ICT Energy Conservation on the UU Campus

Overcoming barriers for energy saving measures

Consultancy Report
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Executive Summary

This report focuses on barriers and solutions for the implementation of energy saving measures for student computer workstations at Utrecht University (UU). In previous years two consultancy reports proposed energy saving innovations that have large potentials for energy and costs-savings. Nonetheless, the given advice has not found widespread adoption at UU. While investigating the contemporary situation of the ICT domain, several barriers that had impeded the implementation were found. For all these barriers solutions were derived in order to support the future implementation of energy saving measures and to promote energy efficiency within the ICT domain at UU. We summarise our findings as follows:

1. There are only minor technical barriers. Computers that reside in standby mode may lead to the perception that these computers are out of order. However, user confusion could be easily prevented through appropriate communication of the energy saving measures, i.e. awareness campaigns by means of stickers, posters, email newsletters.
2. Economic barriers are of major importance. The shared energy bill for all faculties results in low economic incentives for individual faculties to invest in energy saving measures. A new system in which energy costs are distributed by the polluter-pays principle will ensure that this barrier is overcome. An energy management system needs to be implemented subsequently to identify the possible improvements in each faculty.
3. On a macro development level, there is generally low awareness about the energy saving potential. More awareness could be raised through both top-down (i.e. communication from the UU board) and bottom-up initiatives. For the bottom-up initiatives a student task group (STG) with facilitation from the Green Office is proposed to support the Information Technology Service (ITS) in the implementation and to avoid failing on student user demands and usability.
4. The institutional policy is not optimal at the moment. The prevailing barriers in this domain are the decoupling of the responsibility and the executive power in the ICT domain. At the moment the Information Technology Service (ITS) is the executive power while the faculties are still responsible for the ICT services and decide with a majority on the future direction of the ICT domain. Concrete policy targets on energy savings for the ICT domain from the UU board would solve this conflict.
5. In terms of the characteristics of the ICT domain there is a lack of awareness and knowledge on the easily realisable potential of energy savings. By introducing binding energy saving targets and appointing responsible persons with an interest for energy use in the ICT domain, communication and coordination achievements are channelled. The aforementioned energy accounting system could be used to measure progress towards the targets.

While addressing the barriers and by acknowledging the work of previous groups, this report refined the proposed advice into two major energy saving measures that are characterised by an ease of implementation but yet significant cost-savings. These are:

1. A default monitor brightness of 50% (compared to 90% before) for all monitors at UU. This will be applicable to all existing monitors and future procurements.

2. All student workstations - and at a later stage also staff workstations and laptops - will be automatically turned into standby mode after 20 minutes of inactivity once the user has been logged out.

If both these simple measures are implemented for 2000 student workstations, approximately 314 MWh electricity and €38,000 will be saved annually, while simultaneously helping to promote the sustainability of the ICT domain at. The report suggests a six month roadmap depicted in Figure 1 to guide the implementation process.

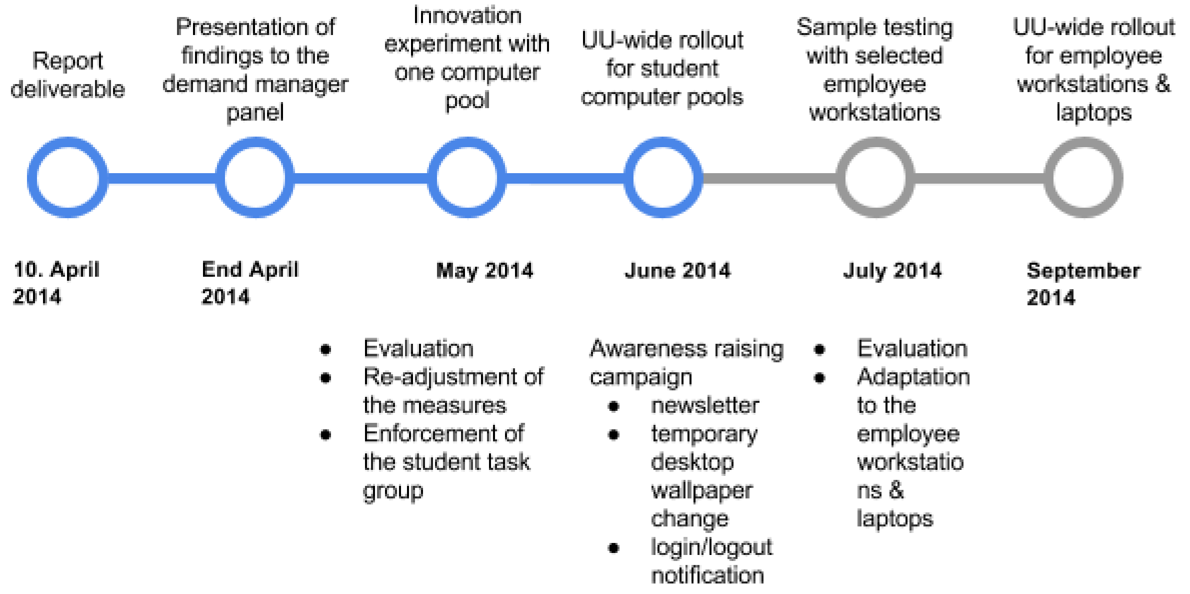

Figure 1: Roadmap for implementation of energy saving measures at UU (Source: own illustration).

1. Introduction

Utrecht University (UU) identified four strategic themes that will guide the future development of the university. One of these core values is *Sustainability*. Sustainability should be embodied not only through means of research but as well by aligning UU as an institution and being a role model for sustainability in practice (UU, 2014a).
One aspect of sustainability is the issue of energy use and energy efficiency. Most prominent energy scenarios assume that in the upcoming decades towards 2030 or 2050, increases in energy efficiency have the largest potentials for offsetting the trend of continuously rising energy demands and a rise in global greenhouse gas emissions (EC 2006; Baroni 2013; IPCC 2007). According to a joint study by the OECD/IEA, up to 50 percent of total global emissions could be saved by 2050 through an increase in energy efficiency (OECD, 2012). One of the sectors under consideration for energy savings to be realised is the information and communications technology (ICT) domain. In 2008, the ICT sector was globally responsible for 3 percent of worldwide energy consumption (Fettweis et al., 2008). Looking at the environmental side, it is estimated that up to 2020 the carbon footprint will rise to up to 1.4 GtCO2e globally if no extra efforts are taken (The Climate Group, 2008).
From this background, the ICT domain of UU has been identified as a target area with relevant energy saving potential. UU is a large educational institution with almost 30,000 students and 6,500 staff members, where ICT services are intensively used and needed. In previous years, two student consultancy reports proposed several ICT energy saving measures (Bernhard et al., 2013; Voorneveld et al., 2011). However, to date none of the given advice has found adoption. This surprising result contrasts UU's own ambitions to play a leading role in achieving higher energy efficiency and its set goal to achieve 30% energy savings by 2020 compared to 2005 energy use (UU, 2014b). This leads to the assumption that certain barriers could have existed that impeded the implementation of the proposed energy saving measures. This report will therefore focus on the identification of these barriers and propose effective solutions to overcome them. From this objective the main research question is derived as follows:

