Article

Green ICT Adoption Using a Maturity Model

Albert Hankel [1,*], Gaston Heimeriks [2] and Patricia Lago [1]

[1] Department of Computer Science, Vrije Universiteit Amsterdam, De Boelelaan 1111, 1081 HV Amsterdam, The Netherlands; p.lago@vu.nl

[2] Department of Innovation Studies, Utrecht University, Heidelberglaan 2, 3584 CS Utrecht, The Netherlands; g.j.heimeriks@uu.nl

* Correspondence: a.c.hankel@vu.nl

Abstract: The field green ICT focuses on the greening of ICT and using ICT to optimise the energy footprint of the ICT-supported processes. For organisations, applying green ICT in the broadest sense presents them with challenges. In this paper we explore what factors are influencing the adoption of green ICT. We follow three organisations that used a green ICT tool, the SURF Green ICT Maturity Model, to identify such factors. Tools like the maturity model help organisations identify the what and how. We found other factors, such as strategic alignment, culture and leadership, determine the why. As ICT is a general purpose technology, it potentially affects all processes in an organisation. To have a greening impact, the main challenge for green ICT is to take a systemic approach and involve all (relevant) parties. ICT departments often position themselves as support (followers, not leaders); this proves to be a big hurdle in the adoption of green ICT.

1. Introduction

Information and communication technologies are a growing part of the global footprint on the environment. ICT can also be used as part of solutions to reduce the environmental footprint of other activities. Activities that reduce the footprint of ICT or use ICT to reduce the footprint of other processes, are part of the field green ICT. There are many publications that describe the potential of using ICT as part of the solution to reduce our environmental footprint. For example, organisations such as the World Wildlife Fund call for a shift of focus "from Green IT to Greening with IT" [1], and the reports by the Global e-Sustainability Initiative [2] claim that the potential of greening with ICT (possible global CO_2-reduction of 16%) far outweighs the footprint of ICT itself (2%).

How can we, as a society, cash in on this potential? This potential is rooted in the fact that ICT is a general purpose technology, something that can affect everything, every action we take. So how can we get green ICT to affect everything? How does this translate to the practical reality? In our work an organisation (any organisation) represents these challenges green ICT has.

In [3], Molla differentiates between the *intention* to adopt green ICT and the actual adoption. The first steps in an organisation are usually taken by a few individuals that are motivated to do so and have enough power to initiate such a change. Even if successful, they often find it difficult to scale up their activities. Molla [3] identified three types of drivers for green ICT: economic, regulatory and ethical drivers. Cost reductions are an example of economic drivers. As ICT is consuming large amounts of energy, energy efficiency can lead to significant cost reductions in operating ICT. Governments can require ICT departments within organisations to become compliant with environmental standards, which are regulatory drivers. For example, directive 2012/19/EU of the European Parliament and the European Council on waste electrical and electronic equipment (WEEE) [4] set recycling targets for all

types of electrical goods. The agreements that the government of the Netherlands has signed agree to, with many sectors (among which is the higher education sector [5]), increase energy efficiency every year by 2%. Finally, ethical drivers refer to the pursuit of socially responsible business practices and good corporate citizenship.

Even if an organisation has the intention to adopt green ICT, this does not necessarily mean that it has the capability to do so. Molla and Cooper [6] argue that there are at least five important properties that they together call the critical capability "G-readiness". These five properties are: attitude, policy, practice, technology and governance. Attitude refers to the extent to which leaders and professionals are aware of and interested in environmental concerns; policy refers to whether there are top-down strategies or other policy documents that push people in the right direction; practice refers to whether the knowledge and skills are present to carry out green ICT actions; technology refers to the presence of a technological infrastructure that allows for environmental friendly actions; and governance refers to the presence of a proper management infrastructure detailing clear roles, responsibilities and relationships [6].

The G-readiness focuses on the ability of an organisation to apply green ICT solutions and wants to do so (the "why"); other tools go more into green ICT solutions themselves and focus on the "what" and "how" of green ICT. The SURF Green ICT Maturity Model is one of such tools.

SURF, the Dutch higher education and research partnership for ICT, developed a maturity model on green ICT in collaboration with the Vrije Universiteit Amsterdam and a number of green ICT experts, the SURF Green ICT Maturity Model (SGIMM) [7]. The model was designed to help organisations assess where they stand and provide inspiration for improvement. The SGIMM conceptually consists of four domains covering negative and positive impacts and aspects of ICT. Three domains and attributes are generally applicable to any organisation, those being: "green ICT in the Organisation", "greening of ICT" and "greening of operations with ICT". The fourth domain is sector-specific and covers "greening of primary processes with ICT". For instance, in the higher education sector, the primary processes would relate to education and research. In previous work [8] we followed four organisations from the Dutch higher education sector that used the SGIMM to see what the effect of the maturity model was when it was used in practice. Both individual participants and organisations as a whole were positive on its use: the SGIMM increased awareness, inspired action and was insightful.

We left the participating organisations from our previous work at the end of the maturity scan, at the point where they knew how to cash in on the enabling potential of green ICT in their own context. But did they actually do so? This is what we wanted to know when we started this follow-up study. Given that green ICT potentially affects everything, we suspect that it would not be trivial for organisations to carry out the suggestions for green ICT actions that followed from the maturity scan. In other words: what do organisations need to adopt as green ICT?

In this study we examined this question by returning to these four organisations after a year to see what happened and whether they were able to carry out green ICT activities. We lost contact with one of the organisations because our participant left the organisation and had no replacement, so we decided to leave them out of this study. We took interviews at the remaining three organisations and we also wanted to do a second maturity scan to measure their progress on green ICT. Our research questions were:

1. What factors of influence affect the adoption of green ICT practices?
2. What role does a tool like SGIMM have in the adoption of green ICT?

2. Method

To answer our research questions, we describe what happened at each of the three participating organisations in a qualitative manner. After a year we returned to each of these organisations and asked whether they would be willing to do another maturity scan. We also wanted to do interviews with our contacts, the project leads, and others involved if possible. After describing each case, we

discussed the observations made and explored the patterns that emerged. We expected to see factors of influence that affected the success of the process of applying green ICT in the organisation.

For the maturity scans, the approach was based on guidelines for a self-scan that are provided in the instructions that come with the maturity model. The following steps were taken (see also Figure 1):

1. The primary contact at the participating organisation was the assessment manager (AM); for example, the CIO or an ICT manager with sustainability in his or her portfolio. It was important that the AM had the influence and the ability to make sure that the maturity scan was properly done and that follow-up actions were implemented.
2. The AM composed an assessment team. This was a group of people that represented the organisation and were tasked to fill out the maturity model. Their scores were used to get an average maturity score for each attribute. After obtaining the averages, they were discussed during an evaluation session at which also a number of possible actions for improvement were defined. To obtain good results, the right combination of team members is crucial.
3. The AM explained the purpose of the model and the assessment process to the team (with or without our presence) and sent the SGIMM spreadsheet to all the participants afterwards.
4. All participants individually filled out the spreadsheet and scored all the attributes. When everyone has sent their scores back to the AM, we facilitated the AM by analysing the results and creating a summary.
5. The summary of maturity scores and how they relate to the individual scores were discussed in an evaluation session with the assessment team. We facilitated this by presenting the results and asking questions to promote discussion amongst the team members. Based on this discussion, actions for improvement were defined. We created a report on the results of this evaluation session and shared it with the AM.
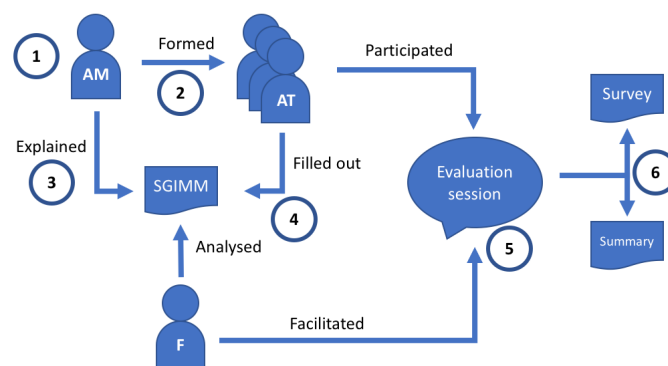

Figure 1. The assessment process in a flow diagram. AM = assessment manager; AT = assessment team; F = facilitator.

