Maturity for Sustainability in IT: Introducing the MITS

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Abstract

Large scale IT usage harms the environment during its life-cycle and this results in a threat to sustainability. This research provides an approach to help IT organizations recognize and prioritize appropriate measures. A green ontology consisting of suggestions to improve IT sustainability is introduced based on earlier work. Then, to be able to judge where sustainability impacts the IT of an organization, the dimensions Govern, Source, Make and Return as derived from the Supply Chain Operations Relationship model are applied within a sustainability context. Furthermore, four maturity levels are defined for IT sustainability based on the available sustainable development literature: Cleaning up the waste, Preventing waste, Product reengineering, and IT as an opportunity. Finally, the resulting Maturity for IT Sustainability (MITS) model is presented which categorizes all ontology measures appropriately within the two MITS dimensions.

Keywords

Green IT; Green IS; Green Computing; IT Sustainability; Maturity Modeling.

1 Introduction: Maturity for IT sustainability

Society has certain expectations for business behavior to act appropriately, which makes business and society interwoven (Wood, 1991; Porter & Kramer 2006). Porter and Kramer however state there is often a lack of integration and alignment between corporate responsibility initiatives and general business strategy. According to Keays (2010) clarity in vision on sustainability is often lacking, preventing organizations to become more sustainable. It has been calculated that the global information and communications technology (ICT) industry is responsible for approximately two percent of global carbon dioxide (CO_2) emissions, a figure which is quite high and supposedly equivalent to the aviation industry (Pettey, 2007; Boccaletti, Löffler, & Oppenhein, 2008). A lot of organizations are not aware of how they can change their operations to combine their concern for rising energy costs with environmental initiatives. Furthermore, 40 percent of U.S. small and medium businesses do not know how much their IT systems contribute to overall energy costs, even though IT can take up to 50 % of the energy costs (McKeefry, 2008). Examples of successfully implemented ideas exist, but little on what should be implemented and in what order to reach a certain maturity level. Furthermore, little or no research has been done on if and how Green IT is related to organizational goals. Porter and van der Linde (1995) have stated that a "Green" strategy paves the way to competitive advantage by forcing companies to innovate. Researching green opportunities provides more innovative solutions than remaining at a regulatory compliance level. The regulatory compliance level is ever changing. Even apart from regulations, it is possible that implementing sustainability measures can not merely provide a competitive advantage on the short term, but also in the long run. Short term advantages can be increasing the capacity of current datacenters. Not sustaining the datacenter may make it impossible to acquire enough power from the power grid which poses a direct threat for the economical sustainability of the IT function (Reams & Brown, 2010), which would not have happened if the company had been more environmentally

sustainable. Longer term advantages can be the great increase of efficiency, by reusing excessive heat for useful purposes like heating a pool (Miller, 2008), or reusing heat for greenhouses (Keijzer, 2009).

The implementation of a more environmentally aware IT is often called "Green IT". According to Gartner's hype cycle (Stevens & Pettey, 2009) Green IT will be mainstream in the near future. However, research on maturity for IT sustainability is still scarce. Recent investigations lead to the conclusion that a lot of companies are missing out on opportunities. According to (Schop, 2010) around 70 % of Dutch companies ignore the opportunities Green IT can bring for their organization. The usage of IT in this case is ambiguous because on the one hand IT can be perceived as being one of the causes of environmental problems, whereas on the other hand IT can also be seen as part of the solution to solving environmental problems. IT usage is a big energy consumer, plus the production of IT components also requires a lot of energy and environment unfriendly production methods.

This study contributes to IT sustainability research by focusing on the organizational view to IT sustainability. This means actual production of equipment is out of scope, but everything influencing the IT organization and its surroundings is within scope. Research on IT sustainability has mainly focused on describing harm done by IT on the environment and scarcely on how IT can be an enabler for sustainability. This research focuses on describing the influence of IT sustainability not in a societal context, but within an organizational context. The Maturity for IT Sustainability model which we develop in this work combines organizational viewpoints with sustainability stages into a tangible roadmap with a multitude of appropriately mapped measures.

Whatever the justifications for a corporate responsibility initiative within an organization, if they cannot be related to the core strategy and operations of any specific organization —or the places in which it operates— its initiatives won't be successful (Esty & Winston, 2006; Porter & Kramer, 2006). According to Olson (2008) an ecologically sustainable —or in their research called "Green"— strategy is one that is complementary to the business, operations and asset strategies and helps an enterprise to make decisions that have a positive impact on the environment. Unlike a green strategy, the business, operations and asset strategies are often well developed as a lot of attention has been paid to them. In order to formulate an effective green strategy the basic principles that are the basis of a green strategy should be leading an organization to make decisions based on solid business logic and which make good business sense (Olson, 2008). A green strategy should be related to the corporate responsibility strategy of an organization. The focus will be on applying the organization's limited resources available on the issues most central to the organization's environmental footprint and reputation. Because the interdependence of business and society is often not recognized, most corporate responsibility initiatives lead to uncoordinated CSR and philanthropic activities that do not connect to the general strategy of the business (Porter & Kramer, 2006) These uncoordinated initiatives do not assist the firm in gaining a competitive advantage, or make any meaningful strategic impact.

Section 2 continues explaining what sustainable development maturity levels we recognize from literature. In section 3 we will show how to interpret these maturity levels within the IT domain. In section 4 we will present and explain the MITS model and how it was developed. Section 5 presents our conclusion and discusses directions for further research.

2 Development stages for IT sustainability

Little research has been done on what stages could be defined with respect to IT maturity. Over the last decades sustainability has become of growing importance for business strategy in general, business strategy literature has increasingly paid attention to the topic. In this section we review non-IT related

literature on stages for sustainability, from which we will derive sustainability stages that could apply within the IT domain.

"Beyond greening: strategies for a sustainable world": According to Hart (1997) there are three stages for a sustainable development strategy for an organization. The starting point, pollution control, assumes that companies are trying to clean up waste after it has been created. This implies a passive reaction to a waste problem, and therefore the stage before sustainable development strategies.

Like total quality management and lean manufacturing, pollution prevention strategies depend on "continuous improvement efforts" in order to reduce waste and energy use (Hart, 1997). Pollution prevention strategies depend on continuous improvement efforts to reduce waste and energy usage for the production process. The main reason pollution prevention strategies are likely to be implemented by companies is that these strategies are already perceived to earn back the efforts that are put in. Furthermore, Environmental global standards have created strong incentives.