> *How can existing energy saving advice be implemented in the ICT domain at Utrecht University?*

In order to be able to answer the research question a set of sub questions is developed. To start an assessment of the implementation of proposed energy saving advice is needed. *What energy saving measures have been proposed in the previous consultancy reports? What is the current implementation status of the given energy saving advice?* It will then further be looked at why the proposed recommendations were or were not adopted and what impeded their implementation. Only by knowing the barriers and the related academic field(s), qualified solutions can be found to overcome the implementation barriers for energy saving measures at UU in the ICT domain. *What are existing barriers that impeded a successful implementation? How can these barriers be effectively overcome?*

The report is structured as follows. Section 2 will present an overview of the methodology that was used to address the research questions. In section 3 the results of the previous consultancy reports will be reviewed and discussed. Section 4 first introduces theoretical insights on innovation processes and their diffusion. Section 5 then proceeds with the identification of stakeholders. In section 6 the identification of the barriers that have impeded the implementation of the existing energy savings advice is described. Section 7 will then discuss concrete steps to overcome these barriers. Section 8 proposes an action plan for direct implementation of a specific set of energy saving measures at UU. Finally, a discussion of the results in section 9 and a conclusion in section 10 will complete the report.

2. Method

An overview of the methods that were used to answer the research questions can be found in Figure 2. To summarise the existing energy saving advice on ICT at UU, a literature review of the existing student consultancy reports (Voorneveld et al., 2011; Bernhard et al., 2013) is conducted. Next, a literature review on the diffusion of energy saving innovations is conducted to adapt a theoretical framework for the identification of implementation barriers at the ICT domain of UU as an educational institution. Thereby, the different barriers can be traced back to their origin and the assessment becomes more structured. All the elements of the theoretical framework are meaningful to explain barriers that can hamper the implementation of energy saving innovations. Subsequently, relevant stakeholders are identified by adopting and adjusting a stakeholder framework. After that, using the theoretical framework and its different elements, an interview guide (see Appendix I) is created to identify existing barriers at UU. For this, the interview guide was used in semi-structured interviews with identified stakeholders.

During the interviews information on the implementation status of all proposed measures, as well as the barriers impeding measures that were not implemented is extracted. The semi-structured interviews were chosen as a method to allow for an open communication and for new ideas to be brought up during the interviews (Cohen & Crabtree, 2006). Semi-structured interviews were also chosen to circumvent the possibility that interviewees withhold information. The aim is to create a comfortable collaborative environment, where solutions, and not errors, and its responsible parties want to be found. Direct and strict questionnaires might impede this objective. After the identification of barriers, solutions to overcome these are derived from literature on the developed frameworks, as well as extended literature, where necessary. Furthermore, if applicable, responses from the semi-structured interviews are used to propose practically targeted solutions.

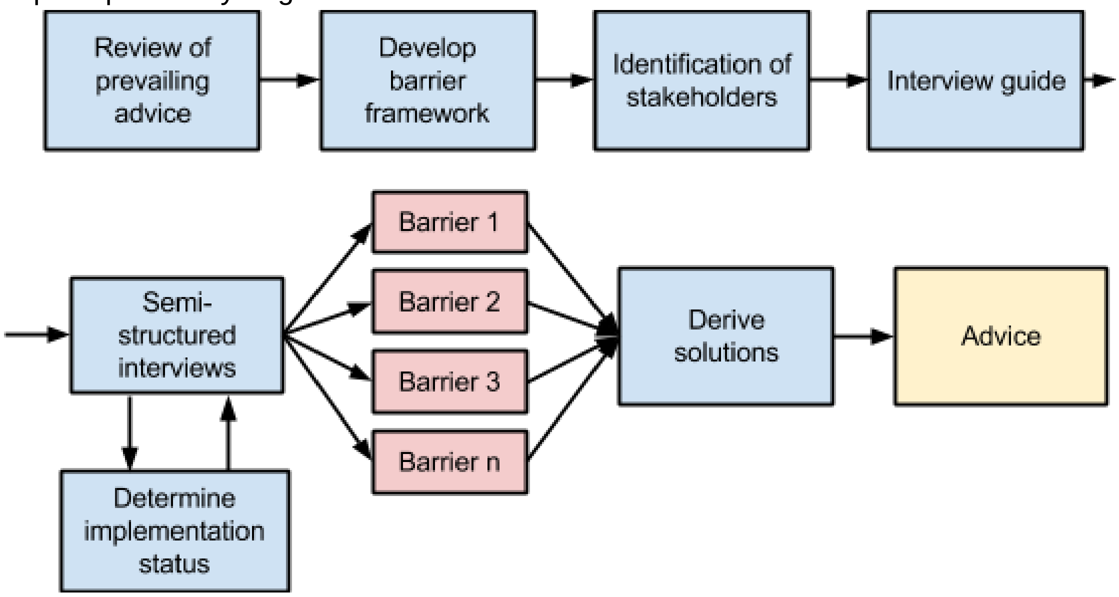

Figure 2: Flowchart of the methodology (Source: own illustration).

3. Previous ICT energy saving advice

3.1 Review of past reports

The first report by Voorneveld et al. (2011) mainly focusses on software solutions due to high expectations of the ICT department for the implementation of new measures. These were reported to be (1) short-term implementation, (2) low costs and (3) high effectiveness. The report by Bernhard et al. (2013) uses a broader scope for possible solutions and also includes measures for servers and datacentres. Altogether, both reports propose options to conserve energy that can be divided in the following categories:

- Workstations
- Servers
- ICT procurement
- Organisation
- Social-behaviour

3.1.1 Workstations

The report from Bernhard et al. (2013) focuses on the upgrade from Windows XP to Windows 7 for all student and employee computers. Due to incompatibility, power management options for PCs cannot be implemented with computers that use Windows XP. The majority of the features that come with other power management software are already included in Windows 7. For instance it offers the possibility to create customised power plans for idle/standby and sleep/hibernation timers, adaptive brightness, core parking, intelligent timer tick and time coalescing. Bernhard et al. thus identify that - given that the right power management options will be enabled - a switch from Windows XP to Windows 7 can save UU €175,000 due to electricity savings up to the year 2016 starting in 2013 when the report was published. However, additional purchasing costs that are required for the upgrade, such as licensing costs, are not taken into account in this calculation. Voorneveld et al. (2011) roughly estimated a potential of €150,000 annually that could be saved by power management software. However, they assumed that student workstations are not switched off at night and calculated with a share of 33% of not switched off workstations on the campus (based on a total of 10,000 PCs at UU). Given the fact that student workstation do - at least now - switch off at night, the figure of €150,000 is likely to be overestimated.

At Liverpool University a software tool was developed that shut down computers when they are not used for a certain time, this tool saves the university £64,000 annually (James & Hopkinson, 2009). At the University of Amsterdam the energy use of computers was reduced by 43% by implementing power management software (Voorneveld et al., 2011). Both the analysis and examples of other universities thus show that the implementation of software solutions is possible and economically attractive.

