustainability in IT. Still, users of datacenters do not critically discuss sustainability in datacenters. Even though datacenters do not act transparent on emissions, for example the year reports are not audited, companies tend to accept this. Another example of datacenters acting autonomously, is selling residual heat. Selling residual heat could be the new business model for datacenters. At some places in the Netherlands this is already done. However, a datacenter interviewee explained that number of companies is not willing to do this as they rather strive less residual heat. To conclude, datacenters are actively implementing and testing Green IT executions. However, this is more based on the goals of the datacenter itself rather than its end-users, who are not pushing them to or even prevent them.

4.3.2.2. IT supplier industry

IT manufacturers are all working on sustainability in their own way. New business models are implemented, second-hand hardware is offered, and entire companies are greening. Still, IT suppliers have a significant percentage of emissions. The two IT disposal interviewees mentioned that there is a lot of ground to cover at the manufacturers/suppliers. However, as these actors are enormous non-Dutch companies, their interaction with the Dutch market is limited. Extension of product life cycle may be a goal in the Netherlands, but this is not in interest of companies like HP, Dell, and Lenovo. According to an interviewee working at a Dutch IT reseller/supplier, sustainability is not yet a significant criterium. From the manufacturer's perspective, there are some second-hand programs, but these are not to visible, according to a business analyst. According to a reseller the Dutch market is mainly focused on new products. As a response to worldwide shifts, manufacturers are more focused on making value out of software nowadays, creating new business models. In the Netherlands Fairphone is a new company, creating modular phones made from recycles material. Several interviewees brought up this company as promising, however they do not have market share to really compete with international companies. Overall, I conclude that this part of industry is making steps towards sustainability. However, manufacturers are not in significantly interacting with the Dutch system. The Dutch market is too small in comparison to these manufacturers' total market to have a significant influence.

4.3.2.3. IT disposal industry

Just as with the datacenters, disposal companies are ahead, and sometimes even constrained, of the market in terms of sustainability. The first IT disposal interviewee mentioned that in

their sector sustainability is a point of discussion for 15 years, the other stated since 2012 or 2013. Reporting, auditing, and certifications are common in this sector. Disposal companies are able to recycle or refurbish old hardware, they hold sufficient knowledge to do so. However, the actors in the market do not always agree on these methods. Based on data safety they rather want to see the hardware destroyed in a lot of cases. Still, the IT disposal companies see that a small shift in preferences is taking place. Sustainability becomes a more significant criterium in tenders. Beside data safety, sustainability is a choice criterion nowadays. One of the interviewees mentioned that this results as well in the frequency that companies ask for certifications concerning sustainability. One of the IT decision makers confirmed this, at the specific company they are more demanding towards IT disposal companies. Still, the amount of reduction of CO2 emissions because of refurbishing receives limited attention from end-users. In fact, the entire refurbished market does not really spark the interest of these actors. Companies rather decide on costs than CO2 emissions or lifecycle when buying IT hardware. The two interviewees mentioned that awareness at these decision makers must improve, both when deciding to buy and sell hardware.

4.3.3. Policy

Analyzing the policy dimension, the CSRD directive is the most important factor. The one interviewee refers to this as "*a present*", while others mention that the reporting resulting from this are a though job. Either way, the CSRD forces a lot of companies to start reporting about their emissions, including IT emissions. As well these companies need to show how they challenge these emissions. For the past several years, the Dutch government raised this topic, however, without consequences. The CSRD directive is yet to be released. The current planning is that from 2024, the CSRD affects more companies every year. Currently, several organizations collaborate to lobby with the aim to steer this CSRD. A good example of this is the NCDD collaborating with 40 companies and delivering a manifest to the Dutch government. As it is clear that some form of reporting is required next year, and there will probably be minor changes in the final directive, companies are starting to collect their data that is needed for reporting. Apart from this European directive, affecting Dutch companies, there is not more legislation currently. However, one consultant mentioned that this might change soon. For the industry there are more legislations, some of them are concerning sustainability.

4.3.4. Technology

Concerning technology, Green IT has multiple applications. From incremental innovations such as simple eco-modus on laptops, to disruptive innovations in cooling in datacenters, requiring large investments. There is not one go-to technology that makes IT usage (more) sustainable. Several different technologies are ready to be used and are implemented at different companies. Some of the interviewee's state that there is enough knowledge available about Green IT, some statements are *"there is enough knowledge, there are massive knowledge bases on green IT", "There is sufficient knowledge to dispose IT hardware"* and *"There is sufficient knowledge at datacenters to calculate usages"*. However, they, and other interviewees state that knowledge is highly fragmentated; *"Knowledge is gained, but every company develops its own methods and vision"*. Consequently, the system falls short in

transparency and measurements. For example, cloud providers are taking action in sustainability, but their clients do not actually know what the profits of these actions are. For other companies energy usage is mostly measured for the entire physical building, not exactly knowing what share is caused by IT, let alone what the improvements could be. One of the consultants stated that this could be explained by the fact that we did not have to measure until now. Now that measurements become more important because of legislation, this gains more attention According to a cloud consultant, new measurement tools pop-up every week, from different actors (e.g., consultancy, science, NGO). Companies individually are addressing these measurements. Besides, several actors join the NCDD, sharing knowledge and creating collaborations. According to interviewees SDIA and sustainableIT.org are working on standardizations.