Product stewardship, the second stage, aims at reducing the environmental impact of products in their full life-cycle. This requires reengineering products to enable recovery, reuse and recycling. This includes streamlining return processes from customers. At this stage companies raise questions like: Can we add value or lower costs while simultaneously reducing the impact of our products? What are the implications for product design and development if we assume responsibility for a product's entire lifecycle?

The last stage, clean technology aims to invest in "tomorrow's technologies". This means investing in technologies that no longer produce non reusable waste in production. At this stage, the following questions can be asked: Is the environmental performance of our products limited by our existing competency base? Is there potential to realize major improvements through new technology?

"The next sustainability wave: Building boardroom buy-in": The stages as formulated in the book by Willard (2005) are derived from the works of seven other researches. At the first stage the organization's goals have nothing to do with sustainability, and the organization prefers to avoid regulations. "It cuts corners and tries not to get caught if it breaks the law or uses exploitative practices that cheat the system. It ignores sustainability and actively fights against related regulations." (Willard, 2005)

In the second stage, the business manages its liabilities by obeying the law and all labor, environmental, health, and safety regulations. It reactively does what it legally has to do and does it well. Emerging environmental and philanthropic social actions are treated as costs, projects to increase sustainability are end-of-pipe retrofits, and Corporate Social Responsibility (CSR) is not seen as important, nor supported by real conviction.

During the third stage, the organization moves from defense to offense. It realizes it can save expenses with proactive and incremental operational eco-efficiencies, cleaner processes, and better waste management. The organization recognizes community investment and social marketing can minimize uncertainty, enhance its reputation, and help maximize shareholder value. However, sustainability initiatives are still marginalized in specialized departments, not built in and institutionalized.

At the fourth stage the firm transforms itself. It re-brands itself as an organization committed to sustainability and integrates sustainability with key business strategies. It captures added value from breakthrough sustainability initiatives that benefit all stakeholders. Instead of costs and risks, the organization sees investments and opportunities. It makes cleaner products, applies eco-effectiveness and life-cycle stewardship, and enjoys competitive advantages from sustainability initiatives.

The fifth stage describes organizations that are driven by a passionate, values-based commitment to improving the well-being of the organization, society, and the environment. The organization helps build a better world because it is the right thing to do. Stage 4 and Stage 5 are very similar; according to the author about 90% of what companies at these stages do looks the same. "Stage 4 companies do the right things *so that* they are successful businesses. Stage 5 companies are successful businesses *so that* they can continue to do the right things"(Willard, 2005).

"Why sustainability is now the key driver of innovation": In (Nidumolu, Prahalad, & Rangaswami, 2009) the authors describe their model for sustainability. Here the first level is described as the first step to sustainability. Although driven by compliance, companies should realize that looking beyond compliance is better. According to the authors looking beyond compliance yields substantial first-mover advantages in terms of fostering innovation.

In the second stage, companies have learned to keep on track with regulation, and they become proactive with regard to environmental issues. Actions at this stage are linked with "reducing the consumption of nonrenewable resources such as coal, petroleum, and natural gas along with renewable resources such as water and timber." (Nidumolu, Prahalad, & Rangaswami, 2009). The efficiency striving at this stage is not only limited to manufacturing, but also extends to offices and value chain. "At this stage, corporations work with suppliers and retailers to develop eco-friendly raw materials and components and reduce waste."(Nidumolu, Prahalad, & Rangaswami, 2009)

In the third stage companies start realizing that there are numerous consumers that prefer products that are less harmful to the environment, and that a competitive advantage can be gained by reengineering products to be more environmentally friendly. "Companies which have continued to invest in eco-friendly products despite the recession, look beyond the public-relations benefits to hone competencies that will enable them to dominate markets tomorrow." (Nidumolu, Prahalad, & Rangaswami, 2009)

In the fourth stage the business model can be adapted, or a new business model can be developed as an alternative to the current ways of doing business. This also requires the skill to understand how the needs of customers can be met on a different way. "Executives must learn to question existing models and to act entrepreneurially to develop new delivery mechanisms. " (Nidumolu, Prahalad, & Rangaswami, 2009)

The fifth and final stage supersedes the fourth. "The experience [from the fourth stage] will lead them to the final stage of sustainable innovation, where the impact of a new product or process extends beyond a single market."(Nidumolu, Prahalad, & Rangaswami, 2009) To develop innovations that lead to next practices now, mainstream practices must be questioned and challenged.

Literature stages overview

	Hart (1997)	Van Willard (2005)	Nidumolu *et al.* (2009)	**This research**
0		Pre-compliance		
1	Pollution control as initial stage (cleaning up waste after is has been created)	Compliance	Viewing Compliance as Oppportunity	"Control waste"
2	Pollution Prevention (Preventing waste)	Beyond Compliance	Making Value Chains Sustainable	"Preventing waste"
3	Product Stewardship (minimizing not only impact from production, but from whole lifecycle)	Integrated Strategy	Designing Sustainable Products and Services	"Product reengineering"
4	Clean technology (start investing in tomorrow's technologies)		Developing New Business Models	"IT as an opportunity"
5		Purpose & Passion	Creating Next-Practice Platforms	

Table 1: Key sustainable development stages mapped onto each other

In general, all the approaches consider the first stages as doing the necessary from a legal perspective. In table 1 stage zero may even include an organization which actively tries to bend legislation, or which avoids legislation by for example moving to another country. Stage 1 is generally aimed controlling the impact of the production-process of a product. In general, companies realize that if they produce less pollution/waste, they save money because of a more efficient production processes. Or they take action to mitigate for future risk or legislation but nothing more. Stage 2 aims at reducing the impact of the production process itself. Continuous improvement programs are introduced to optimize the production processes.

Stage 3 includes a realization that further greening possibilities include the product itself, or even further greening in the production process. Examples of this: the reengineering of the product to streamline the production process, and the substitution of parts or components that are harmful to the environment. Also, a product is considered in its full life-cycle, which means that recycling or reuse of the product or its components have already been taken into consideration. In the case of electric equipment this means that also the energy usage during the use phase has already been minimized.

In stage 4 realizations are that being a sustainable organization is a way to distinguish from competitors. This ranges from introducing green marketing campaigns to the introduction of new products. Stage 4 is about transforming the firm, adapting the business model, or even develop new business models. The business model is committed to sustainability, and uses technologies that produce a minimum of waste in production.