Apart from the software, also savings at the hardware side can be realised, i.e. brightness reduction of workstation monitors. The monitor brightness which most of the time is automatically set at 100% could be lowered to 50% without significant impact on user experience while saving between €3,500 and €5,200 annually (Voorneveld et al., 2011).

3.1.2 Servers

The Power Usage Effectiveness (PUE) is a measure to calculate the energy efficiency of data centres. It is calculated by dividing total energy usage of a data center by the energy used for

the actual servers. The lower a PUE is, the smaller the share of energy needed for overhead. The highest potential for energy saving measures for the overhead energy of a data center can be realised with cooling.
The possibility of energy savings in server cooling are extensively covered by Bernhard et al. (2013). Due to the relatively cold climate in the Netherlands, on 97% of days throughout a year outside air is cold enough to be used for passively cooling the servers. Only on warm summer days (3%) additional active cooling is needed. It is estimated that due to this passive cooling opportunity, altogether up to 80% of the total energy consumption for cooling could be saved. It is also mentioned that because the servers are online 24 hours per day, the payback time of investment into passive cooling would be relatively short. Bernhard et al. (2013) recommends to gain advice from the governmental agency Agentschap NL for choosing the right tailor made options for server cooling.
The report by Bernhard et al. (2013) discusses the options of energy savings through server software extensively. These will bring a running system to a lower power state according to a set of configuration preferences. It acts as a sort of "screensaver" for servers, watching the process table for activity rather than the keyboard or mouse. Utilising this software allows for energy savings while maintaining the same service levels. One of these systems, The PowerNap, was awarded the predicate ‘best practise’ with 74% potential electricity savings. This could save €470,000 up to 2016. Another option is the integration and optimisation of virtual machine software. Thereby the free software Xen has proven to be the best option, offering cost-saving potentials of €310,000 up to 2016 (Bernhard et al., 2013).
Another option, making all other server implementation redundant, is the outsourcing of the computation needs to a cloud provider. This process would eliminate the need to maintain an own infrastructure, generally leading to savings (Bernhard et al., 2013). However, the level of services from the cloud provider of course should be comparable to the current level of services to still being able to meet user demand. Furthermore, Bernhard et al. (2013) highlight that UU is already using cloud computing for certain services, such as Google’s Gmail for the email system.

3.1.3 ICT procurement

Concerning the procurement of hardware, both Bernhard et al. (2013) and Voorneveld et al. (2011) come to the same conclusion that a UU-wide procurement standard should be implemented. Voorneveld et al. notice that the only criteria on procurement of hardware at the moment are direct (i.e. purchasing, instalment etc.) costs and performance, not including energy efficiency standards. Voorneveld et al. argue that the current criteria should be extended by energy efficiency criteria for more energy saving decision-making. Furthermore, it is noticed by Bernhard et al. (2013) that it is not economically feasible to replace all hardware for new energy efficient hardware. Instead only the most inefficient hardware should be replaced.

3.1.4 Organisation

Bernhard et al. (2013) advise that extra management support should be established to keep the sustainability momentum going. Voorneveld et al. (2011) come with a similar solution, which is, to appoint a person that is particularly responsible for energy efficiency in ICT or even a centralized energy savings unit which can conduct further research and influence ICT decisions. Support from the university board is thus vital according to both Bernhard et al. (2013) and Voorneveld et al. (2011).

Furthermore, it could be worthwhile to join an initiative for Green ICT such as the PIANOo[1] and SURF[2] as suggested by Bernhard et al. (2013). Thereby knowledge and experiences about best practises are shared among stakeholders, which could ease the necessary knowledge building on energy efficiency in ICT. These initiatives could also serve as a platform for the communication of the results.

3.1.5 Social-behavioural

Only the report by Voorneveld et al. (2011) discusses the social-behavioural aspects. One possible option is to concentrate users at one part of a building after a certain time, i.e. after 17:00 when many computers are not being used anymore. If all computer rooms - except for a few - were to be closed at this time, computers in this room could be shut down while the users are able to continue working in another room. Another option is to educate the users about energy usage from computers and inform users about the sleep mode option or the benefits of shutting down computers and/or monitors instead of leaving them in idle mode.

3.2 Implementation status of proposed advice

The revision of the previous reports shows that several measures have been proposed that could lead to energy savings in ICT at UU. Indeed there were some measures implemented since the previous reports, but this has been done independently from the recommendations from the previous reports. A reason is that the previous reports were not received by most stakeholders (Scheeren & Yadav, 2014; Schipper, 2014; Iseger & Deuzing, 2014). Furthermore, Ron Mast (2014), who was interviewed for the previous report by Bernhard et al. (2013), received the report but only perceived it as a research project instead of actual advice. Cooperation was therefore only done for the educational value of the research and the advice was consequently not implemented.

Looking at the improvements, a major transformation happened in the server domain. Concerning workstations, organisation, and social-behavioural, we could not find any evidence that the proposed advice has been implemented. All computers have been upgraded to Windows 7, but this was not done due to the proposed advice but because of ending life-time support for Windows XP (Scheeren & Yadav, 2014). Furthermore, Windows 7 or other power saving measures have not been enabled. Concerning the server infrastructure the only evidence can be found for the servers. UU is currently constructing a new centralized data centre, which will begin its operation in April 2014 (Bernhard et al., 2013). The new data center uses technologies that were recommended in the report by Bernhard et al. (2013), i.e. the centralization of the servers, the maximum virtualization of the server and the use of efficient blade-servers. However, the implementation was achieved independently from the outcomes of the previous report and can be considered autonomous technological improvements (Schipper, 2014). Contrary to findings of previous reports, sustainability and energy efficiency are already included as general procurement criteria from the board (UU, 2014c). Sustainable procurement expertise from PIANOo and FIRA[3] are used (van Zeijl, 2014). An overview of which recommendations have been and which have not been implemented is given in Table 1.

[1] PIANOo, Expertise centre for procurement (http://www.pianoo.nl/)
[2] SURF, Collaborative organisation for ICT in Dutch higher education and research (http://www.surf.nl/)
[3] FIRA, http://www.fira.nl/rating-web/visitor/en/FIRA_Platform/FIRA_Platform/Introduction_rating.html

Table 1: Implementation status of energy saving measures (Source: Bernhard et al. 2013; Voorneveld et al. 2011).