4.3.5. Culture

Interviewees largely agree that Green IT is a growing topic. It is still emerging, but it becomes a topic of conversation. A consultant declares that this is the result of IT in general is getting more attention. A business analyst noticed that more newspapers are writing articles about IT emissions with the rise of artificial intelligence. The growing of this topic leads to more pressure. However, media and society are not yet aware enough to make this pressure significant. Beside the external factors, culture within company is changing as well, mostly young employees are demanding more sustainability from their (future) employer. Alliances such as the NCDD are growing, a business analyst pointed out that currently not just pioneers are connected to this kind of organizations.

4.3.6. Science

Science is not necessarily constrained to the Netherlands. The Dutch market could benefit from publications all over the world. However, for tight collaborations this is different. The interviewees pointed towards these collaborations. Universities are collaborating with NGO's, governmental, organizations and companies. Two interviewees mentioned the Digital sustainability center (DISC) from the VU Amsterdam, however, one of them mentioned that more research is needed. A business analyst mentioned that currently sustainability becomes integrated in IT studies at Dutch universities.

4.3.7. Concluding system dynamics

The interviews contributed to the research objective and answering the main research question by providing an overview of system dynamics. The interviews helped to identify the current state of Green IT in the Netherlands, which is fundamental to determine the phase of transition. Briefly summarized the interviews revealed that Green IT is a growing topic in all dimensions. However, that it is still emerging. It is mostly executed by pioneers, who form alliances and prepare for the upcoming policy changes. Standardization is not there yet, and the dimensions culture and science do not show significant shifts yet. In chapter 5, I provide a more elaborative analysis on these dynamics, comparing them to the phase indicators identified in the first sub-question.

4.4. Concluding chapter 4

In this chapter elaborated on the results from the case study. In the first section I introduced the socio-technical system and its important actors. In section 4.2. I provided an overview of the drivers and barriers within the system. In this section sub-question 2 "*What are the drivers and barriers for implementing Green IT in the Netherlands?*". I concluded that the lack of standardization and transparency are the two most important barriers, and the CSRD and the alliances are the most important drivers. Especially the barriers are important to overcome, as they could influence a wide variety of other barriers. Finally, I elaborated on the systems' dynamics in section 4.3.

5. Discussion of the results

In this section I further elaborate and discuss the results from the interviews and the desk study and answer the third sub-question *"In which phase of transition is Green IT in the Netherlands currently?".* The sub-question is answered with the use of the earlier two sub-questions.

5.1. Phase of Green IT in the Netherlands

In the theory I answered the first sub question, sketching how each transition phase of the MLP framework would look like for Green IT. Based on the interviews, followed by desk research for referencing, I identified a state of the art for each of the dimensions of the MLP framework. Below, I merged table 2.1, the standard phases, and the interview insights of table 4.2 into table 5.1.

Table 5.1: comparing Green IT to standard phases per dimension.