With a second maturity scan, we can see whether scores are different from the first scan, and if so, whether that can be attributed to green ICT actions taken. This is an indication on whether the maturity model is effective and correct.

The interviews were semi-structured and addressed the following topics:

- Attitude towards sustainability and the role of ICT in greening the organisation.
- How sustainability and green ICT is organised (responsibilities).
- Opinion and attitude regarding the first scan and its results.
- What happened after the first scan and why?
- What should have happened and why did it not happen?

In order to assess what affects the adoption of green ICT, we used the properties of the G-readiness model—attitude, policy, practice, technology, and governance [6]:

- Attitude—leaders and professionals, both in ICT and in business, are aware of and interested in the role of ICT in resolving environmental problems.
- Policy—green ICT and sustainability policies are developed throughout the organisation and permeate the value chain.
- Practice—the organisation has implemented the policies and takes actions to reduce their carbon footprint through the use of ICT.
- Technology—a green (business) infrastructure is present and updated according to the latest green (ICT) standards.
- Governance—an organisation has clearly defined roles and responsibilities for green ICT activities, administrates them properly, measures their impacts, and has allocated resources for them.

We scanned the results from the maturity scans and the interviews for aspects that affect these five properties. We then framed these aspects in terms of factors of influence (see [9]) that were present and influenced the success of the (adoption of) green ICT. We did so for each organisation and we reviewed the combined results for patterns that might emerge that relate to our research questions. Differences and similarities between organisations were extracted through differences in factors of influence and the drivers behind them or multiple occurrences of the same factor of influence.

3. Field Study

In this section we describe each of the three organisations participating in our study. We start with the results of the first maturity scan and then a summary of the interviews done one year later. If present, we compare the two maturity scans and see whether changes in scores can be attributed to actions taken or not. Finally, we give an analysis of the readiness to adopt green ICT.

3.1. Organisation A

Organisation A is a university of applied sciences in the Netherlands. They are one of the largest universities of their kind, with roughly 30,000 students and 3000 staff. In terms of sustainability, they state that they are one of the front runners in greening their business operations and integrating sustainability in curricula. They also run a centre of expertise dedicated to renewable electrical energy. In addition, they take part in a sector agreement with the government to improve their energy efficiency, which is mainly focused on optimising the energy consumption of their buildings and procuring and generating renewable energy.

3.1.1. First Maturity Scan

At the time of the first maturity scan, Organisation A had a special programme to develop and support sustainability. Budget was made available throughout the organisation to stimulate ideas and projects, from renovating buildings to improving daily issues such as separating waste. Within the ICT department some steps were taken as well. One person, the project lead (PL), was designated to champion the topic and push for change through setting up projects and stimulating others to participate. One of the activities was carrying out a maturity scan to learn where they stand and to get inspiration for improvement actions.

Together with the PL we organised the maturity scan at Organisation A. Ten participants filled out the maturity model which resulted in the scores in Table 1.

We discussed the scores with the participants in an evaluation session. In general they agreed that the organisation of the ICT department was becoming more sustainable but that this was mostly driven by cost efficiency rather than green motives. They had already drafted a green ICT strategy document, but it was not being used in practice. For procurement and e-waste there were good practices but nothing mandatory, so the application of such practices depended on individuals. And by extension, this applied to supply chain management as well. The takeaways from these topics were that the ICT department could document practices better and improve communication on green ICT options so that people are aware of the choices they can make.

Table 1. Overview of average scores of the scans at university A. Minimum score was 1; the maximum was 5. Scores were computed by taking the average of the maturity levels that individual participants scored on each attribute.

	1st	2nd		1st	2nd
Green ICT in the organisation			**Greening of Operations with ICT**		
Green ICT Strategy	1.8		Travel reductions with ICT	3.0	
Governance of ICT services	2.6		Area reductions with ICT	2.7	
Green ICT Procurement	2.1		Energy reductions with ICT	1.8	
E-waste Policy	2.2		Paper reductions with ICT	2.9	
Green ICT in Information Management and Architecture	1.7		Feedback and decision support	1.4	
Community collaboration	2.3				
Green ICT Supply Chain Management	2.0				
Greening of ICT			**Greening of Primary Processes with ICT**		
Housing	2.0		Education	1.5	
Computing infrastructure	1.9		Education support	1.6	
Network infrastructure	1.6		Research	1.7	
Storage infrastructure	2.0		Research support	1.7	
End user ICT equipment	2.4		Valorisation	1.6	
Software and ICT services	1.6		Information access	1.6	

For the ICT infrastructure, continuity and reliability was priority number one. Energy efficiency was not of the highest importance unless it would clearly affect the business in terms of cost reductions. They did take energy saving measures in their data centres and for the end user equipment. Some monitoring was in place, which could be used for sustainability KPIs, for example to calculate server load over energy consumption to estimate energy efficiency. In addition, the participants saw possibilities to improve, especially in making consumption more visible for the business (i.e., education and research). When the impact of primary processes would be more visible, a shift of priorities might become possible (away from too high reliability demands for example).

As for using ICT to green other processes, the ICT department could be more involved, either in the decision making process so that they could offer green ICT solutions or in communication between needs and options already in place. For example, there was an option of high quality videoconferencing between two main locations of the organisation, yet many people still travelled for a meeting because they did not know of this option. Collaboration with the facilities department was not happening very often while there were plenty of opportunities. Similarly, knowledge, manpower, and willpower in education and research (think of specialised scholars, student projects, et cetera) could be used for joint projects and visibility of green ICT.

While discussing the results of the maturity scan, it was clear that the ICT department felt a real tension between what (they thought) the business demands were and their role in the organisation, on the one hand, and trying to be sustainable on the other. Even though the organisation was favourable towards sustainable action, the role of ICT in becoming more sustainable was unknown. "Green ICT" actions were focused on mostly reducing the energy consumption of ICT itself to reduce costs. The effect of this was that the general attitude towards sustainability amongst ICT managers and professionals was positive, but that it did not have priority. Additionally, some of the ICT professionals feared that sustainability actions would affect their principle priorities such as the reliability of ICT. In the end, becoming more green was often a side-effect of normal business practices rather than a conscious choice.

After discussing the results of the maturity scan, we shared all suggestions for improvement that followed from the scan with the PL. He intended to ask the management of the ICT department to prioritise the potential actions so that he could take these projects on.

3.1.2. One Year Later

A year later we returned to the PL to repeat the maturity scan and see if there was any improvement and whether that could be attributed to the actions they had taken. Unfortunately, the PL did not think repeating the scan would be useful. After he shared the results with his management, there was no response on how to proceed. He reminded them a couple of times, but nothing happened. So he was disappointed with the lack of progress over that year. Instead of repeating the scan, we then proceeded with interviewing him and two colleagues that also participated in the first maturity scan: the ICT head manager (ICTM) and the services team lead (TL). We chose these three because we wanted to gather information from different management layers in the ICT department. We used the information from the interviews to derive which factors influenced the decision making and why there was no follow-up from the maturity scan.