ICT domain	Recommendation	Description	Status
Workstations	Extended automated power management	Saving potential for student computers of €38,000 per year[4]	Not implemented
	Reduced monitor brightness	Saving potential of €3,500 - €5,200 per year	Not implemented
	Switch to Windows 7	Windows 7 has energy saving features incorporated that lead to 14% energy savings	Transition is almost completed, but saving measures are not used for students and optional for staff (own choice)
	Concentrate users	Close some computer rooms after a particular hour (due to low student activity on the campus)	Not implemented
Servers	Centralize servers	80% savings in energy costs for cooling + Tax savings (Agentschap NL)	New data centre is centralized, but the energy savings are yet unknown
	Server software	Energy savings: 10% (OnDemand Governor), 50% (Linux RK), 76% (Powernap) Increased virtualization level has an energy saving potential of approximately 33%	Virtualization optimised
	Outsourcing computation, storage and	Feasibility/willingness	Not implemented

[4] Own calculations, see section 8.1

	network to a cloud provider		
ICT Procurement	Introduction of energy efficiency criteria	Include EnergyStar regulations in procurement policy	EnergyStar criteria (via PIANOo) and CSR[5] criteria (via FIRA) No additional criteria
	Centralize ICT purchasing decisions for servers and hardware	Create general binding policy via board of directors that guides purchasing decisions	Central hardware procurement by ITS through one supplier, faculties decide on specific purchases
Organisation	Appoint a person particularly responsible for energy efficiency within ICT	Having centralized data on energy consumption and potential savings.	Not implemented
	Establish central energy saving unit	Having centralized data on energy consumption and potential savings.	Not implemented
	Join an initiative for knowledge sharing on Green IT	PIANOo/SURF	Work with PIANOo. Also with SURF, but extent unknown
Social-behaviour	Awareness campaign on energy efficiency and energy savings targeted on staff and students	Raise sensitivity to own behaviour	Not implemented

Source: Based on interviews and email communication with staff and Section 3.1.

[5] Corporate and Social Responsibility

4. Theoretical framework

For the purpose of this study, we define energy savings measures in the ICT domain as the innovation in question and the widespread adoption at UU its successful diffusion. Innovations are commonly defined as the introduction of something new (Lambooij, 1988, p. 13). They are the result of a more or less rational decision-making process after the discovery for a need of adapting current production or consumption processes (Dieperink et al., 2004). After successful introduction in one field, innovations can be adopted in other fields which is referred to as the *diffusion of an innovation* (Lambooij, 1988, p. 16). As described in the previous section, many of the proposed innovations have not yet diffused at UU. In order to derive the barriers and to explain why energy saving innovations have not been implemented, we base our analytical approach on a framework proposed by Dieperink et al. (2004, p. 780). The framework offers two major advantages that make it very suitable for the UU case. Firstly, it has been specifically designed for understanding energy saving innovations. Secondly, it combines insights from a variety of fields such as technology dynamics, the sociology of innovation, policy sciences, and business administration and is thus well suited to approach complex decision-making in a large-scale educational institution such as UU. Yet due to its focus on the industrial sector, the framework was modified with regards to some aspects to make it compatible with the educational environment. Figure 3 presents the framework adapted to the specific characteristics of the ICT domain of an educational institution[6].

4.1 Nature of the decision-making process

The core of the framework is constituted of the decision-making process of the educational institution. The characteristics of the decision-making have a major impact on whether an energy saving innovation will be adopted. For instance, feedback interactions between decision-makers can reinforce certain behaviours over time and could thus accelerate diffusion (Brock & Durlauf, 2001; Dugunji & Walker, 2005). The decision-making process is separated into four steps. First, the institution must perceive a serious need to innovate and change its current use of ICT resources. Otherwise it will not enter the decision-making stage. Second, the institution must be aware of the available energy saving innovations and capable to have an unbiased perception of their qualities. Third, the general nature of the decision-making at the institution will influence how thoroughly the assessment in step four will be conducted and whether it will follow a mostly rational path as assumed in economic analysis. Fourth, in the last step the innovations are assessed using various indicators and criteria such as economic factors, technical properties of the hardware, functionality/quality, new window of opportunities offered by adoption, compliance with policies, or abated CO_2 emissions.

Each of the steps in the decision-making process is influenced by several other variables which are explained in detail in the follow sections.

4.2 Characteristics of the ICT domain

The characteristics of the ICT domain of an institution are crucial as they influence the entire decision-making process and thus have direct impact on whether energy saving innovations will be implemented. Within the ICT domain, important variables are for instance the available

[6] We intentionally aimed at preserving the generic character of the framework to ensure applicability to institutions other than Utrecht University.

knowledge about energy saving, the properties of the existing hardware infrastructure, the current electricity consumption and how accurately it is allocated to consuming units, the general willingness to innovate, and the existence of management systems for energy consumption.

4.3 Energy saving measure

The characteristics of the innovation is considered by decision makers in step four of the decision-making process: *the assessment stage*. Assuming a predominantly rational assessment process in most institutions economic aspects such as the payback period of the investment are important factors for implementing energy saving innovations (Stoneman, 1983; Thirtle & Ruttan, 1987). Furthermore, technical aspects such as the fit into the existing ICT infrastructure, ease of operation and competing options will determine which of the available energy saving innovations will be considered for implementation.

4.4 Macro developments

Macro developments can have both an impact on the assessment process and on the ICT domain of an institution. For instance, the general public awareness of sustainability at the educational institution could lead to changes in the demand of users for more energy savings of the ICT domain. Changes in electricity price in turn can influence the willingness of the ICT domain to innovate, assuming that electricity consumption, and thus costs, can be directly allocated to the ICT domain.

4.5 Context of the educational institution

Stakeholders and institutional policy can have a major impact on the ICT domain of an institution. From a policy perspective, regulations, subsidy/incentive programs and covenants can either compel or induce a serious occasion to innovate. Yet apart from their existence, their effectiveness of top-down policy is equally important (Kemp, 1997; Arentsen & Hofman, 1996; van der Doelen, 1989). Support for knowledge transfer, offered by local or national governance can furthermore ensure that the perception and assessment of energy saving measures is conducted correctly. Secondly, stakeholder groups can influence the characteristics of the ICT domain. For instance, if users of the institution demand for more energy-efficient software implementation. The role of external software company partners on the other hand can lead to a lock-in of existing software structures and thus hamper the implementation of energy saving innovations. Furthermore, software suppliers could have such an influence that the decision-making for the adoption of an innovation is based to a large extent on their external advice.

Finally, the level of cooperation (Jacobs, 1990) and the role of communication (Rogers, 1995) of the ICT domain with other departments within the institution can influence the extent to which the ICT domain will perceive a serious need to innovate.