The final stage 5 describes companies that go even further. According to Willard (2005) stage 4 and 5 are 90% equal, but companies in stage 5 are truly operating altruistic. Stage 4 companies "do the right things" *so that* they are successful businesses. Stage 5 companies are successful businesses "*so that"* they can continue to "do the right things" (Willard, 2005).

3 Translating sustainable development stages to IT

We are now ready to translate the findings from the previous section into IT sustainable development stages for use in the MITS model under development.

0 Or Pre 1		Pre-compliance	

The starting position describes a situation where companies actively try to avoid complying with regulations and legislation, possibly by moving to another country when regulations become too stringent. In the MITS model this stage is deemed of lesser importance, because on the is a lack of stringent regulations for sustainability in IT (Calder, 2009). Furthermore the MITS developed in this research describes sustainable development, whereas this stage describes the lack of development.

1	Pollution control as initial stage(cleaning up waste after is has been created)	Compliance	Viewing Compliance as Oppportunity
	"Control waste"		

In the first stage of the aforementioned maturity levels, the general aim is usually to reduce the waste after the production of a product. Applying this principle to IT, this would involve reducing the CO2 output or energy usage of creating or delivering the product. For example, consider an organization where IT is supporting the primary process with a physical machine running an e-mail server. Optimizing the internal air flow for optimal usage, or even allowing the datacenter temperature to rise with 1 degree Celsius provides savings, meaning less CO2 emission. The above example shows how to use green opportunities without affecting the primary process, or even changing the product that is delivered, in any way. Opportunities at this level are typically of the responsive CSR nature. To sum up, this development stage with respect to IT sustainability as described above will be refered to in the MITS model as "Control waste".

2	Pollution Prevention (Preventing waste)	Beyond Compliance	Making Value Chains Sustainable
	"Preventing waste"		

In the second stage of the model an organization realizes that in the current situation there is more room for improvement. This still happens (almost) neutrally to the primary process. Instead of "cleaning up waste", this stage tries to prevent waste during the production. For example when referring to energy usage, what does not get used does not need to be accounted for. A possibility would be to consolidate the server running the e-mail server to a virtual machine, if it is possible to combine with other virtual servers. Opportunities at this level are of the responsive CSR nature. To sum up, this development stage

with respect to IT sustainability as described above will be referred to in the MITS model as “Preventing waste”.

3	Product Stewardship (minimizing not only impact from production, but from whole lifecycle)	Integrated Strategy	Designing Sustainable Products and Services
	“Product reengineering”		

During this stage the product is assessed for opportunities to be more sustainable. In the sustainable development stages from literature this entails (re)engineering the product to adapt it for easier production, requiring less energy and harmful or rare materials. Even substituting harmful components with components that are less harmful for the environment. This imposes changes to products or the primary process. An example of reengineering the product could be application renewal. Application renewal could assist an organization by optimizing legacy software for modern platforms. This could even entail porting to a new architecture. An example of substituting (parts of) a product could be cloud computing. Cloud computing would in this case offer on demand capacity whereas otherwise an organization would need its own server park readily available. The cloud computing vendor has economies of scale, helping in an overall better sustainability. At this level the initiatives start to be of a strategic nature. To sum up, this development stage with respect to IT sustainability as described above will be refered to in the MITS model as “Product reengineering”.

4	Clean technology (start investing in tomorrow’s technologies)	Integrated Strategy	Developing New Business Models
	“IT as an opportunity”		

These stages from the reviewed literature show a full commitment to sustainable development. New reengineered products might also provide opportunities for new business models. When this is seen in the context of IT organizations within companies, this is the stage where companies realize that sustainable IT entails more than reducing the negative environmental impacts that IT has, IT provides opportunities to reduce negative environmental impact on other areas. This improves the overall organizational sustainability, made possible by IT. Initiatives in this category are typically the strategic corporate responsibility initiaves. An example of how IT can provide a sustainability opportunity for an organization would be teleworking. By allowing its employees to use teleworking more often an organization cuts on its CO_2 emissions for travel. To sum up, this development stage with respect to IT sustainability as described above will be refered to in the MITS model as “IT as an opportunity”.

5		Purpose & Passion	Creating Next-Practice Platforms

The fifth and last stage can be described as a stage where the organization generally operates out of an altruistic viewpoint. This stage is left out in the model in this research because this moves outside the organizational IT scope. Real altruism does not depend solely on the IT department, and should be part of an organization wide vision and mission. Important is to realize that at this stage the probability that initiatives do not connect to the value chain of the organization is higher, and according to Porter &

Kramer (2006) this forms a risk as such initiatives often don't bring any benefit to an organization and should better be left to other parties.

Maturity levels

To summarize, out of the aforementioned stages we can derive the following four stages that we deem applicable to the IT sustainability domain: *Control waste, Preventing waste, Product reengineering* and *IT as an opportunity*. The stages described are in order of expected impact, they start with the low hanging fruit, or responsive CR initiatives, and build up until IT is used as a strategic enabler for organization wide sustainability. Important is the shift from narrow technical focus where the responsibilities lie with the IT department to an organization wide approach where also end users are involved and where organization wide awareness of IT sustainability issues rises. The next section will demonstrate how these stages are placed into a model with which the state of development of IT sustainability can be measured, or that can be used to create a roadmap for the organization.

Corporate dimensions for IT sustainability

Up until now we described which stages we derived for IT sustainability. In order to assess where an organization is in these stages it is important to differentiate between the development stages regarding IT sustainability across the various dimensions within an organization. We selected the Supply Chain Operations Reference (SCOR) model for this purpose. This model was developed to "impose a modus Operandi, which unconditionally divides an organization's IT activities into an unending sequence of projects to modify IT services." (Zarnekow, Brenner, & Pilgram, 2006) This model is used to describe the relevant scope and key activities of IS management, aiming at the whole IS management discipline. This model has also been adapted for sustainability by adding a return process into the supply chain operations. (Schmidt, Erek, Kolbe, & Zarnekow, 2009). The original SCOR model is aimed at industrial management; it has also been transferred to IS software and IS service providers by Zarnekow et al. (2006).