	Phase 1 (experimentation)	**Phase 2 (stabilization)**	**Phase 3 (diffusion, disruption)**	**Phase 4 (institutionalization, anchoring)**	**Summary of interview insights**
Market, user preferences (demand side)	- Uncertainty about the users and their preferences - Incremental innovations from users - Some networks are built	- Novelty is used in small market niches - Increasing interactions (e.g., alliances, feedback) - Bundling knowledge - No clear match to technology	- User preferences shift towards greener IT execution - Number of actors using Green IT is growing - Actors realize the benefits of Green IT	- The majority of users switch to Green IT - Green IT is normalized and anchored in business practices	Green IT is a rapidly growing topic in the market since the last 2 to 4 years, both in frequency and in importance. Despite the growing attention, Green IT is still mostly executed by pioneers. These pioneers are actively inspiring other companies, causing a small shift in user preferences and making more market players implement Green IT. Based on the limited Green IT users and knowledge sharing, the market is in phase 2
Industry (supply side)	- Different initiatives of Green IT pop-up - industry trying to get more attention	- Green IT practices start to standardize - Better functionality and more attraction	- Increasing information/feedback due to interaction with market	- Green IT is normalized	Datacenters/cloud providers and IT disposal companies are ahead of the market. Incrementally these actors are executing several practices of Green IT, starting years before this was a topic in the market. The sustainability measures do not necessarily match the market preferences, in some cases the industry is even constrained by the market. IT suppliers have limited interaction with the Dutch market; however, this industry does make steps towards sustainability. The standardization and the imperfect match to the market indicate to phase 2.
Policy	- No certain policy on Green IT - No standards	- IT emissions policy is on the agenda - Market and industry lobbying	- Green IT policy is created - Standardization becomes more prominent - Adjustments in policy are on the agenda	- Clear regulations (e.g., performance requirements, professional standards) - Clear emission standards	The European Union is creating the Corporate Sustainability Reporting Directive (CSRD). This will affect the large companies in the Dutch market, some of them are lobbying to steer this directive. The policy creation and lobbying clearly indicate phase 2.
Technology	- Low performance - Uncertainty and competition	- Green IT becomes more clear - Practices stabilize	- Technology improves significantly - Technology becomes more attractive to the market.	- New, more sustainable, technologies replaced the existing technologies - Incremental improvements in new technologies	Technologies are developed by a lot of different actors. However, knowledge remains fragmentated. Measurements and standardization become more important, some actors strive to bring knowledge together and create this standardization. Green IT becoming more clear to some actors, however, it remains unclear to the majority, hinting towards phase 2.
Culture	- Low awareness, starting to increase	- New norms arise - Green IT gets accepted and promoted	- Cultural changes towards Green IT as a standard	- Culture stabilizes new user habits and views of normality.	Green IT is an emerging topic. Alliances are forming and there are small shifts in the culture, however, culture is not changing significantly. The unawareness of society aligns with phase 1.
Science	- Rather experimental, researching uncertainties of Green IT	- Number of articles rise, mostly negative	- Green IT performances and developments are researched	- Green IT becomes a standard research topic	Green IT slowly gains ground in the Academic world, universities collaborate in network organizations. However, research on Green IT remains limited. The limited amount and the nature of the articles indicate phase 1.

Market: Projecting the current market status to the four phases I conclude that the market is most comparable with the second phase. There are increasing interactions; companies are sharing knowledge and alliances are formed. The novelty as well is used by some market players.

Industry: Scaling the industry in the phases I conclude that the Netherlands is currently in the second phase. The industry is ahead of the market, improving functionality and starting to standardize technologies such as air cooling and residual heat. There is not an appropriate match to the markets, user preferences do not align with the industry. This means that there is limited feedback or interaction yet, which would have indicated to phase 3.

Policy: Currently there is policy created and several companies/alliances are lobbying to influence this, clearly indicating towards phase 2. In 2023 when the policy is introduced, phase 3 becomes within sight, based on the adjustments and extensions the European Union is planning on.

Technology: Technology shows aspects from the second phase. Green IT becomes clearer, as the first pioneers implemented this. However, there is significant uncertainty for the majority of the market, in terms of costs and benefits. There is a need for standardization and more transparent measurements.

Culture: Culture is mostly aligned with phase 1. There is a clear shift in societal norms in terms of sustainability, however this is not fully experienced in the field of IT yet. Citizens and employees are unaware of companies IT usage and the consequences of it. This awareness slowly starts to increase, mostly due to younger generations, this already hints towards phase 2, accepting and promoting Green IT.

Science: Science is in phase 1, there are few articles in the Netherlands on Green IT. In the past years it slowly grows but the research maintains mostly experimental in collaboration with alliances.

Green IT transition phase: Aggregating the dimensions of Green IT in the MLP framework, I see that there are aspects indicating the first and the second phase. I conclude that most of the ongoing processes indicate towards phase 2, stabilization. System-wide we see that the standardization is an ongoing topic, alliances are actively collaborating with several different actors to achieve this. Some market players embraced Green IT yet and user preferences are slowly shifting. In the industry standardization seems within sight. I deem the market and the industry the most important pillars. These are the two dimensions where the transition actually happens, Green IT is brought in to practice here. The two dimensions lagging behind, culture and science are less significant. It seems highly unlikely that culture will not change towards a more sustainable IT system when the market and the industry do, the first signs of phase 2 are visible as well. For science the same conclusions could be drawn, science starts to get more involved.

Drivers and barriers: The drivers and barriers that are identified in sub-question 2 again indicate transition phase 2 systemic wide. The driving force of forming alliances, increasing interactions and pioneers inspiring other companies with their practices reflect with phase 2.

The other main driving factor concluded in sub-question 2 indicates phase 2 of the policy dimension. Although the directive is not in effect yet, it drives companies to rethink their IT emissions. The barrier lack of standardization holds the system back to reaching the third phase and thus aligns with phase 2. With standardization the technology would become more attractive, feedback would increase and there will be significant improvements which are all processes indicating phase 3. As well, the alliances challenging this barrier is something that is likely to be in the second phase. Low transparency show hints from phase 1 and 2. Due to this barrier there is low cultural awareness, indicating phase 1. However, the upcoming CSRD forcing transparency indicates the second phase.