The attitude of the PL towards sustainability was very positive. He thought it was important to reduce the human environmental footprint so that we preserve what we have for future generations, took actions at home, and was happy to be able to contribute through his work as well. He was designated by the ICTM to take the lead on sustainability projects for the ICT department. No one else in the ICT department had (or was given) time to work on such projects and his colleagues showed little interest in his activities. When he started working on green ICT, the entire organisation was strategically pushing sustainability so it was relatively easy for him to get things done. In that year, sustainability was deemed by the board to be part of the daily responsibilities of the staff and lost its special status. Together with pressure to cut budgets, he saw this as the cause for the low priority of green ICT in the ICT department and this affected his motivation as well. The PL saw the maturity scan as an opportunity to promote green ICT in the ICT department and to make it a shared responsibility instead of something only he worked on. He also wanted to push management to take the lead. This did not happen and that left the PL frustrated. He had come to the realisation that something else was needed, such as pressure from outside (e.g., governmental policies).

The ICTM described a similar turn of events after the maturity scan. He acknowledged that he still had to respond to the request of the PL and felt guilty about the lack of response. He was happy with how sustainability was organised at the ICT department and how the PL carried out his work, but he also saw the PL struggling. He wanted to support but did not take action. The main reason for this was that he had priorities elsewhere. The business demanded more efficiency; there were structural changes in the ICT organisation, daily issues, et cetera. While he considered sustainability important, he was not able to apply this in his daily work. He acknowledged there were opportunities to do so, incorporating green ICT principles in road maps for example, but did not act upon it. The ICTM also mentioned other reasons for not doing so: he missed a top-down strategy on sustainability; he could use examples from other organisations; ICT people are focused on technology and not on sustainability which makes them difficult to move; there was no money for green ICT projects. All in all, the ICTM still wanted to do something with the results of the maturity scan, but at the same time had little confidence he would do so due to the reasons mentioned above.

Finally the TL stated that he did not know how to contribute towards sustainability in his specific area. He thought others could have a larger contribution than the marginal gains he could make. At home he considered himself quite sustainability-minded and transferred such views to his work environment by thinking the buildings could be equipped with light sensors, replacing paper cups with mugs, et cetera. He did not really have knowledge of green ICT, and therefore, needed good examples from others. In addition he felt the pressure of daily issues and needed to hear from head management that this had priority, including having targets.

3.1.3. Analysis of Actions and Scan Results

Since there was no second scan, we could not make a comparison and see if changes in scores relate to what happened in the past year.

3.1.4. Analysis of Adoption of Green ICT

Up until the time of the first scan, sustainability was being stimulated by the board at Organisation A. While the ICT department was not a big part of the sustainability programme, the general attitude of the maturity scan participants towards green ICT was positive during the discussion and the evaluation of the scan. In terms of policy, a general green ICT strategy was present but not being used, and there were little to no policy guidelines on topics such as procurement or e-waste. Because of this all, whether green ICT actions were taken was strongly dependent on motivated individuals. In addition, participants of the maturity scan showed surprise when green ICT solutions were shared in the group and argued for more communication between these expert individuals and the rest of the ICT department on this topic. A similar comment was given on communication of the (green) services the ICT department had to offer to the rest of the organisation. The way green ICT was governed reflected this, because green ICT responsibilities were delegated to a few individuals motivated and interested in green ICT instead of making it a shared responsibility of the entire department. Finally, the technical infrastructure could become a bottleneck in the future if steps were to be taken to let energy consumption match the demand on the infrastructure. At this point the infrastructure was designed according to "always on" principles because continuity and reliability are the highest priorities. These aspects of the readiness to adopt green ICT at Organisation A at the time of the first scan are listed in Table 2.

From the interviews after a year we can derive a number of factors of influence that can explain the lack of progress when applying green ICT in Organisation A.

First, it seems that several things were happening in the area of attitude. On a personal level, the interviewees all responded positive towards sustainability. However, in their work green ICT clearly had low priority (PL, ICTM, and TL). Both the PL and TL were missing leadership from the ICT management which they could demonstrate by saying it was important, allocating funds, and setting targets. The ICTM found it difficult to act for several reasons. One was that he believed the ICT culture did not match very well with sustainability aspects. It seemed that sustainability was accepted and important where it affected their work environment (more efficient buildings, use of cups versus mugs, et cetera) but people responded in a rather lacklustre way when it affected the work itself (i.e., green ICT). In addition, the PL and the ICTM mentioned the organisation changed its strategy on sustainability and emphasised cost effectiveness and other priorities over sustainability (and green ICT).

The area of policies already scored weakly during the first scan, and no changes were mentioned during the interviews. In the area of practice, the observation that green ICT actions were dependent on motivated individuals was confirmed in the interviews where the PL said things only got done when he was pushing it and the ICTM and the TL delegated everything on green ICT to the PL. In addition, the TL mentioned a lack of knowledge of how to apply green ICT in daily practices. As there was no follow-up on the maturity scan, very little action was taken since. The PL, therefore, saw the governance of green ICT as a real problem: there was no shared ownership in the ICT department. Furthermore, there was a lack of funding to run green ICT projects (PL and ICTM).

The ICTM, who had the power to change some of these blocking issues, realised this on the one hand, but also admitted he probably would not do anything about it (even though he said he wants to). In addition to the reasons mentioned above (organisational strategy, ICT culture) he thought examples from other organisations would help as well (sector standards). Similarly, the PL thought that external pressure from the student population (market forces) or the government (compliance) would push the organisation to give sustainability and green ICT a higher priority.

In Table 2 we listed the factors of influence we derived from the interviews and the maturity scan. As can be seen, there are factors that have a negative influence on the adoption of green ICT in all areas of readiness.

Table 2. Readiness to adopt green ICT at Organisation A.

	State of Readiness at First Scan	Factors of Influence
Attitude	positive attitude but not high priority in ICT department	*Strategy/alignment with business*: Organisation changed strategy on sustainability, causing a low(er) priority at the ICT department (PL, ICTM)
		Culture/leadership: there is a lack of leadership from the ICT management regarding Green ICT (PL, TL)
		Culture/internal motivation: the ICT culture is more focused on technology rather than topics as sustainability (ICTM)
		Culture/internal motivation: all interviewees personally respond positive towards sustainability in general, but act differently in work practice (PL, ICTM, TL)
Policy	general strategy present but no concrete guidelines	*Corporate policies*: there are no policies (e.g., procurement or e-waste) documented that help stimulate Green ICT actions
Practice	actions have been taken but highly dependent on motivated individuals	*Governance/roles and evaluation*: there are no targets for green ICT so no incentive to act (TL)
		Current state/knowledge & skills: there is a lack of knowledge and skills on Green ICT (TL)
Technology	designed for energy efficient "always on"; other priorities may prevent further steps	*Current state/technical infrastructure*: the current infrastructure might become a bottleneck when more advanced green ICT actions are required
Governance	delegated to individuals; not seen as a shared responsibility	*Governance/ownership*: ownership of green ICT is delegated to a few individuals rather than a shared responsibility (PL, ICTM)
		green ICT business case: there is no budget for green ICT projects (PL, ICTM)

3.2. Organisation B

Organisation B is a university of applied sciences in the Netherlands. They provide education to roughly 35,000 students and employ nearly 3000 people. Sustainability is a key strategic area for Organisation B. They see being sustainable as a duty to society and as a requirement for the future. Sustainability is stimulated throughout the organisation in education, research, and operations. In operations the main focus lies on efficient buildings, efficient use of space, and mobility. Green ICT is not specifically mentioned but there is always room for good ideas that contribute towards the sustainability goals of Organisation B.