The Govern process encompasses the strategic functions, procedures, and measures, which ensure that allocated IS products and services contribute to the business goal achievements. The Source process covers all tasks within the supplier relationship management. The Make process comprises all tasks for the management of IS product and service production. The Delivery process is responsible for the customer relationship management and depicts the classical sales part. In this research the deliver process is left out. This process is aimed at the customer service part and manages the relations with the customers of the IT organization. Because this is mainly a service handling function, it does not seem like a fruitful opportunity for greening. As the research focuses on IT organizations *within* organizations these customers are of course internal. This would mean greening initiatives that involve the clients of the IT organization would remain within the same organization. Therefore, the Delivery function is excluded from the research scope. The Return phase depicts the processes of recycling, preserving and reusing tangible or intangible resources, clarifying that possessed resources or means of production used or produced in the value chain are recyclable and fundamental information (e.g. customer requirements) has to be documented and preserved for internal analysis and future strategic directions of the organization.

4 The Maturity for IT sustainability model (MITS)

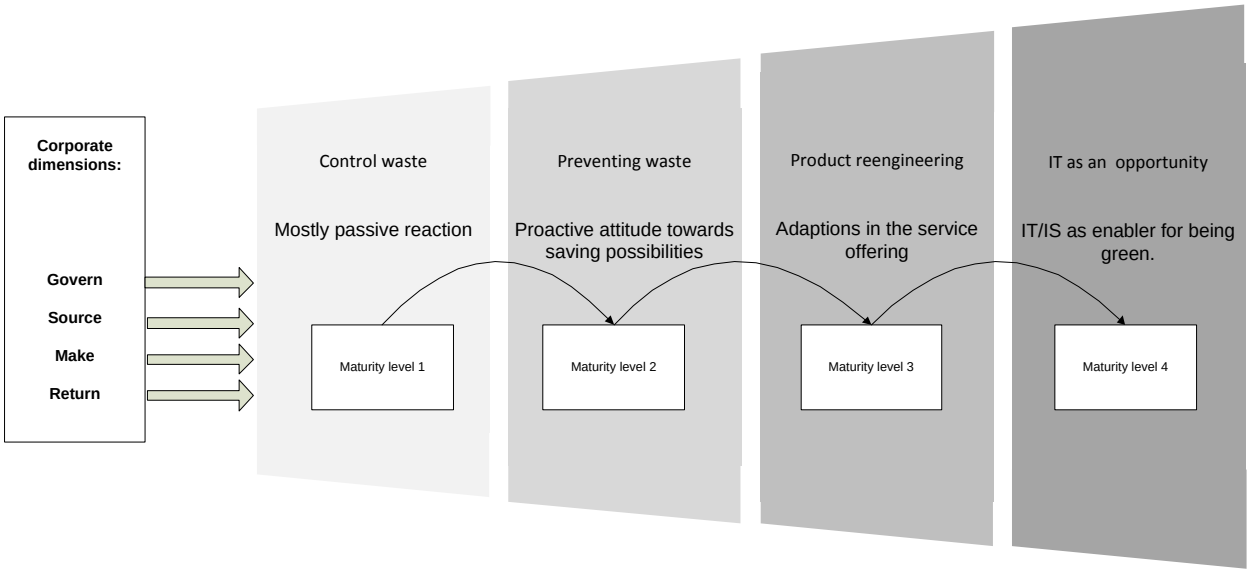

Figure 1 Conceptual sketch of how the model works

In Figure 1 the dimensions—or organizational viewpoints—are depicted as the left white square. For each of the dimensions a mapping to the maturity level can be made as will be shown in the next section. This model is meant to show that IT applied by an organization can be classified into different stages. For an organization reaching a higher stage this means that the IT usage of an organization is more environment friendly than it was in the previous stage as illustrated by the color and size of the stages, from light to darker shades of grey. To reach a higher maturity level the initiatives undertaken by the organization have to be of a more strategic nature, and impact a larger part of—or surroundings of—the whole organization than at previous levels. To create a detailed model we need several building blocks. In Figure 1 the general aim of the model is made clear. Per dimension there are different stages in which a company can reside. To decide where a measure belongs within this model, it has to be known how influential the impact is. Does it remain within the IT department or does it provide opportunities for the company as a whole? Furthermore, it has to be known in what dimension it belongs and if it affects the way the IT organization delivers services to its customers.

4.1 Sustainability measures

In order to structure the measures organizations can take to sustain their IT organization, the dimensions described in section three are used. These dimensions are expanded with measures identified in previous research (Smeitink & Spruit, forthcoming). What makes this structuring preferred is that it offers an organizational perspective, instead of a technical perspective as found in the research by (Murugesan, 2008), among others.