Based on the system dynamics and the drivers and barriers I conclude that the answer to the third research question: *"In which phase of transition is Green IT in the Netherlands currently?"* is that the Dutch Green IT transition is in phase 2 (stabilization) system-wide with some of the dimensions lagging in the first phase. The dimensions market, industry, policy, and technology all relate to the indicators of this second phase. However, culture and science show more similarities to the first phase, the number of scientific articles are not significantly increasing yet and Green IT is not at the point that it actively promoted by society. The drivers and barriers identified in this research point towards the same conclusion.

5.2. Drivers and barriers

In chapter 4 I answered the second sub-question. This answer is based on the outcomes of the interviews and desk research. In these methods I mainly focused on the earlier identified categories and the drivers and barriers that lay within the regime level of the MLP framework. However, there could be other factors that influence the transition towards Green IT. First, there could be landscape developments could have significant influence if Green IT is accepted or not. One example of this that is highly relevant nowadays is the war in Ukraine, causing increasing prices for electricity, this might be an extra financial motivation to organizations. Other factors could be economic (de)growth influencing decision making of organizations. As stated earlier, these landscape developments are behind the influence of the actors and thus are not included in answering sub-question 2, however it is important to mention these. Moreover, the levels in the MLP framework influence each other, occurrences such as higher electricity prices are likely to be yet intruded into the regime level. Beside landscape developments there could occur other external events that influence the system. Green IT could for example be rapidly growing in another country, the Dutch system could learn from this and this could be a driver. Similar to growing knowledge in other countries the public opinion towards Green IT could as well shift on a global level, influencing the Netherlands. I deem analyzing international or global shifts concerning Green IT infeasible for this research.

5.3. Concluding chapter 5

In this chapter I discussed the results of the second sub-question, highlighting that there are other drivers and barriers that could influence the system, which are not within the scope of this research. More important, in this chapter I answered the third sub-question: *"In which*

phase of transition is Green IT in the Netherlands currently?". I concluded that the Dutch Green IT is mostly aligned with the second phase of the MLP framework. Four out of six dimensions are in the second phase, the science and culture dimension lag, being in the first phase. In the last chapter, both the second and the third sub-question are used to answer the main research question.

6. Conclusion

In this chapter I answer the main research question in the first section. In the second section I reflect on the relevance of this thesis. Finally, the limitations of this research are discussed, and future research is proposed.

6.1. Main research question

Global warming is a growing problem, day by day new emissions are emitted. As the world evolves and industrializes, the intricate balance of our planet's climate systems is under increasing threat. One of the reasons of this increasing threat is the amount of IT used in the world. In the last decades IT became a necessity for business and for private life in large parts of the world. The demand of IT increased rapidly and is expected to further grow. A consequence of this growing demand is that the share of emissions by IT is expected to grow rapidly. IT usage is already responsible for the significant share of worldwide emissions of approximately 1,8 to 2,8%. This is expected to grow up until 14% in 2040. Based on this growing problem, there must change something in our IT usage. Governments and the European Union have set goals to limit emissions, for IT and in a broader context. However, literature shows that this is yet to become on the agendas of most companies. Even though companies are heavy users of IT, as IT is being a clear business necessity nowadays. There is a clear need of taking more responsibility of our IT usage, aiming to limit and reduce emissions. Reducing the negative ecological impact of IT is called "Green IT".

Currently Green IT is far from the norm. Literature shows that companies do not execute Green IT, it is not frequently researched and there is not much societal pressure to make IT more sustainable. To reduce the growing IT footprint, I concluded that it is needed that a transition how we use IT takes place. A transition towards a system in which Green IT is the norm, the new way of using IT. The research on transforming and accelerating the transition of the worlds' IT usage is relatively underexplored. To explore such transitions, I identified the Netherlands as a case study. The Netherlands is one of the leading countries concerning IT. The IT infrastructure in the Netherlands is reliable and the Dutch government is ambitious in challenging emissions. This transition tends to be very slow currently, so I aimed to answer the following main research question:

"How could a transition towards Green IT in the Netherlands be accelerated?"

To answer this research question, I used the multi-level perspective framework. This framework is used to explain transitions of (large) socio-technical systems. The system is formed by a wide variety of actors, acting in six different dimensions. In this framework, the system passes four phases, from experimenting with Green IT to the moment that Green IT is widely adopted and is seen as the new norm. Additionally, I contributed to this framework by synthesizing a phase-based Green IT transition framework. Based on literature I drawn up characteristics for each dimension indicating one of the four phases in the framework.

To find out what must happen to accelerate the transition, it is important to determine in which phase the Netherlands currently is for Green IT. Literature taught us that different phases need different approaches to proceed, and we can aim to reach the next phase. The first and third sub-question are answered to identify the current phase. Answering the first sub-question *"How could the transition phases for Green IT look like?"* I identified indicators for each dimension in each phase. These indicators form a blueprint of theoretical transition phases of Green IT. This sub-question is answered by using literature.