3.2.1. First Maturity Scan

The maturity scan was presented at Organisation B as a source of inspiration to become more sustainable. As such, it was not difficult for the project leader (PL) to get people involved to participate in the scan, including those from outside the ICT department. Another reason was to make both

the environmental impact and the potential for other green processes more visible to the rest of the organisation. Five participants filled out the maturity model and the results are presented in Table 3.

Table 3. Overview of average scores of the scans at university B. Minimum score was 1; the maximum was 5. Scores were computed by taking the average of the maturity levels that individual participants scored on each attribute.

	1st	2nd		1st	2nd
Green ICT in the organisation			**Greening of Operations with ICT**		
Green ICT Strategy	1.8	2.2	Travel reductions with ICT	3.0	3.0
Governance of ICT services	3.8	3.0	Area reductions with ICT	2.6	2.6
Green ICT Procurement	2.6	3.0	Energy reductions with ICT	2.0	2.4
E-waste Policy	3.2	3.6	Paper reductions with ICT	2.8	3.0
Green ICT in Information Management and Architecture	2.0	2.2	Feedback and decision support	2.0	2.2
Community collaboration	3.0	4.2			
Green ICT Supply Chain Management	2.6	3.0			
Greening of ICT			**Greening of Primary Processes with ICT**		
Housing	2.2	2.4	Education	2.0	2.4
Computing infrastructure	2.2	2.4	Education support	2.0	2.6
Network infrastructure	2.2	2.0	Research	1.8	2.4
Storage infrastructure	2.0	2.0	Research support	1.8	2.6
End user ICT equipment	2.6	2.2	Valorisation	1.6	1.8
Software and ICT services	1.6	1.4	Information access	2.0	2.8

While there were many green ICT activities at Organisation B, there was no specific green ICT strategy. The strong push for sustainability from the board was enough to stimulate motivated individuals to take up such activities. However, to achieve higher ambitions, the participants felt a need to develop a green ICT strategy to make the activities more coherent and in connection with other strategic sustainability activities, such as the reduction of the footprint of mobility. Similarly, there were general procurement guidelines that pushed sustainability, which also had an effect on choices the ICT department had to make, but there were no specific green ICT procurement policies. E-waste was properly disposed of, but this was not well known outside the ICT department, which led to the situation of some people not properly disposing of their ICT equipment. As for community collaboration, Organisation B was partnering with other schools and universities regionally as well as nationally to share knowledge and resources on ICT (and by extension on green ICT). In the supply chain, the participants saw room for improvement by getting the vendors more involved in sustainability and tracking their scores on responses to tenders.

The participants felt that the ICT department had done what it could to make the ICT infrastructure more energy efficient. They explained their "lower" scores by saying that they should keep track of a number of metrics to have KPIs and insight in the true performance of the ICT infrastructure. The same went for end user equipment, where the population of workstations and printers had been significantly trimmed down, but the ICT department could not really make it visible to the rest of the organisation because they did not keep track of KPIs. The participants thought the way ICT was organised was something to be proud of, so they recommended making use of KPIs throughout the infrastructure. Finally, sustainability in software and services had not really been touched upon.

As for the role of ICT in greening other processes, the participants were mildly positive in the actions that had been taken up until then. They saw the potential ICT could have, especially in contributing towards reduction of the footprint of mobility and buildings and the use of space, both of

strategic importance to the board. They felt that the ICT department should take a more prominent role, should positively demand a seat at the table so to speak, and communicate about the potential of green ICT solutions. Similarly, the collaboration with the primary processes education and research could be improved and is something that could be mutually beneficial: ICT offers many solutions to help green education and research; and education and research could help the ICT department take next steps and be more innovative through joint projects.

The results of the maturity scan were presented to the PL, together with a number of suggestions for improvement with which he could get to work. A year later we returned to Organisation B to see what had happened.

3.2.2. One Year Later

After a year we invited the PL to repeat the maturity scan and the same participants filled out the scores. The second scores can also be found in Table 3. In addition, we interviewed the PL to get some more insight into what happened during that year.

The PL was very passionate about sustainability. It was important for him to do what he could, as he worried about the state of the world and the direction it was going. In his daily work, he approached this in a pragmatic way, doing what he could; the organisation gave him the freedom to do so.

The PL was happy with the results of the first maturity scan as it provided a good reflection on the current state and a means to talk about the potential of green ICT outside the ICT department. Unfortunately, he was not able to take up many of the suggestions that followed from the scan, as the the ICT department had a number of other priorities, among which were changes in the organisation of ICT and changes in the technical infrastructure (moving some of the on-premise services to the cloud). So there was little room to move on hard actions; yet on the other hand, some things did change on the softer side: the potential of green ICT became better known as ICT was more involved with projects of other departments. They also grew the number of student projects that studied or piloted potential green ICT solutions. And by extension, suppliers were interested in joining such student projects, increasing the scope to beyond the own organisation. Even in non-green ICT projects, sustainability was always part of project plans through a mandatory chapter.

Reflecting on that year and how sustainability at Organisation B was organised, the PL found that the clear message from the board that sustainability was important helped him in his (side) projects. There was always room for good ideas and he felt he had the freedom to act (and to fail). The PL would like to see the culture change at Organisation B go faster, suggesting sustainability should be "by design" (which in terms of maturity is quite a high ambition). The pace differed between organisational units, and in this case, the ICT department was more a follower than a leader. The department did not have its own green ICT strategy and the managers did not champion it. They also did not block it, but their priorities were elsewhere. The effect of this was that success depended on motivated individuals and that collaborations with other units (i.e., outside ICT) more focused on sustainability had a higher chance of success.

3.2.3. Analysis of Actions and Scan Results

Organisation B carried out a second maturity scan after a year (see Table 3) so we could compare scores and see whether changes in the scores reflected actions taken.

In the first domain of green ICT in the organisation, most attributes scored better than the previous year, but one attribute (governance of ICT) dropped significantly. The reason for this was that part of the technical infrastructure moved to the cloud, which participants viewed as a loss of control (temporarily probably, because they needed to learn of other ways to improve control). Attributes that were related to policies (strategy, procurement, e-waste, architecture) all scored higher because there was more communication on and knowledge about sustainability in ICT. The increase in community collaboration can be explained with the participation of the organisation in national projects to develop joint infrastructure which promised to significantly reduce the footprint of the ICT department. Finally,

the supply chain management scored higher because of improved communication and joint projects with suppliers on sustainability.

In the domain greening of ICT, not much changed. Most scored roughly the same (i.e., minimal change of <= 0.2). The lack of change lay in the fact that the ICT department was working on large infrastructural projects (with the potential to improve scores), but they had not been implemented yet. The focus on such projects left little time and incentive to improve the existing infrastructure.

The final two domains of greening operations and primary processes with ICT all showed (marginal) improvements. This was clearly attributed to the improvement in communication about the potential of green ICT and ICT participating in multidisciplinary teams. In addition, the ICT department providing research questions for student projects had a positive impact as well.

3.2.4. Analysis of Adoption of Green ICT

At the time of the first scan, sustainability was an important topic in the general strategy of Organisation B. This was felt throughout the organisation and at the ICT department. There were no specific green ICT policies, however. Guiding principles on sustainability usually followed from general policies, for procurement, for example. There was a wish to develop such policies though. At Organisation B many green ICT activities were being put to practice, but they struggled with promoting new possibilities to users throughout the organisation. green ICT successes were not visible outside the ICT department. Even though the policies side was lacking, in practice, sustainability was almost always considered in projects and activities, because of the top-down push from the board. In terms of governance, roles and responsibilities were defined and resources were available. The links with other departments outside of ICT could be stronger, but there were connections with facilities and the general sustainability staff. The technical infrastructure was efficient and potentially adaptable to demand. In general, in both technical aspects and user adoption the possibilities to grow and use green ICT to become more sustainable were there, but the next steps have not been taken yet.