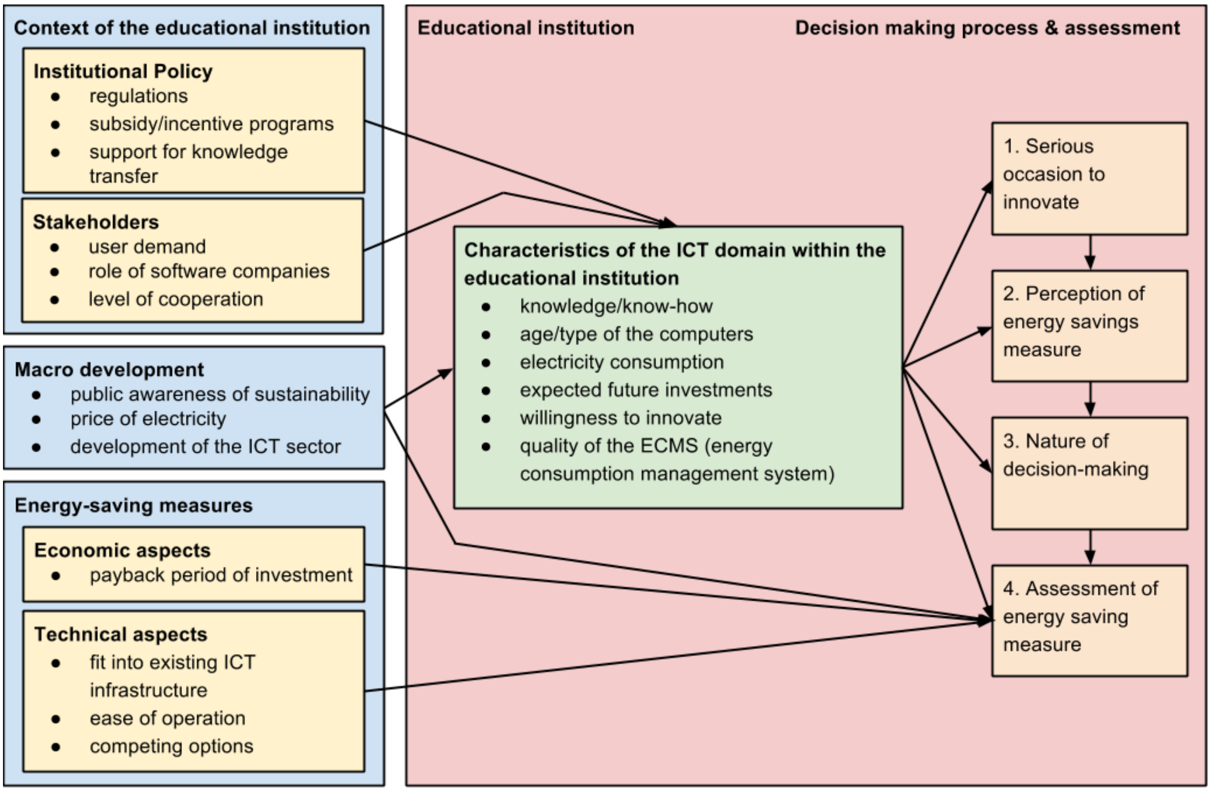

Figure 3: Theoretical framework adapted to the specific characteristics of the ICT domain of an educational institution (Source: adapted from Dieperink et al., 2004).

5. Stakeholder identification

To identify the barriers on implementing energy saving measures for the ICT infrastructure of UU, involved stakeholders and their interests need to be identified. Often the organisational structure of an institution is so complex that the diffusion of new technologies is significantly reduced (Berardi, 2013). For a successful implementation of energy saving measures, ideally all stakeholders are integrated in the decision-making process. All the stakeholders' interests must be represented to arrive at a common denominator and support the final implementation decision: *"....strong support from engaged stakeholders has sometimes been a driver for spurring this transformation"* (Berardi, 2013, p.521).

5.1 Stakeholder mapping

Stakeholder mapping consists of three steps: stakeholder identification, determination of stakeholder's concern, and stakeholder impact analysis (Mitchell et al., 1997). In Table 2, four groups of stakeholders are identified that are relevant for implementing energy saving measures in the ICT of UU. Herein their main focus and objectives are described. The identification of stakeholders is an important step in the implementation process of energy saving measures, since the interests and powers of stakeholders become clear and proposals can be done much more specifically to the stakeholders with the most influence on the decision making process.

Table 2: Stakeholder categories and their focus and objectives (Source: own adaption).

Category	Main focus	Stakeholders	Objectives
Client	Economic savings	University board	Energy consumption/economic savings, quality, time of investments return, sustainable image
User	Usability	Students and staff	User friendliness, sustainable ICT by keeping equal service level,
Maintenance management	Technical feasibility	Information Technology Services	Quality, functionality according to clients and users' needs, reliability
Executive Management	Logistics and implementation	Information and demand managers of the faculties	Reliability, implementation process, stakeholder integration

The organisational structure of ICT has proven to be quite complex. To give an overview, we visualized the structural relations between the university board, students and staff, the ITS and the Information and Demand managers in Figure 4.

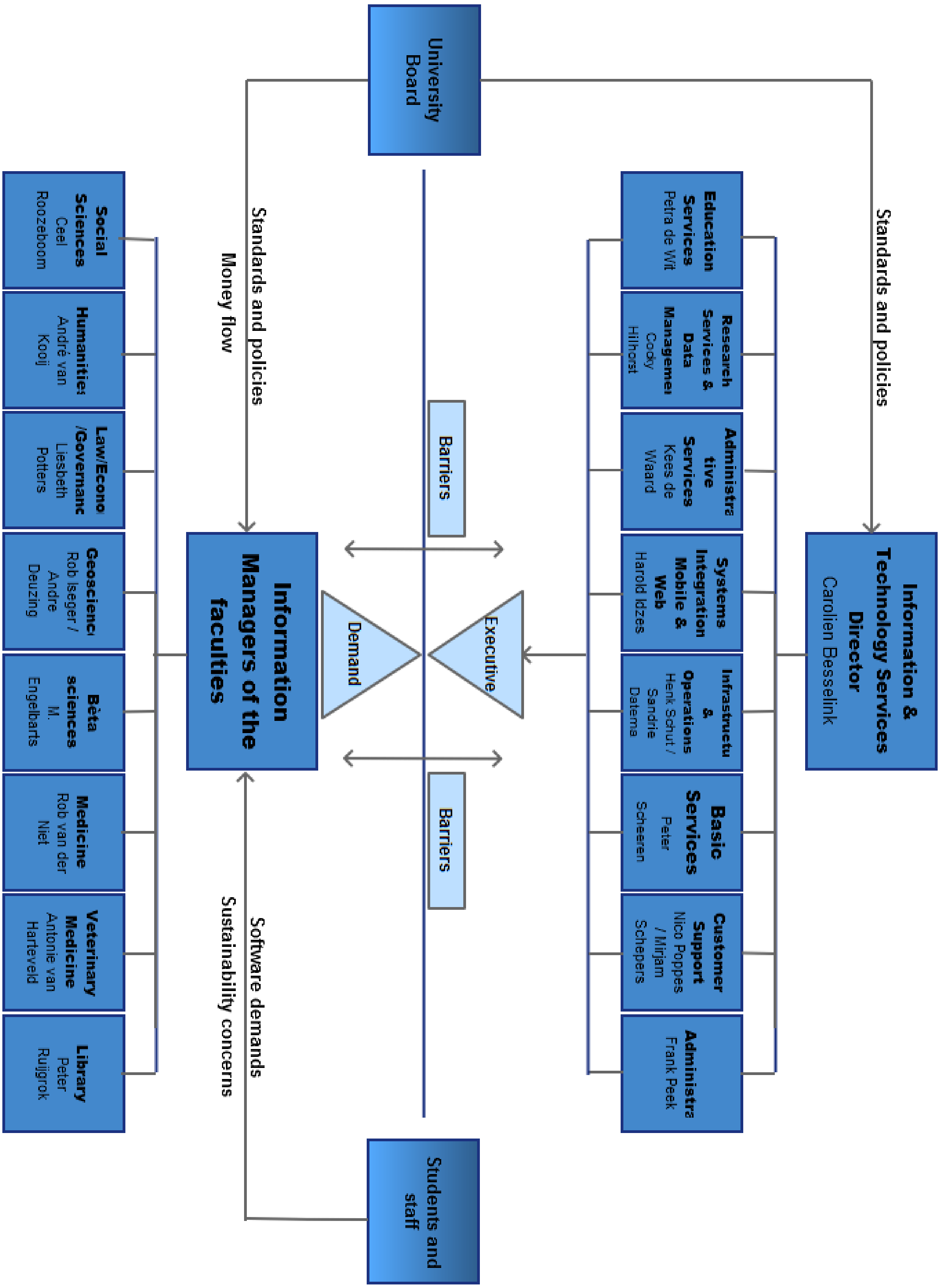

Figure 4: Organisational structure in the ICT - hierarchy and relations (Source: own illustration).