By answering second sub-question *"What are the drivers and barriers for implementing Green IT?"* I summarized an overview of drivers and barriers. To answer the main research question, it is important to know what drives the transition and what hampers it. The interviews formed the basis of the answer to this sub-question. In the interviews I asked the experts about four forces (economic, regulatory, normative and knowledge). Not all identified drivers and barriers classified to one of the four forces, so additional forces are added. The findings of the interviews are triangulated with other sources, such as company websites and business reports.

To answer the third sub-question *"In which phase of transition is Green IT in the Netherlands currently?"* I used the phase-based Green IT framework of sub-question 1 and the drivers and barriers from sub-question 2. To form a state-of-the-art of Green IT in the Netherlands I conducted interviews. In the interviews I spoke to a wide variety of experts, asking them about their view, the execution, and different forms of changes of Green IT. Based on the interviews and the comparison with the standard indicators, I concluded that the system as a whole is currently in transition phase 2 (stabilization phase), however, the dimensions culture and science were more comparable to the first phase. The most prominent drivers and barriers of the second sub-question indicated phase 2 as well. The difference in phases between dimensions require an additional strategy in answering the main research question, aiming to align the dimensions.

Combining the answers to the sub-questions and the theory, the main research question can be answered:

"How could a transition towards Green IT in the Netherlands be accelerated?"

Based on the third sub-questions I concluded that we are currently in the stabilization phase of the MLP framework. The systems seems to follow a reconfiguration pathway; there is sufficient landscape pressure, triggering small adjustments to the regime level (as described in section 2.5, p. 17). Until now the market implements incremental innovations brought up by several actors. Answering the second question I substantiated that creating standardization and forcing transparency are the two main focus points. These focus points eliminate most barriers and exploit most drivers. I elaborated that standardization would increase awareness for both organizations as society and makes Green IT more attractive. Increasing transparency will create a more levelled playing field, in which society, partner companies could force sustainability in IT towards an element of competition.

Transition studies thought us that between phase 2 and phase 3 the old system must be phased out. Phasing out old systems constrains old technologies and creates space for new

technologies to evolve and to normalize. To phase out the old system (how IT currently is equipped), significant changes in multiple dimensions are required. As system dimensions closely interact with each other, changes in one of the dimensions will influence others. An action creating momentum could be initiated in multiple dimensions. I foresee an important role for the Dutch government and the European Union as they could force a significant momentum desired for the transition.

The European Union has taken the first steps for acceleration, forcing large corporates with the Corporate Sustainability Reporting Directive (CSRD) to start reporting on their emissions and their sustainability agendas from 2024. The CSRD rapidly increase companies' transparency. This directive aims to phase out old IT practices, forcing companies to innovate and become more sustainable (in IT). This policy measurements directly affects part of the market, forcing them to accelerate drawing up their Green IT agendas. Associated with these agendas Green IT is brought in to practice more, this makes several phase 3 processes more likely to occur. Indicators of these processes could be technology improvements and cultural changes, better accepting Green IT. The proposed measurement provides more clarity to the industry. Providing more information, feedback, and interaction, market actors must improve these practices. These interactions improve the technology, making Green IT more attractive to other market actors, creating a positive feedback loop of phase 3 processes. As well the CSRD forces transparency, making sustainability (in IT) a competitive element, and encouraging society to thrive acceleration by increasing pressure.

The out phasing of old IT practices thrives on the enforcement of this directive. Again, the Dutch government has a highly important role in this. Green IT could only be accelerated in the Netherlands if CIOs take on the new directive, starting to measure their IT emissions, and act based on the gained insights. The Dutch government must keep a close eye on the company reports, making sure their reports are in order and creating a conversation with companies. Only with clear enforcement the CSRD, being a driver of acceleration, this driver could be exploited. Another measure to exploit this driver is to enlarge its influence on the market. The European Union currently intends to include a larger group of companies into this directive every year. These expanding steps included SME's and non-European companies (with businesses in Europe). It is important to bring these intensions to completion. Including a larger group of companies in the CSRD helps phasing out old IT practices as more companies must start innovating them. Expanding the CSRD each year leads to a constant accelerator towards phase 3 (or even phase 4).

Beside the enforcement and the expansion of the CSRD, evaluation is important. The Dutch government and the European Union must track how the CSRD unfolds. If included companies do not act based on the new directive, developments must be made based on the situation. Examples of this is the fining the companies who do not report or report falsely or to tighten the directive where possible.