From the two maturity scans and the interview with the PL, we found a number of interesting factors that influenced the adoption of green ICT (see also Table 4).

First, the positive attitude and leadership of the board towards sustainability was a strong driver for success at Organisation B. Motivated individuals like the PL felt enough support to act on their ideas. Similarly, the PL really felt that sustainability was part of a long-lasting culture change, and even though he thought the change could go faster, it was not difficult for him to promote and push ideas on sustainability and green ICT. The PL did notice that the ICT management showed different leadership opposed to the board of the organisation. In this respect, ICT was more a follower than a leader and this had an effect on priorities.

For policy, there was not much in place at Organisation B regarding green ICT. However, the strong general policies on sustainability did have an impact on the decision making in ICT. During the year, best practices on procurement and e-waste became better known, although they were not fully documented in specific policies.

In practice, there were no specific sustainability targets for ICT. As an effect, sustainability was not highly prioritised throughout the ICT department. Organisational policies and mandatory paragraphs on sustainability when drafting a project or a tender did have their effect though.

As for the technological infrastructure, Organisation B was performing well in terms of architecture, technical solutions, and how they approached balancing supply and demand through cloud solutions. The use of the infrastructure was not fully optimised because there was no measurement of sustainability indicators.

Finally the governance of green ICT was limited. A few enthusiastic individuals had some leeway to act on good ideas but there were no other roles defined in the ICT department or targets that the organisation held them accountable for. The difference in attitude between the board and ICT management could be a blocking factor to further advancements.

Table 4. Readiness to adopt green ICT at Organisation B.

	State of Readiness at First Scan	Factors of Influence
Attitude	positive attitude, both from general management as in ICT department	*Strategy/alignment with business*: the board strongly pushes for sustainability, stimulating the necessary culture change *Culture/leadership*: there is little management leadership in the ICT department (i.e., followers not champions)
Policy	none in place	*Corporate policies*: there are no specific green ICT policies (e.g., procurement or e-waste) documented that help stimulate green ICT actions. There are strong general sustainability policies though that have an effect on ICT.
Practice	many actions have been taken; struggle to get users to take advantage	*Governance/roles and evaluation*: there are no targets for green ICT, but every project does need to consider sustainability in a dedicated chapter
Technology	potential present but not fully taken advantage of	*Current state/technical infrastructure*: as the infrastructure is adding components from the cloud, it gains the potential to be flexible and provide just enough to meet demand
Governance	roles and responsibilities defined; resources available	*Governance/ownership*: ownership of Green ICT is delegated to a few individuals *Green ICT business case*: the organisation is willing to consider solid Green ICT business cases, but the ICT management is somewhat reluctant

3.3. Organisation C

Organisation C is one of the biggest universities in the Netherlands, with over 30,000 students and 5000 staff. Sustainability is an important topic for Organisation C and they have set themselves targets on reduction of CO_2-emissions, energy efficiency, and reducing waste. Especially in reducing waste, they see a prominent role for ICT, as digitisation leads to less use of materials (e.g., paper). Other than that, their sustainability strategy focuses mainly on procuring renewable energy, producing renewable energy themselves, and increasing the energy efficiency of buildings.

3.3.1. First Maturity Scan

At the time of the first maturity scan, the ICT department of Organisation C just finished a reorganisation. They thought this was a good moment to measure the current state of sustainability in ICT and to make a start with green ICT in the new organisation. The project leader invited nine colleagues to participate. The scores of the first maturity scan are shown in Table 5.

In the domain green ICT in the organisation, strategy did not score high, because the ICT department did not have a specific green ICT strategy. The organisation did have a general strategy, the effects of which were visible, and there were plenty of activities that related to sustainability. Participants did recommend translating the general strategy to a green ICT strategy and incorporating current activities. This would also provide a means to communicate more about green ICT activities, as

they were not well known, even inside the ICT department. The governance for ICT services was at an acceptable level, but some employees would still buy their own ICT equipment rather then turning to the ICT department for support. There were some procurement guidelines but they were not heavily enforced. In addition, there was an e-waste policy but this was not well known. Participants were not entirely sure everyone followed the policy and recommended communicating more about it.

Table 5. Overview of average scores of the scans at university C. Minimum score was; the maximum was 5. Scores were computed by taking the average of the maturity levels that individual participants scored on each attribute.

	1st	2nd		1st	2nd
Green ICT in the organisation			**Greening of Operations with ICT**		
Green ICT Strategy	1.6	1.1	Travel reductions with ICT	2.3	2.1
Governance of ICT services	2.6	2.6	Area reductions with ICT	2.3	2.1
Green ICT Procurement	2.1	2.2	Energy reductions with ICT	2.0	1.5
E-waste Policy	2.3	2.7	Paper reductions with ICT	2.4	2.2
Green ICT in Information Management and Architecture	1.4	2.1	Feedback and decision support	1.7	1.4
Community collaboration	1.8	1.7			
Green ICT Supply Chain Management	1.8	2.1			
Greening of ICT			**Greening of Primary Processes with ICT**		
Housing	1.8	1.7	Education	1.9	1.8
Computing infrastructure	1.8	2.0	Education support	1.7	1.8
Network infrastructure	1.6	1.5	Research	1.4	1.5
Storage infrastructure	1.6	1.6	Research support	1.8	1.6
End user ICT equipment	1.8	1.9	Valorisation	1.2	1.4
Software and ICT services	1.4	1.1	Information access	2.2	1.4

As for greening of ICT, a large infrastructural project impacted the scores in this domain. Many changes had been implemented that should have a positive influence on future scores. Changes such as virtualisation, use of cloud services, and potential use of sleep mode in unused devices. The score of the attribute end user ICT equipment could be explained through the many desktops still present at the campus. There were plans to shift towards a bring-your-own-device approach.

In the domain greening of operations with ICT, the ICT department offered services to work from home and had a number of projects to reduce the use of paper. However, such services were not always well-known or stimulated in the organisation. Similarly, the ICT department saw potential to help reduce the use of energy and buildings but was not responsible for these areas and there was little communication between them and the facilities department. In terms of feedback and decision support, there was plenty of information stored through monitoring and logging, but there was no reporting on green ICT performance indicators.

Finally, the participants responded to the scores of greening of primary processes with ICT with that this was basically new territory. Again, there were enough opportunities for the ICT department to provide services that could help green primary processes, but this was not happening because of a lack of communication between ICT and primary processes. Furthermore, the participants thought they could show more initiative to bring these services to the customers rather than responding to requests alone.

3.3.2. One Year Later

Not long after the maturity scan, the project leader left Organisation C. This had a major impact on their progress on green ICT activities.

After the first scan was finished, the old project leader (OPL) wrote a report on the scores with a number of recommendations. Because he felt that they were just starting, he suggested taking up a number of small initiatives first, combined with formulating policy documents such as a green ICT strategy to provide a solid base for future steps. Among the initiatives were adding a sustainability chapter to all project documents and communicating more about what the ICT department was already doing and how ICT services could improve sustainability for the whole organisation.

A year later, nothing happened with the report because the OPL left and there was no replacement. Recently, a new project leader (NPL) was appointed by the ICT director (ICTD) and she requested to repeat the maturity scan to make a new start. We did so (scores added to Table 5) and we interviewed those three to reflect on the past year.