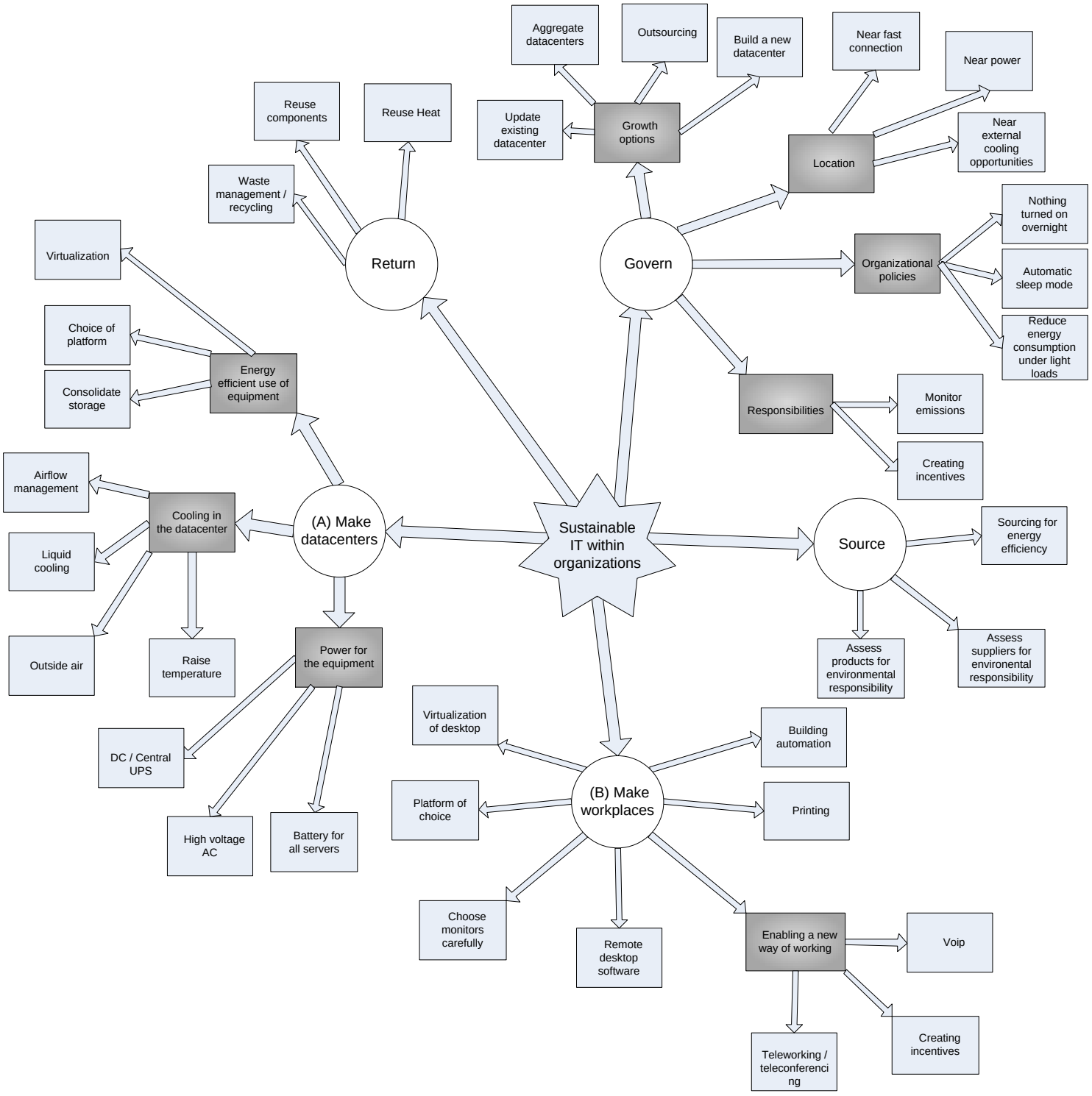

Figure 2: The Green IT ontology (Smeitink & Spruit, forthcoming)

4.2 Applying the MITS model

If the model is used when creating an IT strategy it can help grow awareness on how to address environmental and social issues, and how the IT department can become an enabler for organization wide sustainability. It remains important to realize this model is not written for a specific organization, or even a specific sector.

The MITS model shows that one should start with initiatives that show immediate enhancements for the environmental sustainability (the first level, "Cleaning up the waste") without involving customers or other parties than the IT department. This is to start on a small scale, and prepare the department for changes and to give a good example.

At maturity level 2 ("Preventing waste") the direct customers of the IT department can be involved and again the quick wins are executed. At this stage the environmental impact of the measures is growing. Again this serves as a preparation for higher levels. As Porter & Kramer (2006) explained in their research, being responsive to issues in the value chain is important but strategic CR requests more commitment.

Maturity level 3 ("Product reengineering") is about out of the box thinking, how the current application of IT can be done in another way. At this point the customers of the IT department will notice things have changed. For example, where people requesting for a testserver used to get assigned a physical machine, they now get assigned a virtual machine. At this stage the IT department has its share in the sustainability goals set for the whole organization.

To reach maturity level 4 organizations must realize IT poses not only a threat, but it can assist parts of the organization to do certain things in another way that is more environmentally friendly, which can in turn help differentiate from competitors.

4.3 Placing the Green IT measures in the MITS-model

This section shows how measures that an organization has identified to be applicable to its situation can be divided in maturity stages. We hereby use measures that were found to be contemporary during the validation phase, and were found to be applicable to a general organization. For specific sectors custom models can be created. The used measures and dimensions are directly derived from (Smeitink & Spruit, forthcoming).

Dimension: Govern

At the first stage in the Govern dimension we identified 'Nothing turned on overnight' and 'make IT pay for electricity'. Both do not impact the user experience, and are an example of an initiative to improve corporate responsibility.
The second maturity level exists of 'power saving schemes' and 'update and aggregate'. Power saving schemes can impact user experience slightly although most users probably never notice. Update and aggregate is about updating or aggregating datacenters. This potentially influences the user experience, for example delay in transactions if a datacenter is placed on another continent.
The third maturity level explains how an existing way of doing things can be reengineered. If in an IT department someone gets the task to proactively search for Green IT initiatives this helps make IT sustainability a way of life. 'Automatic sleep mode' can put a machine to standby if users are away from the keyboard for a prolonged period. For example during lunch breaks or long meetings. If datacenters are centered near cooling opportunities and renewable power this helps the business sustainability greatly. Good cooling opportunities are moneysavers to start with, and locating near renewable power seems more

and more required by public opinion (Greenpeace, 2010).
The fourth level describes how IT can assist the whole organization, or how usage of IT saves in other areas. For 'Monitor emissions' it is clear that this helps in registering emissions for the whole organization. The other two, 'Automated turn off and awake' and 'Auto load balancing between DCs' describe ways of applying IT to automate certain user actions.

Dimension: Source

The first stage in the Source dimension presents 'Comply to legislation'. By complying to legislation the organization shows its willingness to comply. The second stage features 'Renewable energy sources'. Using renewable energy sources, the service itself is not changed. The third stage describes 'procure energy efficient', when procuring energy efficient apart from capital expenses the operational expenses are also taken into account, by lowering the energy costs. Lower energy costs ultimately result in a lower Co2 output. The fourth stage describes 'Assess supplier environmental responsibility'.

Dimension: Make – Datacenter

For the first stage of the dimension Make (Datacenter) 'air flow management and 'higher temperature' were identified. Allowing the temperature to be a little higher can save a lot on air-conditioning costs. In traditional datacenters that have a lot of airconditioning capabilities it makes obvious sense that this saves on electricity costs, and thus saves on the Co2 output. Raising the temperature from 20.5 celsius to 23.3 saves about 12.7% on airconditioning costs (Gibson, 2009). Both are measures that are unnoticeable for customers, and both are reactive to a problem.

The next stage features measures that prevent waste. 'High voltage AC' and 'Hot aisle / cold aisle' 'outside air' and 'consolidate storage' all describe efficiency gain. For example, using a Hot aisle / cold aisle approach helps overcome heat in the cabinets due to cold air being placed in front of the equipment cabinets and hot exhaust air is expelled behind equipment cabinets. With the help of this layout the problem that one air intake gets the hot outtake air from other equipment is eliminated (Ritschard & Herrick, 2009).