The Dutch government has another important responsibility beside enforcing the directive. They must take an active role in standardization of Green IT and Green IT measurements. Being in the second phase of transition we must aim to accelerate it in to the third. The indicators of phase 3 reveal that a lot of dynamics thrive on standardization. Standardizations provide clarity to market players, making benefits clearer, shifting the preferences and

increasing the implementations. The increased clarity will have the same effect on the culture, normalizing Green IT, aiming for the third phase. As culture currently is in the first phase and must be aligned to the other dimensions, it needs some extra attention within the strategy. Society is hard to steer, awareness must be created. The most straightforward approach to achieve this awareness is by supplying more information about the consequences of IT usage and the Green IT as a solution. This could be done using a variety of channels. Again, the government is the most powerful actor to structure this, publishing reports or setting up information campaigns. When Green IT is normalizing and becoming accepted and known by society it is likely that scientific interest grows along. As an additional strategy the government could create more awareness in the science dimension by reaching out to universities, starting a conversation about how Green IT could be a more attractive research topic. I propose this additional strategy aiming to align science to the other dimensions. Industry and technology benefit from the standards because the attraction increases, and it provides them with more security about the coming years. Beside the growing attraction the standardization of measurements will simplify the interactions of green IT. Companies could compare emissions, barriers to start greening of IT flatten and the government could track emissions more easily.

6.2. Relevance of the research

6.2.1. Scientific relevance

This master thesis has multiple scientific contributions. This research explores and examines the dynamics of Green IT at the sociotechnical system level. I identified this as a knowledge gap in academic literature as no research was conducted in this context yet. This research contributes to filling this knowledge gap. It advanced our understanding of systemic dynamics in the context of Green IT in the Netherlands. This understanding is Fourfold.

Firstly, I gained knowledge about the relevant actors of all dimensions within the system. This delivered an understanding about how the socio-technical system looks like. We now know end users (from multinationals to family companies), datacenters, IT disposal companies, international IT manufacturers, the European Union, the Dutch government, consultancies, network organizations, NGO's, universities, and Dutch society all have a role in the system. The knowledge that is collected adds to the limited academic knowledge in literature about Green IT in the Netherlands and could be retrieved by other researchers.

The second knowledge contribution is the identification of what is currently motivating and hampering the implementation of Green IT. Both the general categories that I used to structure this research as the specific drivers and barriers add to Green IT knowledge. This research showed that the lack of standardization and transparency are the two most important barriers, and the CSRD and the alliances are the most important drivers.

Thirdly, I supplied an overview in this research of current (and recent) system dynamics, actions and interactions of different Green IT actors and executors. Again, with the limited knowledge about Green IT this is a new contribution, helping to understand what currently occurs in this field. We now know that Green IT is growing since the last couple of years and

starts to stabilize now, the technology improves, attention is growing (because of multiple actors), and the first pioneers are actively executing Green IT.

Finally, I proposed a strategy to accelerate a Green IT transition in the Netherlands. This strategy proposes phasing out the old system of executing IT by increasing transparency and aiming for standardization. Beside the contribution to Green IT knowledge this is beneficial to the knowledge of accelerating strategies.

Beside these specific contributions this research could be retrieved in other related studies. For example, when executing similar Green IT research in another country aiming to further fill this notable knowledge gap, this thesis could be used as a comparison, or as an example of the used approach. Even more general this research builds upon the knowledge of transition studies. Aspects from this research, such as identified drivers and barriers could be valuable knowledge for another research in sustainable transitions.

Apart from the knowledge that is contributed to Green IT (in the Netherlands) and transition studies, I contributed to the MLP framework and the MLP literature. Even though this is widely respected by researchers and is commonly used for over a decade, it is rarely used as a phase-based transition framework. With table 2.2 answering the first sub-question I contributed by synthesizing relevant concepts to identify indicators to each of the phases for every dimension. Although these indicators are specific for Green IT, this approach could inspire other researchers to take on the same approach or could be consulted for studies planning this approach. Besides, it is likely that there are similarities in some of the processes in other transitions as the included papers in the literature review are not constrained to Green IT.

6.2.2. Societal relevance

In this thesis I addressed part of one of the biggest problems to society nowadays, global warming. This overarching problem is caused by many factors, including IT usage. The societal relevance of researching this topic out of all these factors is twofold. The first reason is that IT usage has been growing rapidly in the last decades, and it is expected that this will continue in the future. Along with the IT usage, the IT emissions increased rapidly as well, becoming a more significant number of total emissions every day. Along with this increasing problem it becomes more important to society to execute research on this topic. The second point of relevance is that despite the increasing usage and emissions, the societal awareness lags behind. Comparing IT to other emission factors, such as car usage or the flight industry, society is less knowledgeable. With the rise of artificial intelligence, such as ChatGPT, societal awareness on IT usage becomes more relevant than ever. Society plays an important role in challenging IT emissions (and global warming), because of their individual actions and their power to steer institutions such as companies. This thesis aimed to create awareness about IT emissions and provides a strategy helping to overcome this societal problem.