5.2 Power-interest relationship of stakeholders

Not all stakeholders have the same power in the decision making process or the same interest in, in our case, energy saving measures in ICT. Unfortunately, as Berardi (2013) is pointing out, stakeholders with high power to make the implementation of new technologies often have a low interest in actually doing so. A reason for this could be the fact that most often the one that has to pay for the implementation of a new technology does not receive the benefits of it (Pinkse & Dommisse, 2009), a so called principal-agent problem. Key is to identify the stakeholder with the most optimal power-interest relationship and try to get them convinced to work together with the other stakeholders to raise their interest and to implement the proposed energy saving measures. Figure 5 illustrates the power-interest relationship of the identified stakeholders regarding energy saving measures in ICT on UU. We can learn from the power-interest relationships who are the most interesting stakeholders to target our energy saving measures proposals to, for the highest chance of implementation. Linking this to Table 2, we can find the objectives of the key players in the decision making process. These should be considered in our proposal.

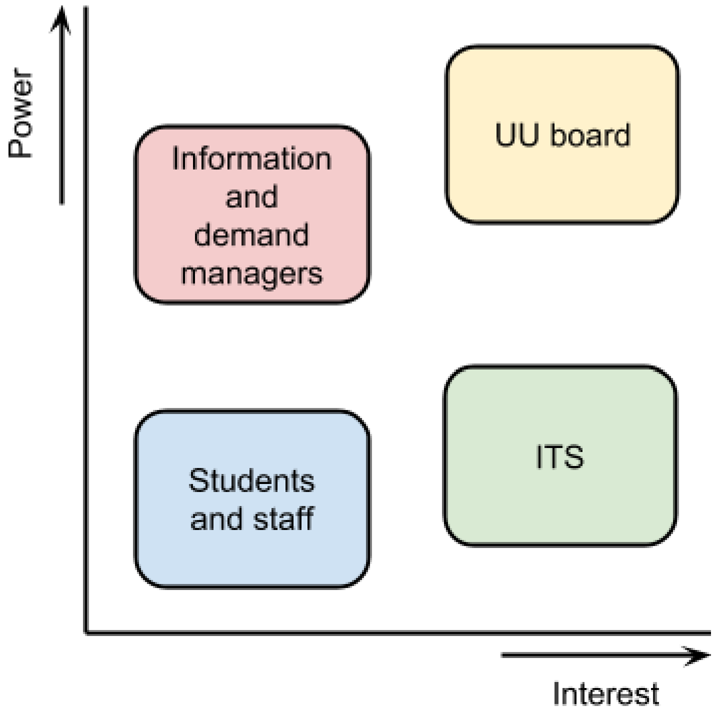

Figure 5: power-interest relationship stakeholders (Source: own illustration based on interview responses).

Furthermore the decoupled responsibility and split incentives with regard to energy saving measures is depicted. On the one hand the Information and Demand managers have high power in the decision making process, but are not responsible for the technical implementation. Their interest consequently is low due to the lack of knowledge about the possibilities.

The ITS department facilitates the technical part of the implementation. Their interest is high, they are aware of the relative simplicity of implementing energy saving measures. However, they do not have the power to implement energy saving measures on their own behalf (Scheeren & Yadav, 2014). The university board has both high power and high interest. Their interest is high in the context that they want to emphasize and communicate a sustainable image. Students and staff have both low power and low interest regarding energy saving measures. Their main interest is in maintaining a high level of user friendliness.

It can be concluded that for implementing energy saving measures in the ICT domain on UU, the key players that need to be targeted are the Information and Demand managers of every faculty and the ITS department. The stakeholders with high power and low interest and the ones with low power and high interest.
We decided to approach Peter Scheeren, manager Basic Services of the ITS, and several Information and Demand managers of the faculties. In the end we had interviews with Peter Scheeren and Shashi Yadav (ITS), Rob Iseger & André Deuzing (Information and Demand managers of Geosciences) and Ron Mast (Demand Manager of Social Sciences). For questions regarding the new data center we had email contact with Jeroen Schipper, who designed the plan for the new data center.

6. Barriers

Several particular energy saving measures were introduced by previous reports (Section 3). With respect to technical barriers the analysis will focus on given advice on workstations. Barriers concerning the server environment are not looked further into due to the start-up of the new server data center. Economic aspects concern the organisation of the ICT domain as a whole and their effects on implementing energy savings. The remaining sections all address existing barriers in UU as a whole, regarding institutional policy, stakeholders and ICT characteristics in the ICT domain.

6.1 Energy saving measures

6.1.1 Technical aspects

With regard to workstations there are energy saving options available in Windows 7 that automatically put the computer into a standby mode (such as sleep or hibernate) and according to ITS these options can do everything needed for saving energy and no separate power management software is necessary (Scheeren & Yadav, 2014). The transition of all UU computers to Windows 7 is almost completed and ITS will not support old computers that cannot run Windows 7, thereby forcing the faculties to replace them. Some faculties also use computers without Windows, but they are not supported by ITS and they represent only a marginal part of all computers. Implementation of the energy saving options in Windows 7 is no problem, the ITS can centrally install it on all required computers (Scheeren & Yadav, 2014). The problem, however, is that IT departments of the faculties fear that student users misinterpret energy saving measures; *"students have the intention to think a PC is broken when the screen is black, this can cause a lot of confusion"* (Scheeren & Yadav, 2014). Furthermore, it is necessary that the computer can be reactivated by using the keyboard or mouse, rather than only the on/off switch, because this switch is not or difficult to access on many computers (Mast, 2014). Since the hibernation mode can only be reactivated by the on/off switch[7], this is not a suitable option. Standby mode can be reactivated by mouse movement or keyboard use, so using the standby mode is preferred. Not all computers can be switched off to save energy because they are used for research or remote access. Putting logged in computers automatically into standby mode is not practical because it takes some time before the computer is reactivated again and data can be lost when the computer is accidentally switched off. For these reasons standby mode should only be activated when computers are logged out (Iseger & Deuzing, 2014).

Decreasing screen brightness of computer monitors has to be done manually on each monitor and is therefore a labour intensive job. This option is sometimes already advised by the faculty IT departments to employees whose eyes are hurting (Iseger & Deuzing, 2014).