The third stage exists of 'Battery or central UPS' 'virtualization' 'liquid cooling' 'choice of platform' and 'application portfolio renewal' that describe various perspectives of thinking towards a solution. The product the IT organization offers is reengineered, sometimes even in cooperation with the customer. For example, if an IT organization offers Rackspace to clients, changing the service to include liquid cooling has impact for the client. Besides being efficient and thus possibly cost saving, liquid cooling has a larger capacity and sometimes even enables cooling through circulation from a cooling tower, thus without power consuming airco units (Patterson & Fenwick, 2008). In this case thinking with the customer could also result in offering the client a virtual machine if that is suitable in their specific situation. Virtualizing servers in order to be green is especially useful if you have multiple servers running with a very low load.

The fourth stage exists of 'cloud computing', which describes how usage of "the cloud" presents savings opportunities. Here, using cloud services provides huge greening opportunities if the cloud provider is also green. The cloud service provider has economies of scale and can better handle the difference in low loads on a server and the peak loads on a server.

Dimension: Make – Workplaces

In the dimension Make (Workplaces) 'Print double sided' becomes the default option for printers which reduces harmful effects of quick prints. The second stage features 'Monitors' and Platform of choice' which present ways to reduce harmful effects by making the workspace more efficient. The third stage

features ‘Desktop virtualization’, ‘Voice over IP’ and ‘Prints from account’. All present a more or less alternative to measures mentioned in the last stage.

In Stage four ‘Building automation’, ‘Teleconferencing’, ‘Teleworking’ and ‘Green competition / Paperless working’ present ways how IT presents opportunities to reduce harmful effects on the environment that is caused by other areas than IT. For example building automation, to further cut the energy requirements of facilities HVAC (Heating, Ventilation and Air-Conditioning) and lights sensor networks can be applied to monitor for presence. This enables to automatically keep the desired temperature, keep the air quality and lightning as required only when people are present. It has been estimated that 25 to 40 percent reductions in lighting energy usage are possible by implementing an automated lighting control program, and most facilities will return on these investments in two years or less (Piper, 2004).

Dimension: Return

This dimension begins at stage 1 with ‘Recycle’ where companies have to make sure the equipment they depreciate gets properly recycled instead of tossed away. Stage two presents ‘Follow up on waste management’ which ensures that equipment that is submitted for recycling is actually recycled properly. Stage three presents ‘Reuse’, the current way of thinking requires equipment that is economically depreciated to be replaced where it can also be used for different functions within the same organization. This represents a shift in thinking. However, we don’t only have to think of reuse in terms of equipment. A datacenter uses a lot of electricity that is almost all turned to heat. All the generated heat must get out of the server room, but if the building that is housing the datacenter also has other uses than storing servers, like office space, savings on heating costs are a nice possibility. The main issue here is that if it is a large datacenter, it generates so much heat that even the office space does not require all the heat.There are initiatives that reuse the heat for district heating. This way the heating is not limited to one office space, but residential areas can use the heat generated by a datacenter (Gelens, 2009). Stage four presents ‘Track environmental info’ and is about how IT helps the organization to track how harmful its waste management is.

IT sustainability stages:		*Stage 1*	*Stage 2*	*Stage 3*	*Stage 4*
Corporate dimensions:		**Control waste**	**Preventing waste**	**Product reengineering**	**IT as an opportunity**
Govern / policies		Make IT pay for electricity Nothing turned on overnight	Power saving schemes Update and aggregrate	Make person responsible for Green IT Automatic sleep mode Locate near cooling opportunities Locate near (renewable) power	Monitor emissions Automated turn off and wake Auto loadbalancing between DCs
Source		Comply to legislation	Renewable energy sources	Procure energy efficient	Assess supplier environmental responsibility
Make	Datacenter	Air flow management Higher temperature	High voltace AC Hot aisle/ cold aisle Outside air Consolidate storage	Battery or central UPS Virtualization Liquid cooling Platform of choice Application portfolio renewal	Cloud computing
	Workplaces	Print double sided	Monitors Platform of choice	Desktop virtualization Voice over IP prints from account	Building automation Teleconferencing Teleworking Green competition / paperless
Return		Recycle	Follow up on waste management	Reuse	Track environmental info

Table 2 The Maturity for IT sustainability (MITS) model

4.4 Validation

Expert	Function	Organizational type
		Public sector:
Expert #1	Head ICT at Bèta faculty	Dutch university
Expert #2	Program manager Green IT	Large dutch government organization
Expert #3	Technical expert	Large dutch government organization
		Commercial organizations:
Expert #4	Green IT project leader	Large energy seller
Expert #5	Product Solution Manager	Large international softwarecompany
Expert #6	CSR spokesperson	Producer of multifunctionals / copiers
		Consultancy:
Expert #7	Lead Green IT projects	Large consultancy firm
Expert #8	Sustainability & Green IT consultant	Located at same large energy seller as above
Expert #9	Lead sustainability	Large consultancy firm

Table 3 Cooperating experts in the validation of the MITS model.

In order to validate the research artifacts nine experts in the field of IT-sustainability have been contacted and kindly requested to provide their input. An overview of their roles and affiliations are depicted in Table 3. The selection of respondents was not chosen to reflect specific sectors or organizations. The aim for the model was for it to be generally applicable to different kinds of organizations, which is why we chose to question respondents from organizations of various sizes and various sectors. We wanted to have experts from at least a public organization, a commercial organization, and an organization to promote Green IT. In total we interviewed nine experts. Eight were able to add to whole subject Green IT, and one person only about the subject sustainability.
For this validation we chose semi-structured expert reviews and all experts were interviewed face-to-face. The motivation to do this is because it seemed the most effective approach to explain how the artifacts were actually constructed if necessary. Even despite sometimes limited available time, all participants were prepared to participate in this research. As already explained in previous sections the model consists of the maturity levels, corporate dimensions and the ontology measures. In order to prevent the experts from being overwhelmed with information and thus too easily agreeing with what was shown to them, we asked their opinion on possible dimensions, measures & maturity levels upfront before the results of this research were shown.