6.2.3. Relevance to MSc. Complex Systems Engineering and Management

The master Complex Systems Engineering and Management aims to learns students to explore innovations in complex socio-technical environments. Students learn to take a wider

look than just technology, including other aspects such as society and policy regulations. A variety of tools and methods are presented to students to help students analyze and improve such systems. In this master thesis, several aims and methods from the CoSEM program are exhibited. I analyzed socio-technical system, being the Dutch IT system. Within this system there are multiple actors, with alternative perspectives and goals. Green IT brings social, economic, and technical components together. I took an encompassing view on the system, providing a strategy to intervene in this system, aiming to align systemic dimensions. Aligning these dimensions, I attribute the government a coordinating role as this is the most powerful institution to do so. Beside the topic and its aspects, the multi-level perspective recurs from the master program as well. This framework is one of the provided theories to analyze socio-technical systems as taught in the master program.

6.3. Limitations and future research

One of the limitations of this thesis is the reliability. Reliability is one of the typical limitations associated with a case study. Besides, using interviews have the same effect. When conducting multiple case studies, one could prove a replication in findings, ruling out that this is dependent on the sample of the case study. For this research, specifically the test-retest reliability is limited. If another researcher would conduct the same research, using different interview respondents it is possible that other respondents have different visions about Green IT. Even though the interviewees varied in company, sector, actor group, etc. it could not be fully discarded that the findings are coincidental. I aimed to reduce this limitation by interviewing multiple actors with the same interview profile, and by triangulating the findings with other sources. Giving the time constraint it was not possible to conduct more interviews to reduce sample bias probability.

As this research only includes one case it currently is not safe to say that the findings of this research could be generalized to any other country or another socio-technical system within the Netherlands. Limited by time it was not feasible to conduct more cases. Still, one of the main contributions of this research is the approach, adding the phases and its related indicators to the framework. However, the findings could be retrieved when conducting likewise research.

One of the main contributions of this research is the adding the phases and its related indicators to the framework. However, for the sake of time this phase-based framework is not validated with experts. This lack of validation forms a limitation to this study, it limits the generalization of using this framework. In line with this limitation, it might be interesting to follow-up this research by testing my additions to this framework, for example by examining another Green IT system or the same system in a couple of years. This could deliver an interesting comparison of the countries and could refine the framework and its indicators.

Finally, in this research I underscored the importance of standardization of this research. A logical and interesting follow-up research would be exploring how this standardization must look like. In standardization one aims to harmonize and equalize norms and procedures. This could affect a variety of topics concerning Green IT, some examples that could be researched

are transparency norms, emission norms, energy usage. Along with these standardization consequences of not meeting those could be researched.

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Appendix A: Interview protocol

Interview script:

Van te voren vermelden;
Inleiding (snel en kort, respondenten weten over het onderwerp)
De opwarming van de aarde is een groeiend probleem. Als gevolg hiervan treffen overheden maatregelen om dit terug te dwingen. Voor 2030 zal de uitstoot met 55% gereduceerd moeten worden in Nederland. Deze maatregel gaat ook de IT aan, uit onderzoek blijkt dat deze sector verantwoordelijk is voor 1,8 tot 2,8% van de uitstoot, en dat dit aantal kan groeien tot wel 14% in 2040. Het terugdringen van emissies als gevolg van IT heet groene IT, kortweg uitgelegd als het verduurzamen van de IT.

Introductie onderzoek
Vanwege deze urgente verandering doe ik onderzoek naar hoe de transitie naar een maatschappij waarbij groene IT de norm is versneld kan worden. Ik doe dit door te identificeren in welke fase van transitie we zitten en uit te vinden wat voor verschillende actoren drijfveren en barrieres zijn om groene IT te implementeren.

Interview uitleg en dataverwerking
- Uitleggen hoe het interview eruit ziet en wat ik van de interviewee verwacht
- Toestemming vragen voor geluidsopname
- Verwachting uitspreken voor open en eerlijke mening, uitleggen dat het niet om bedrijf X gaat maar om observaties/interacties in het systeem.
- Overleggen of ik mag quoten of eerst terug moet sturen voor toestemming, uitleggen dat het publiekelijk beschikbaar is

Start van het interview (4 min)
Introductie (6 min)
1. Kunt u een korte introductie geven over uzelf, uw bedrijf en uw eigen rol?
2. Kunt u in een paar zinnen uitleggen wat u verstaat onder Groene IT?

(uitleg groene IT en niet IT for green)
3. Ligt de focus bij u vooral op IT inkoop, intern IT gebruik of IT verwerking?

Fases (10 min)
4. Wanneer hoorde u voor het eerst over groene IT/ het verduurzamen van IT bij IT-afvalverwerkingsbedrijven?
5. Kunt u schetsen hoe de aanwezigheid van groene IT sinds dat eerste moment is veranderd? Bijvoorbeeld door de importantie op de agenda of hoe zwaar verduurzaming weegt in beslissingen?
6. Is duurzaamheid op gebied van IT gestegen op de agenda, of wordt er vooral naar andere takken binnen het bedrijf gekeken voor duurzaamheid? (jaar rapporten)
7. Ziet u een verandering in duurzame eisen aan vanuit partners of vragen jullie zelf meer van partners (zoals datacenters/cloud providers, IT leveranciers, IT verwerkers)?
8. Ziet u een verandering in sociale druk op het verduurzamen van IT?
9. Ziet u een verandering in politieke druk op het verduurzamen van IT?
10. Ziet u een verandering in technologische en/of wetenschappelijke kennis van verduurzaming van het verduurzamen van IT?
11. *Uitleg van fases uit mijn vooronderzoek* in welke fase zou de transitie plaatsen?