6.1.2 Economic aspects

A barrier for implementation is the responsibility of the costs that have to be paid for the use of energy - for a single faculty this is determined on the basis of a budget for housing costs that is annually determined by the Corporate Real Estate and Campus office (V&C) (van Rijt, 2014). The energy bill is determined on the basis of a budget, not on energy use (van Rijt, 2014). Furthermore the energy bill is divided over the square meters that are used by a faculty.

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[7] Tested on UU student computer

E.g. if faculty X uses one quarter of a building and faculty Y uses three quarters of a building then the energy bill for this building is paid for, for one quarter by faculty X and for three quarters of faculty Y.
This methodology was partly chosen by Utrecht University to keep the process of determining energy costs as easy as possible. Furthermore the consequence that users (the faculties) will not suffer from a higher energy bill, just because they are located in an older building with a higher energy usage, was weighted heavily in this decision (van Rijt, 2014). Nonetheless, the chosen methodology has a negative side-effect. Whenever a faculty in the current system invests in energy saving measures, the total energy use of the University will decrease and therefore the budget determined by V&C will decrease. In the current system all faculties would benefit a small, equally proportional part from the investment of one faculty. Consequently the payback time, (i.e. the time it takes for the energy costs that are saved to accumulate to the initial investment) for the faculty that invests would greatly increase, making energy saving measures economically unfeasible. To conclude, the system makes measures cost ineffective for faculties while they may be cost effective by themselves. Nonetheless faculties could and should implement these energy savings even if cost savings are not achieved by a faculty.
This situation is comparable to the classical landlord-tenant problem for energy efficiency improvements. In the landlord-tenant problem the energy costs for the tenant are fixed and included in the rent. The energy costs are thus not related to the actual energy use giving the renter no incentive to reduce his energy usage. This situation results in a maintained high energy bill, while investing in energy efficiency will actually be economically feasible. This is described by Fischer & Rothkopf (1989) as a market failure.

6.2 Macro developments

The price of electricity was not reported to be an incentive driver for energy savings. This is most likely due to the shared energy bill that significantly reduces the incentive of a single faculty to implement energy savings (see section Energy Bill). Regarding other macro developments, there are several examples for a significant strengthening of awareness on sustainability on the campus. Firstly, sustainable institutional management became a core principle at UU in 2012 (UU, 2014d), with a strategic outline until 2020. Secondly, on an operational level sustainable practices are reinforced by a sustainability office, the “Green Office” that has been opened in October 2013 (GOU, 2013). These developments confirm a general positive trend for sustainable development. However, all the interviewees confirmed that institutional sustainability was not reported to be a major driver - i.e. energy savings and efficiency are not part of institutional policy. Also, energy saving measures were never discussed within the panel of demand managers. This hints to the fact that even if sustainability plays an increasing role on the campus, it does not mean that the topic is equally present in the consciousness of the people that are in charge of business operations at UU.
As a result, we can conclude that general awareness of sustainability within the ICT sector is relatively low, because no autonomous incentives were reported to introduce more sustainable practices.

6.3 Context of the educational institution

6.3.1 Institutional policy

Institutional policy changes of UU are believed to be a major influence on the decision-making process. In 2008, a central ITS has been implemented to facilitate knowledge transfer and cost reductions (Scheeren & Yadav, 2014). Yet it led to an adverse effect of outsourcing of responsibility and control over the ICT. One case which has been reported in the interviews is illustrated in Figure 6 below.

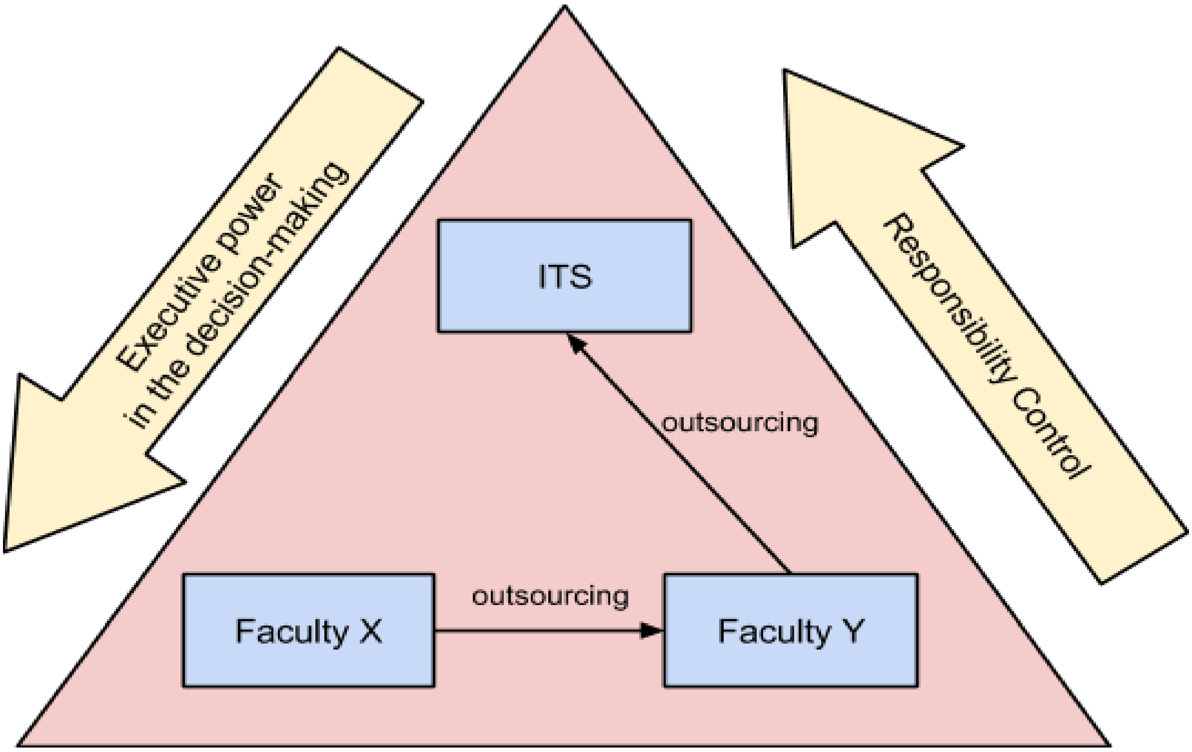

Figure 6: Adverse effect of outsourcing of responsibility and control (Source: own illustration based on interview responses).

Faculty X, one of the smallest faculties at UU, pays for the outsourcing of maintenance and control over their own student workstation pools to faculty Y. Faculty Y in turn authorised the ITS over the maintenance of their workstation pools, including the pools of Faculty X. Thus, the ITS exhibits the highest responsibility and control over the workstations but has little executive power in the decision-making process[8].

Through the introduction of a centralised ITS a process of outsourcing of responsibility and maintenance has been induced that decouples ownership and executive power from responsibility and control (see Section 5.2). As a consequence the perception for innovation needs is seriously compromised[9].

Another problem relates to the fact, that energy efficiency is not really recognized as a core objective within the ICT sector by the relevant stakeholders - especially with respect to student workstations. This also means, that policies to increase energy efficiency, set by the UU board, do not appear to reach the ICT domain.