In his daily life, the OPL considered sustainability important and he found it satisfying that he could work on sustainability through his green ICT activities. He was happy with the maturity scan and found the results useful, regretting leaving at the point where actions could be taken. He did consider it indicative that nothing happened after he left. There was no real (formal) strategy, so anything that happened depended on the persons involved and their individual motivation. He experienced that most people were positive to the initial ideas, but that their responses were lacklustre or negative when it came to the business case. The reason for this was the lack of push, top-down, in terms of leadership and targets. During his time as a "champion", the OPL found that his role was necessary to pave the way and keep people involved, but that he lacked the support and a mandate to create movement. This was a matter of culture and leadership and the OPL thought such change should start at the top. He saw the ICTD as supportive, but not really pushing green ICT so the middle management was mostly ignoring it. Finally, outside pressure from the municipality or the government could help, but should be made more specific, as general pressure on sustainability was not felt at the ICT department in Organisation C.

The NPL just started after roughly a year, but did participate in the first scan. She was passionate about sustainability herself and was convinced that she and her colleagues at the ICT department should do more to promote green ICT solutions. She was motivated to pick up where the OPL left off, but also saw some organisational problems that could block progress. These were similar to what the OPL mentioned: there was some support from the top, but this was lacking on the middle/tactical level. There were no targets of green ICT so it did not have priority and anything that happened depended on enthusiastic individuals taking up bottom-up initiative. There was not much communication on what ICT could do for sustainability, although there were opportunities in procurement and architectural principles to improve sustainability at the ICT department.

Finally, the ICTD also had a positive attitude towards sustainability. He saw a role for green ICT and what the ICT department could do for the organisation, but he did not get any directions from the board, so it was difficult to prioritise it. He saw more potential to succeed in seizing sustainability opportunities when possible, such as when procuring new equipment and making sure they followed the latest sustainability standards. Therefore, green ICT was not really organised (other than having a champion) but something that should be part of everyone's thinking. A champion was necessary to keep green ICT visible, but should not be responsible (it should be a shared responsibility). Also, he did not think that they were doing very bad in terms of green ICT as he saw a lot of activities that could be related to sustainability, such as how they approached procurement and e-waste, virtualisation of servers, flexible work and travel services, digitisation of paperwork processes, et cetera. He was also open to new ideas and proposals from his staff, willing to make money and time available for such projects. He did think it could help to get inspiration from other universities and see how they are doing.

3.3.3. Analysis of Scan Results

Because Organisation C redid the maturity scan, the expectation was that there were not many differences between the two scans. The scores in Table 5 confirm this. Additionally, the evaluation of the second scan with the participants did not lead to new insights (similar conclusions were drawn).

3.3.4. Analysis of Adoption of Green ICT

From the first scan and evaluation we could say the following about the readiness to adopt green ICT at Organisation C. The ICT department was more formal in their approach to the topic. There was not a specific push from the board to become more sustainable and this was also reflected in the ICT department; it did not have a high priority. The general attitude towards sustainability was cautious, but positive. Green ICT activities should not affect other business processes negatively. ICT was not fully centralised, which meant that the governance of ICT infrastructure and services was also not fully covered. For both governance and policies there were no specific green ICT documents implemented. In practice, some green ICT actions had been taken, and some efficiency steps could also be labelled green. Individuals were certainly willing to take such actions, but sometimes lacked the empowerment or the resources. Awareness of green ICT outside the ICT department was not present, probably caused by a lack of communication of the possibilities of green ICT. Finally, the technical infrastructure did offer possibilities to make use of green ICT solutions, but as with other organisations, the priorities of the ICT departments were not at saving energy but keeping the infrastructure available for all users. In Table 6, we summarised this.

Table 6. Readiness to adopt green ICT at Organisation C.

	State of Readiness at First Scan	Factors of Influence
Attitude	cautious but positive attitude; not a priority	*Strategy/alignment with business*: the organisation as a whole considers sustainability important but the ICT department is not strategically aligned. There is no demand from the organisation and no push from the ICT department. *Culture/leadership*: there is little management leadership in the ICT department. The ICT director is positive, but does not champion it. The middle management is passive.
Policy	none in place	*Corporate policies*: there are no specific Green ICT policies (e.g., procurement or e-waste) documented that help stimulate Green ICT actions.
Practice	some actions have been taken; mostly driven by motivated individuals	*Governance/roles and evaluation*: there are no targets for Green ICT
Technology	potential present but other priorities may collide	*Current state/technical infrastructure*: changes in the infrastructure to move to virtual servers and cloud services can be used for Green ICT solutions.
Governance	nothing defined	*Governance/ownership*: the ICTD wants Green ICT to be a shared responsibility but sets no target, with the effect that no one prioritises it outside a number of motivated individuals. *Green ICT business case*: the ICTD is willing to consider solid Green ICT business cases

From the scans and the interviews one year later, we found a number of factors that influenced the adoption of green ICT at Organisation C.

First, the attitude at the ICT department at Organisation C was mostly determined by the organisational strategy and the leadership and culture at the ICT department. While the organisational strategy on sustainability had a clear direction, including targets for energy and CO_2-reductions, there was no link with ICT services. And it seemed that from both sides, from the board towards the department and from the ICT department towards the rest of the organisation, there was little initiative or motivation to make this link stronger. Within the ICT department, the ICTD showed his support when discussing green ICT solutions, but he did not champion it. As a result, the general attitude towards sustainability in the ICT department was not positive or negative but passive.

The passive attitude affected all other indicators for adoption. There were no specific policies on green ICT, although those could be derived from good practices already in the department, such as e-waste. There were some good practices but these were dependent on motivated individuals, whereas other were not pushed by targets they had to meet. The current state of the technological infrastructure did provide some opportunities to take green ICT actions, but none were taken.

Finally, the way green ICT was governed was not bad in theory, as the ICTD thought everyone should be involved and that green ICT was a shared responsibility. He was also willing to support green ICT projects if the business case was sound. However, it was also ok for members of the ICT department to not be involved, so there was little action.

4. Discussion

Now that we have described each of the three participating organisations in our study, we can use the data collected to see whether any patterns emerge that help us answer our research questions.

4.1. Many Factors Influence the Adoption of Green ICT

From the field study, we see that there are many factors at play that influence whether green ICT solutions will be adopted or not. We mapped these onto the five properties of G-readiness [10] for our three organisations. From these results we found a number of prominent factors of influence: strategic alignment, culture and leadership, ownership, knowledge and experience, and technical infrastructure. These all seem to be prerequisites, or at least areas that need to be attended to, once an organisation wants to apply green ICT solutions.

4.1.1. Strategic Alignment

All three participating organisations had green ICT champions who pushed forward on the topic. On the top level, their organisations made sustainability a priority which gave the champions the motivation and freedom to act. Some of them, however, got frustrated along the way. This is because there was a difference in priorities concerning sustainability between the board level strategy and the strategy of the ICT department. They were not strategically aligned (enough) to get green ICT beyond the ad hoc projects stage. Even within the ICT department, we observed at Organisation A that the ICT manager (department lead) took a different position from the middle management (team leaders). Such different priorities at different layers in the organisation make it difficult for champions to move forward on green ICT. There is also a lack of strategic knowledge of the impact of green ICT that makes (the role of the) ICT department rather invisible; organisations focus on greening their buildings, recycling, et cetera, but not much on applying green ICT. This is what we saw at Organisations A and C, which have made sustainability a strategic priority, but do not translate this to the ICT department.