Drivers en barriers
Algemeen (8 min)
12. Wat zijn volgens u de grootse motivaties voor bedrijven om te verduurzamen in de IT?
13. Wat zijn volgens u de grootse barrieres voor bedrijven om te verduurzamen in de IT?
14. Kunt u de vier categorieën van druk/mogelijkheden (of de afwezigheid hiervan) economisch gewin, wetgeving/beleid, sociale/culturele druk en technologische kennis (hoe groene IT uit te voeren en wat de winsten zijn) ranken op basis van meest motiverend naar minst motiverend voor bedrijven die IT gebruiken?

15. Zou u deze zelfde categorieën (evt herhalen) ook kunnen ranken op basis van meest naar minst belemmerend voor bedrijven die IT gebruiken?

Per categorie (13 min, 4x3 + 1)

16. Wat zijn binnen economische factoren de grootste drijfveren en barrieres om IT te verduurzamen, en waarom?
17. Wat zou er volgens u moeten gebeuren om voor meer economische motivatie te zorgen en om barrieres te verhelpen?
18. Wat zijn op het gebied van wetgeving de grootste drijfveren en barrieres om IT te verduurzamen, en waarom?
19. Wat zou er op het gebied van wetgeving gebeuren om voor meer motivatie te zorgen en om barrieres te verhelpen?
20. Wat zijn op sociaal-maatschappelijk gebied de grootste drijfveren en barrieres om IT te verduurzamen, en waarom?
21. Wat zou er sociaal-maatschappelijk gezien moeten gebeuren om voor meer motivatie te zorgen en om barrieres te verhelpen?
22. Wat zijn technologisch gezien de grootste drijfveren en barrieres om IT te verduurzamen, en waarom?
23. Wat zou er technologisch gezien moeten gebeuren om voor meer motivatie te zorgen en om barrieres te verhelpen?

Slot (6 min)

24. Wat is volgens u de verantwoordelijkheid van de bedrijven in de markt in het verduurzamen van de IT?
25. Voorziet u dat de markt voor 2030 een transitie kunnen doormaken tot een systeem waarin groene IT de norm is? (evt doorvragen wanneer reeel zou zijn)
26. Zijn er nog andere belangrijke inzichten die u zou willen delen?

Bedanken voor het interview, bespreken het vervolg en het delen van de thesis.

Appendix B: Interviewee information statement

U wordt uitgenodigd om deel te nemen aan een onderzoek genaamd accelerating the transition towards Green IT in the Netherlands. Dit onderzoek wordt uitgevoerd door Floris Kreuger van de TU Delft tijdens een stage bij Deloitte. Het betreft een master thesis.

Het doel van dit onderzoek is het in kaart brengen van de status van Green IT in Nederland. Door middel van desk research en interviews zal de transitiefase van Green IT worden geïdentificeerd en zullen de motivaties en barrieres in kaart worden gebracht. Het interview zal ongeveer 45 minuten in beslag nemen.

U wordt gevraagd om uw visie te delen over groene IT vanuit uw perspectief door middel van het beantwoorden van mijn vragen. De data zal geanonimiseerd worden en gebruikt worden voor het eindproduct mijn master thesis. Het eindproduct van de thesis wordt gepubliceerd in het repisotory van de TU Delft, het onderzoek is hier publiekelijk verkrijgbaar.

Zoals bij elke onlineactiviteit is het risico van een databreuk aanwezig. Wij doen ons best om uw antwoorden vertrouwelijk te houden. We minimaliseren de risico's door de opnames op te slaan in mijn persoonlijke OneDrive in de TU Delft omgeving. De enigen die toegang hebben tot de data zijn mijn scriptiebegeleider van de TU Delft en ik. Deloitte heeft geen toegang tot het interview en het transcript. Wanneer de opnamen uitgeschreven zijn zullen deze worden verwijderd. Wanneer het onderzoek voorbij is, eind augustus, zullen ook de transcripten worden verwijderd. De opnames en het transcript zal dus niet publiek gemaakt worden.

Uw deelname aan dit onderzoek is volledig vrijwillig, en u kunt zich elk moment terugtrekken zonder reden op te geven. U bent vrij om vragen niet te beantwoorden.

Voor vragen voor of na het onderzoek kunt u mij bereiken via f.h.a.kreuger@student.tudelft.nl

Indien akkoord met bovenstaande informatie ontvang ik graag via email een schriftelijke toestemming