The experts were first asked for suggestions on where an organization should be judged (1) , then the dimensions explained in section three were shown and we discussed which would best fit for the goal of this research (2). The results are shown here:

Expert	Comments:
# 1	(1) I would say datacenter and workplaces are of most importance for an average organization. (2) There is room for both these in all models you show which means all divisions could be made fit. This makes the SCOR defendable
# 2	(1) We ourselves run a lot of working spots, and also a big datacenter with different kinds of equipment (2) The SCOR model is a nice solution as it includes an overview of the surroundings of the IT organization
# 3	(1) To be able to know where an organization should be judged the scope of the research has to be known Apart from DC and workplaces sourcing and environmental friendly production/ recycling should be key components. (2) SCOR model seems like a good choice if scope is aimed at within organizations the Green IT within an organization, and not the phenomenon as a whole.
# 4	(1) I suggest you read the research done by Murugesan (2008). (which made us continue to (2)) (2) In the end, all stages you show offer a high enough abstraction level to base a model on. For us we have chosen the stages by Murugesan et al.
# 5	(1) Make sure the role of IT in reaching organizational sustainability OUTSIDE of the IT department is used, base it on the problem and make it grow to enabling. (2) SCOR looks good.
# 6	I am mainly focusing on workplaces and don't really have an opinion about this.
# 7	Depending on the definitions all are usable. Even the first (by Murugesan, 2008) could be used if the definitions are loosely interpreted. I recommend that you clearly describe why you use the dimensions you chose.
# 8	(1 & 2)"The stages Sourcing, Operations, and end of life management are found in most divisions I have seen. It might be best to follow the majority"
# 9	No opinion

Table 4: A selection of experts' comments with respect to the dimensions of the MITS model.

As can be concluded from the table above the SCOR model is defendable as the choice of dimensions for this model. Expert #4 insists on the dimensions from Murugesan (2008) where Green IT is described in the full life-cycle. The author of this research still thinks SCOR fits better because the scope is on Green IT within organizations. Furthermore, the dimensions by Murugesan (2008) seem less obvious with regard to IT as an enabler for sustainability. Expert #8 argues to "follow the majority" by choosing Sourcing, Operations, and End of life management, this is a choice. From the literature study performed for this research however cannot be concluded that those three dimensions form the majority.

Expert	A selection of notable expert comments:
# 1	Making a division like this is good, and for levels aimed at environment this should work. I however would like to see the influence of budget in the levels.
# 2	These levels seem to work out fine. What I like is the IT as an opportunity.
# 3	I think you are well on your way, but what I miss from the levels themselves is how to assure monetary investments pay off for the organization.
# 4	Nothing wrong with thoughts behind the levels. I however mostly read about models with 5 levels. Have you thought about why you have exactly 4 levels? The last level should be very hard to reach ("over the top"), and that's something I don't recognize here.
# 5	I like how you took several existing ones from literature and made your own interpretation.
# 6	I can mainly talk about anything concerning the workplaces. I personally am kind of sceptical to how most IT measures can help to sustain the organization as a whole (stage 4) without affecting the way the company works. Of course teleworking is an example of how it could work, but do people want that?
# 7	I know what we have, but better talk to person # 9.
# 8	Make sure that people understand IT can be used as enabler.
# 9	We ourselves use the division set by the book "From Green to Gold" (Esty & Winston, 2006). I recognize parts of it in your model. Maybe it could be complementary to your research?

Table 5: Some experts' opinions on the MITS model

At least experts #1 and #3 would like the model to take financial performance explicitly into account. This was however never the goal of the research, as the goal is to map how IT-related opportunities in organizations can support a sustainable environment and to investigate how these can be incorporated into organizational goals. However, when moving from responsive to strategic measures, in order to enhance the overall performance of the company, financial costs are of course a serious consideration. Furthermore, a lot of measures save energy which is an expensive commodity. Another expert asked if the bar for the last level should not be a lot higher, making it impossible to reach. The problem with the last level is that putting measures into that level would make the model case specific. The most general measures found from literature are already incorporated. Expert #6 is critical if IT can actually function as an enabler of organizational sustainability. This expert is not alone in this thinking (Fuchs, 2008), but as sources supporting the measures in section three suggest, the measures included here do. Further evaluation of the model takes place in the next section.

5 Conclusion & Discussion

Sustainability has in the last three decades quickly become an important management subject. Sustainability in IT—often found under the terms Green IT, Green Computing or Green IS—is a relatively new topic, not every organization is aware of its existence. The impact of IT on sustainability is not always clear to organizations, especially when no efforts have yet been undertaken to implement existing Green IT measures. However, IT can take up to 50% of the organizational energy usage depending on the primary process. The necessity for IT sustainability has been described in section one.

In our literature study we were not able to find maturity models concerning sustainability for IT. To enable the judging of the sustainable IT maturity we have used sustainability models from general strategy literature and translated them to the IT domain, resulting in the Maturity for IT Sustainability (MITS) model. We developed the model to help measure the state of Green IT maturity in organizations. This research helps organizations in creating a strategy to take the environment into account for their IT organization. The model consists of corporate dimensions and maturity levels for these dimensions.

For the validation of the created model sessions with persons responsible for (green) IT from various organizations were organized, and to be able to make the proposition that this model applies to companies of different sizes, the validation sessions were held with companies of different sizes and sectors.

Although certain aspects of green IS are taken into account in this research the subject does deserve further research. As can be recognized from the last maturity stage, IT is described as an enabler of sustainability in business. Known under the term Green IS, the subject has gained an increasing attention in recent literature. The goal of the model is to assist in judging the maturity of the greenness of IT which makes Green IS a logical next step, but without the help of a model that is made fit to specific situations it is hardly possible to say anything about Green IS. For example, we could add fleet-route optimization software to the model. This makes obvious sense for companies with large transportation fleets like postal services or distribution services. However, adding this fleet-route optimization to the model would mean that an organization without a big fleet would still be expected to have route optimization software. A possible research objective could be to map for example the value chain of porter with Green IS initiatives found in literature, and investigate if this can be made specific to certain sectors.

From comments during the validation phase we can conclude that follow-up research ought to look into adding budget as a factor for the model. While the aim of this model was environmental friendliness, some experts advised to include budget in the model. For being a Green IT study this is not necessary (based on the definition study in section three) but we find it worth investigating if progress in the maturity in the model also means an increase in budget required for specific measures at that maturity level. When applying the steps derived from Porter and Kramer (2006) described in section four, it is important that measures with a combination of the lowest cost and highest outcome will be selected. It would be interesting to know (supported by empirical evidence) which measures represent the most savings opportunities. Chances are however, that this would be very case specific, plus the risk rises that environmental effectiveness is no longer taken into account. Furthermore, there is no guarantee that the most cost effective measures allow for the best end result in the long term. Measures more visible to the public, or measures that lower the chance of negative publicity or even lawsuits might be better for the company result as they prevent larger costs with some investment. IT advisory companies like Gartner also state they expect growth in regulations. This makes investments in sustainability also an investment in continuity.