4.1.2. Culture and Leadership

A consequence of different (and low) priorities at the management level in the ICT department is that there is a lack of leadership. In such situations, as we have seen at Organisation A (and to a lesser extent at the other organisations), the topic of green ICT is delegated to the champions and no one else feels responsible. As we have argued, sustainability is typically a topic that needs to be carried throughout the organisation. This leadership does not need to come from the ICT department but

can also come from higher up such as the board, as we have seen at Organisation B. As long as the leadership is strong enough, it will be sufficient support.

Leadership is strongly linked to culture. The ICT department typically positions itself as a service and support unit, which translates to followers not leaders—not only in behaviour but also in belief. There are also beliefs from ICT professionals that green ICT actions have a deep impact on the quality of the ICT infrastructure and services (e.g., repeatedly turning equipment on and off has an impact on the life cycle). The ICT manager at Organisation A believes that ICT professionals are mostly interested in the newest technology and not the most energy efficient technology. Such beliefs impact how leadership acts on and prioritises green ICT.

Finally, there is a typical behaviour linked to sustainability that is also recognisable in the ICT department: people say sustainability is important, but they do not act on it. They need external motivation (e.g., hard targets, priorities) before their behaviour changes. This is often linked to the idea that sustainability equals renewable energy, recycling, fair trade, et cetera, and not changes in one's own daily work.

4.1.3. Ownership

We followed three organisations that showed a positive attitude towards sustainability and were (in principle) willing to take some green ICT actions. As green ICT is not common ground, these organisations are not representing the average but rather the early adopters. Even so, or maybe because of this, green ICT is not anchored in the organisation of the ICT departments. At all three organisations, there was a clear champion (or a few) whom had all responsibilities delegated to them. This is an indicator of low maturity and a lack of readiness.

Both Organisations A and C mentioned this in their interviews, and they thouhgt a sense of shared responsibility was needed to proceed further (and not frustrate the motivated individuals). While Organisation B has a similar organisation of green ICT in the ICT department, there is strong support (and sense of responsibility) outside the department, which helps in having successful green ICT projects.

4.1.4. Knowledge and Experience

Something that was continuously returning in the maturity scan and interviews was the lack of knowledge of green ICT and the lack of communication on green ICT solutions already present in the organisation. So there is very little knowledge of green ICT and the solutions it can provide within the organisations and even within the ICT departments. This affects new ideas for green ICT projects; the willingness to participate in green ICT activities; developing policies and strategies on green ICT; and users applying green ICT solutions. This is also where Organisation B was most successful at between the two maturity scans: there was a lot more sharing and collaborating between the ICT department and other departments within the organisation.

4.1.5. Technical Infrastructure

All three organisations did not show very high scores in the domain "greening of ICT". That is because they applied the quick wins (motivated by cost efficiency) with data centre cooling techniques and virtualisation techniques, for example—techniques that make the use of ICT more energy efficient. But they have not applied the more advanced green ICT techniques that focus more on dynamic use of ICT, and thus, creating a better fit between supply and demand on a day to day basis. Yet, from a readiness perspective, the state of the technical infrastructure and the services provided is not a blocking issue. The technology is ready for green ICT solutions.

4.2. Tools Like SGIMM Help Adoption Once an Organisation Is Ready

The SURF Green ICT Maturity Model is designed to give organisations a practical and accessible way to reduce the environmental impact of ICT and make use of green ICT solutions. After the first

scan participants confirmed that the model helped them understand and apply green ICT. In general, they found it a useful (and efficient) way to get an overview on where their organisation stands and quickly generate ideas for improvement. Furthermore, the use of the model increased their own awareness, they learned more about the possibilities of green ICT (beyond actions in the data centre and also applying ICT as an environmental solution in business processes), and two thirds actually planned to apply green ICT principles in their daily work.

From the results of our field study and the way other factors were of influence, we can derive the basic conclusion that using tools like SGIMM is not by itself sufficient for organisations to adopt green ICT. So what role do tools like SGIMM have in the adoption of green ICT?

4.2.1. Tools Can Measure Progress

The SGIMM provides a maturity scan, which is a snapshot of the state of green ICT an the organisation at that moment in time. We assumed that repeating the maturity scan one year later would reflect changes made in between the scans. For that, the model needs to be reliable enough, which means changes in maturity scores can be explained by actions taken and vice versa (no actions taken equals no change in scores).

Starting with the latter, at Organisations A and C there were no green ICT actions taken in between the maturity scans. Organisation A saw no point in repeating the scan, but C wanted to make a fresh start and redid the scan. We found that the scores were quite similar, meaning that the model is reliable when there are no changes.

At Organisation B a number of changes took place. We found the use of the maturity model itself had positive effects on the organisational aspects of green ICT, such as through policies. Because people from different disciplines within the ICT department participated in the maturity scan, this allowed them to share good practices and discuss improvements for policies, such as with e-waste and procurement, not only because these were identified as areas for improvement, but also because the maturity model provided a shared language and made it easier to discuss and implement policies.

In addition, involving participants from outside the ICT department increased awareness of green ICT solutions for the whole organisation. One of the main outcomes from the scan was to communicate and collaborate more on green ICT. From the interview, we understood that the ICT department is more actively searching for collaborations with other departments, with student projects (primary process) and with vendors (supply chain). Many attributes of the maturity model improved their scores because of this proactive behaviour.

Aside from the organisational aspects, the model also describes technical aspects of green ICT. In the year between the scans, there were no significant technical green ICT projects at Organisation B that could impact the results of the second scan. The main reason was that larger ICT projects prevented green ICT activities starting (the timing was not right). However, there was a change that had a significant impact on the scores. The governance of ICT scored significantly lower in the second scan due to the strategic decision of moving part of the ICT infrastructure off the premises and into the cloud. In terms of reliability, this is important because other (non-green ICT) technical activities can impact the results of the maturity scan.

4.2.2. The Use of Tools Can Help Identify Potential Bottlenecks

The maturity model is designed to identify areas of improvement and make suggestions to improve them. It focuses on "what" would benefit from green ICT in an organisation and "how" they can do so. We see that the factors of influence we identified in the field study are more related to "why" an organisation would (not) apply green ICT solutions: individual or strategic motivation, culture, organisational structure, who benefits and who does not, et cetera. It seems that if the "why" is not in order, this will be a bottleneck to getting green ICT solutions beyond a certain (maturity) point.

While tools like the maturity model do not address the "why", the results of the maturity scan can be used to identify potential bottlenecks. For example, the fact that there is no green ICT strategy

implies there is no strategic alignment with the organisation on the topic of sustainability. The fact that there is little communication on current green ICT solutions and sharing of good practices, implies that there is no shared ownership and that any progress is dependent on motivated individuals. Such implications can then be used with models like the G-readiness model by Molla ([6]) to target specific bottlenecks and address the "why".

4.2.3. Ready to Adopt and Implement

While simply using a tool like SGIMM is not enough to make organisations act on green ICT solutions, once an organisation is ready, the SGIMM is an effective tool to identify what needs to be improved and how. In addition such tools can be used to measure progress and identify potential bottlenecks in the adoption of green ICT. Combined with a model like the G-readiness from Molla [6], they cover the bases of "why", "what", and "how" to get organisations ready to adopt and implement green ICT solutions.

4.3. Green ICT Adoption Needs a Systemic Approach

Green ICT seems to be different from some other technologies in the sense that there can be many bottlenecks that prevent its adoption. We argue that this is because green ICT adoption needs a systemic approach from the organisation.

First we have to recognize that ICT is a general purpose technology, meaning that it is a technology that can affect an entire economy and drastically alter society. Likewise, it can have such an impact on an organisation, affecting all business processes.

ICT can affect processes in a number of different ways, but they can be basically divided in two categories: ICT solutions that automate or optimise processes, improving on what we have but not changing the way we do it; and ICT solutions that change the workflow of the process; for example, by dematerializing or substituting parts in flow. Generally speaking, the first are easy to implement, but the latter requires a behavioural change of those working on that process. For green ICT, this means that to fully cash in on its enabling potential, everyone needs to be on board and willing to change the way they work.

From an environmental sustainability perspective and starting from the big picture: we have a global challenge to reduce our footprint in order to prevent global warming and climate change. The way we collectively act can change the course, but if we act individually we do not see its impact (generally speaking) and gain little benefit from it. In other words, as an individual or as an organisation we do not feel the pain and the need to change even though we rationally know this is the right thing to do. This difference in priority and impact repeats itself over and over again in every layer of society and on every management level in an organisation. As a consequence, there are often different priorities at the organisational, department, team, and individual levels, as we saw in our field study.

This combination of, "I need to change the way I work", and "Why should I change my behaviour if I have so little impact and gain no benefit from it?" makes it difficult for individuals to act on green ICT. While few actions can be carried out by individuals or are such low hanging fruit that other incentives, such as significant cost reductions, pave the way, most green ICT activities require involvement from multiple parts of the organisation and a certain (often different from current) mindset. Often the benefits of such activities are at a different part of the organisation than where the costs are (ICT department). This again requires a step up in the hierarchy in the organisation to make it work. Therefore, green ICT adoption needs a systemic approach from the organisation.

5. Conclusions

In this study we followed three organisations that used the SURF Green ICT Maturity Model. Through our field study, we wanted to find out what organisations need to adopt green ICT. Specifically, we wanted to know what factors of influence affect the adoption of green ICT and what role tools

such as the SGIMM have in this adoption process. All three organisations used the model to make a maturity scan and discussed the results with the participants. This led to suggestions for actions they could take to improve their green ICT. We returned to these organisations a year later to repeat the scan and see if there were any differences in the results. We repeated the scan at two of the three organisations and took interviews to collect information on what happened in between the scans and why.

Taking the perspective of green ICT readiness [6], we took the results from the scans and the interviews and derived factors of influence at each of the three organisations that affected the adoption of green ICT. We found that there are many factors that influence the adoption of green ICT and discussed five important ones. The first is strategic alignment of all the (management) layers in the organisation; we found that if on some layer there are different priorities (and the rest of the organisation seems ok with this), this will block green ICT adoption. Second is that bottom-up enthusiasm is not enough; leadership is required also because sustainability actions often cannot be contained—they affect a larger part of the organisation. A third factor is culture and beliefs on ICT and sustainability that need to be changed. Fourth is about ownership and how green ICT is governed: it needs to go beyond the motivated individuals and be made a shared responsibility. Lack of knowledge of and communication on green ICT solutions is the fifth factor of influence we found. Finally, we concluded that the technical infrastructure is or will not be a bottleneck for adoption of green ICT.

Tools like the SGIMM can help organisations adopt green ICT once they are ready to do so. Their main role is to identify areas of improvement ("what") and generate suggestions how to do so ("how"). Tools can be used to measure progress (like we did by repeating the scan) and they can also be used to identify potential bottlenecks in the organisation (some results like the lack of a green ICT strategy, imply a lack of strategic alignment if there is a green strategy on the organisational level). If at the organisational level there is no good answer to "why", they should work on green ICT, as tools like the SGIMM can make only a small difference.

The key insight is that green ICT requires a systemic approach from the organisation because it affects the workflow of all members of the organisation and every process they carry out. It cannot be delegated to a few individuals without taking some (shared) responsibility. As long as members or groups are not willing to look beyond their own tasks, organisations cannot grow much more mature and are limited in their adoption of green ICT.

5.1. Future Research Directions

The approach we took in this study was to combine two models to explore the "why," "what," and "how" of green ICT adoption in organisations. For future research it would be interesting to integrate these models into one approach that can be used in research and in practice by organisations themselves. This approach should help organisations in the adoption of green ICT and predictions of bottlenecks on all levels. Research should focus on the quality and effectiveness of such an approach.

Another research direction is to consider other approaches of adoption. As we have seen, much depends on leadership in an organisation and we are used to the difference between top-down and bottom-up dynamics. ICT, especially tools like social media, can have a role in breaking through the traditional hierarchical culture and creating more matrix-like social networks (e.g., [11]). We see potential in future research on how adoption could be improved by using such tools.

Finally, our understanding of a systemic approach could be improved by sharing our insights with ICT managers and other key personnel in organisations through interviews and a survey (expanding on [12]). The focus should be on the balance between long term thinking and short term goals, clashes of costs and benefits on the organisational level with those on lower levels, and perhaps a reconsideration of the role (and impact) of ICT in an organisation and how this affects ambitions of becoming more sustainable.

Conflicts of Interest: The authors declare no conflict of interest.

References

1. Pamlin, D.; Pahlman, S. From Green IT to Greening for IT. In *A Billion Tonnes of CO$_2$ Reductions and beyond through Transformative Change*; WWF Sweden: Solna, Sweden, 2009.
2. GeSI. #*SMARTer2030, ICT Solutions for 21st Century Challenges*; GeSI: Brussels, Belgium, 2015.
3. Molla, A. GITAM: A Model for the Adoption of Green IT. *ACIS 2008 Proc.* **2008**, 64. Available online: https://aisel.aisnet.org/acis2008/64 (accessed on 25 August 2019).
4. EU. *Waste Electrical and Electronic Equipment Directive*; EU: Brussels Belgium, 2012.
5. VROM, WWI, VSNU en HBO-raad maken afspraken over duurzaamheid in het hoger onderwijs. https://www.parlementairemonitor.nl/9353000/1/j9tvgajcovz8izf_j9vvij5epmj1ey0/vi0l85n1b3vf?ctx=vhhfh58d8uzm&start_tab0=60 (accessed on 4 December 2008).
6. Molla, A.; Cooper, V.; Pittayachawan, S. IT and eco-sustainability: Developing and validating a green IT readiness model. *ICIS 2009 Proc.* **2009**, 141. Available online: https://aisel.aisnet.org/icis2009/141 (accessed on 25 August 2019).
7. Hankel, A.; Oud, L.; Saan, M.; Lago, P. A Maturity Model for Green ICT: The Case of the SURF Green ICT Maturity Model. In *EnviroInfo 2014—28th International Conference on Informatics for Environmental Protection*; BIS Verlag: Oldenburg, Germany, 2015; pp. 33–40.
8. Hankel, A.; Heimeriks, G.; Lago, P. Green ICT Assessment for Organisations. *J. ICT Standard.* **2017**, *4*, 87–110. [CrossRef]
9. Hankel, A.; Heimeriks, G.; Lago, P. A Systematic Literature Review of the Factors of Influence on the Environmental Impact of ICT. *Technologies* **2018**, *6*, 85. [CrossRef]
10. Molla, A.; Cooper, V. Green IT Readiness: A Framework and preliminary Proof of Concept. *Australas. J. Inf. Syst.* **2010**, *16*. [CrossRef]
11. Amato, F.; Moscato, V.; Picariello, A.; Sperlí, G. Diffusion algorithms in multimedia social networks: a preliminary model. In Proceedings of the 2017 IEEE/ACM International Conference on Advances in Social Networks Analysis and Mining 2017, Sydney, Australia, 31 July–3 August 2017; pp. 844–851.
12. Hankel, A. National Collaboration on Green ICT in the Dutch Higher Education: Lessons Learned. In Proceedings of the First International Conference on Information and Communication Technologies for Sustainability, ETH Zurich, Zürich, Switzerland, 14–16 February 2013; p. 203.