For the near future it can be expected that the impact of large scale IT usage on the environment will be reduced as the realization grows and the technology improves. It is not hard to predict the impact of IT as an enabler for sustainability will grow rapidly. Techniques like smart grids or sensor networks have the potential to counter the environmental sustainability questions we ask ourselves today. At this moment the fourth level in this maturity model is filled with some of the measures from the ontology that help companies become sustainable with the use of IT. The amount of measures that qualify for this level will probably grow as technology advances.

6 Bibliography

Boccaletti, G., Löffler, M., & Oppenhein, J. (2008). How IT can cut carbon emissions. *The McKinsey Quarterly* .

Calder, A. (2009). *Compliance for Green IT: A Pocket Guide.* IT governance publishing.

Esty, D. C., & Winston, A. S. (2006). *From Green to Gold.* Yale University Press.

Fuchs, C. (2008). The implications of new information and communication technologies for sustainability. *Environment, Development and Sustainability* , 291-309.

Gelens, M. (2009). *Datacenter krijgt dubbelrol als cv-ketel*. Retrieved March 10, 2010, from ZDnet: http://www.zdnet.nl/news/101231/datacenter-krijgt-dubbelrol-als-cv-ketel/

Gibson, S. (2009). DataCenter Waste Watch. *Smarter Technology* , 18-21.

Greenpeace. (2010). *Facebook update: Switch to renewable energy now*. Retrieved August 18, 2010, from Greenpeace.org: http://www.greenpeace.org/international/en/news/features/facebook-dump-coal190210/

Hart, S. L. (1997). Beyond Greening: Strategies for a Sustainable World. *Harvard Business Review* , 66-76.

Johnson, G., Scholes, K., & Whittington, R. (2008). *Exploring Corporate Strategy: Texts and cases.* Edingburh: Pearson education.

Keays, G. (2010). *5 stages of sustainability continuum*. Retrieved April 14, 2010, from Lansbridge University Blog: http://www.lansbridge.edu/blog/index.php/tag/5-stages-of-sustainability-continuum/

Keijzer, R. (2009). *Rekencentrum midden tussen de kassen*. Retrieved March 10, 2010, from automatiseringgids: http://www.automatiseringgids.nl/artikelen/2009/29/rekencentrum-midden-tussen-de-kassen.aspx

McKeefry, H. L. (2008). A high-energy Problem. *Eweek* , 18-19.

Miller, R. (2008). *Data Center Used to Heat Swimming Pool*. Retrieved March 10, 2010, from DatacenterKnowledge: http://www.datacenterknowledge.com/archives/2008/04/02/data-center-used-to-heat-swimming-pool/

Murugesan, S. (2008). Harnessing Green IT: Principles and Practices. *IT Pro* , 24-33.

Nidumolu, R., Prahalad, C., & Rangaswami, M. (2009). Why sustainability is now the key driver of innovation. *Harvard Business Review*, 56-64.

Nusca, A. (2010). *HP opens first wind-cooled green data center; most efficient to date* . Retrieved March 17, 2010, from smartplanet: http://www.smartplanet.com/business/blog/smart-takes/hp-opens-first-wind-cooled-green-data-center-most-efficient-to-date/4191/

Olson, E. G. (2008). Creating an enterprise-level "green" strategy. *Journal of Business Strategy* , 22-30.

Patterson, M. K., & Fenwick, D. (2008). *The State of Data Center Cooling.* Intel / Digital Enterprise Group.

Piper, J. (2004). *Making the Switch: Automated Lighting Control Strategies*. Retrieved August 26, 2010, from www.greenbiz.com: http://www.greenbiz.com/business/research/report/2004/03/05/making-switch-automated-lighting-control-strategies

Porter, M. E., & Kramer, M. R. (2006). Strategy & Society: The Link Between Competitive Advantage and Corporate Social Responsibility. *Harvard Business Review* , 78-92.

Porter, M., & van der Linde, C. (1995). Green and Competitive: Ending the Stalemate. *Harvard Business Review* , 120-134.

Reams, C., & Brown, D. (2010). Toward Energy Efficient Computing. *communications of the ACM* , 50-58.

Ritschard, M. R., & Herrick, D. R. (2009). Greening your computing technology, the near and far perspectives. *Proceedings of the ACM SIGUCCS fall conference on User services conference*, 297-304). ST louis: ACM.

Schmidt, N.-H., Erek, K., Kolbe, L. M., & Zarnekow, R. (2009). Towards a Procedural Model for Sustainable Information Systems Management. *Proceedings of the Fourty-Second Annual Hawaii International Conference on System Sciences (HICSS-42),*. Waikoloa, Big Island, Hawaii.

Schop, E. (2010). *Meeste bedrijven laten 'groene ICT' links liggen* . Retrieved June 23, 2010, from www.automatiseringsgids.nl: http://www.automatiseringgids.nl/it-in-bedrijf/kosten-en-baten/2010/25/meeste-bedrijven-laten-groene-ict-links-liggen.aspx

Smeitink, M., & Spruit, M. (forthcoming). Maturity for Sustainability in IT: Introducing the MITS. In P. Ordoñez de Pablos (editor), *Green Technologies and Business Practices: An IT Approach.* IGI Global.

Stevens, H., & Pettey, C. (2009). *Gartner's 2009 Hype Cycle Special Report Evaluates Maturity of 1,650 Technologies*. Retrieved February 2010, from http://www.gartner.com/it/page.jsp?id=1124212

Watson, R. T., Boudreau, M.-C., & Chen, A. J. (2010). Information Systems and Environmentally Sustainable Development: Energy Informatics and new directions for the IS community. *MIS Quarterly* , 23-38.

Widmer, R., Oswald-Krapf, H., Sinha-Khetriwalb, D., Schnellmannc, M., & Boeni, H. (2005). Global perspectives on e-waste. *Environmental Impact Assessment Review , 25*, 436–458.

Willard, B. (2005). *The Next Sustainability Wave: Building Boardroom Buy-in.* Gabriola Island: New society publishers.

Zarnekow, R., Brenner, W., & Pilgram, U. (2006). *Integrated Information Management: Applying Succesful Industrial Concepts in IT*. Berlin: Springer Berlin.