6.3.2 Stakeholders

The interviews with key change agents of the ITS and the IT departments of the faculties allowed to gain the following insights with regards to barriers that impeded the successful implementation of energy saving measures.

[8] As one of the means the ITS has a representative in the monthly faculty demand managers meeting.
[9] See Step 1 from the decision-making process.

Currently many ICT tasks are centralized in the new ITS department. In the beginning coordination among faculties and ITS has not been optimal. *"However, since two years the cooperation is going perfectly, and I'm not seeing any frictions between the ITS and the faculties anymore"* (Scheeren & Yadav, 2014). A monthly meeting where ITS and Information and Demand managers come together ensures the alignment of goals and communication. However, the issue of energy savings is not a topic in these meetings (Scheeren & Yadav, 2014; Iseger & Deuzing, 2014).
Another factor that is worth mentioning and also originates in the split incentives mentioned above in 6.3.1 is that the ITS is exclusively looking at the users demands, e.g. always running workstations.

6.4 Characteristics of the ICT domain at the UU

There is a lack of awareness and knowledge at the IT departments of the faculties about existing energy saving measures. The previous reports were only received by few stakeholders. Another factor that impedes the perception for energy saving innovations is the lack of monitoring explicitly the energy consumption of ICT equipment, e.g. workstations. At the moment, energy consumption is measured only per building. Without monitoring the actual energy use, energy use cannot be analysed and potential efficiency improvements cannot be measured.

7. Solutions to overcome the identified barriers

As the analysis above shows, technical issues do play only a minor role in achieving energy savings. The main problems lie in the institutional organisation and communicating the topic of energy savings throughout the ICT domain. Several barriers were identified that affect all stages in the decision-making process and in fact impede that energy saving measures do enter the evaluation process in the first place. To overcome the barriers in implementing energy saving measures, the following solutions are proposed. The solutions are divided into top-down and bottom-up solutions.

7.1 Top-down solutions

7.1.1 Energy savings on the ICT agenda

Addressed barrier: Decoupling of responsibilities, awareness of potential

Sustainability is one of the core principles of UU as established by the board. The topic however does not reach the ICT domain (see Figure 7). Realizing energy savings and contributing to a more sustainable energy use is not seen as an objective. This needs to be corrected by bringing the topic of energy efficiency on the ICT agenda. One way of doing this is to set binding energy saving targets. By this means, the ICT departments of the faculties are committed to include the topic of energy efficiency in their operations. By expanding the board's energy saving policies to the ICT domain, a process will be induced where the ICT departments will intrinsically become interested in pushing energy saving measures into implementation. As a consequence, the faculties will have to appoint dedicated persons that supervise ICT energy consumption, implement energy saving programs and function as contact person regarding ICT energy use.

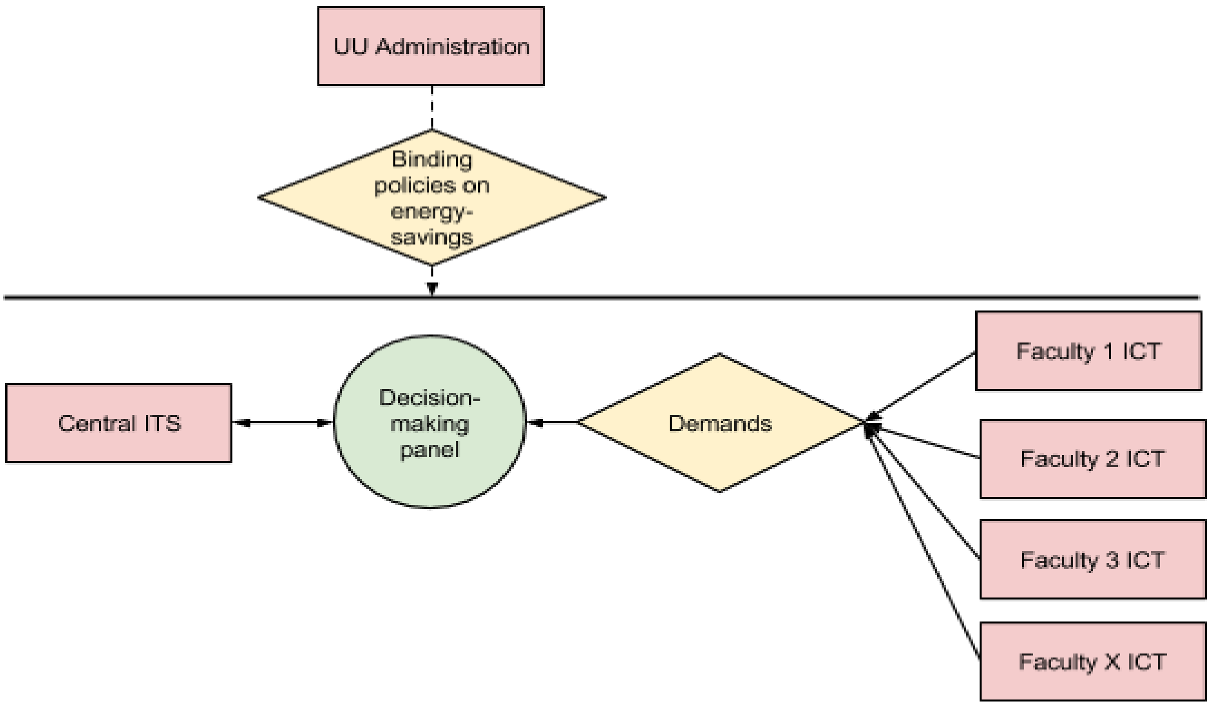

Figure 7: Top down sustainability policy (Source: own illustration based on interview responses).

7.1.2 Energy management system

Addressed barrier: No insight in energy use

In order to be able to report on energy saving targets, it must be possible to assess the energy use of ICT devices, i.e. workstations. However, currently this is not being done. It therefore becomes necessary to establish an energy monitoring system that is able to measure the energy consumption in computer rooms. Only then the performance in realizing energy savings can be tracked.

7.1.3 Re-organisation

Addressed barrier: No economic incentives

Next to binding energy saving targets, the accounting of energy bills should be re-organised. The problem regarding the shared energy bill can be solved by the UU board by reorganising the way that the energy bill is determined. This can either be achieved by letting the faculties pay the real electricity costs or by paying for part of the energy saving measures. However, to let faculties pay the real electricity costs more detailed measurements are required and it is unclear how electricity costs for non ICT expenses should be distributed. A more attractive option is to let the UU board share in the expenses for energy saving measures, by which these measures are more likely to become cost effective. This can either be done by co-investing or by paying a faculty - that has achieved energy savings - afterwards.

7.1.4 Workstations

Addressed barrier: Technical barrier

At the time that energy saving options like the automatic standby mode are implemented on all workstations, students and staff needs to be made aware how to deal with them, i.e. when does this measure start and how to reactivate the computer. In the weeks before and after the implementation process all users have to be informed in different ways on these changes. This can be done through posters and flyers (see Appendix VI for an example) inside the computer rooms, the university website and by e-mails from the study department.

7.1.5 Awareness raising

Addressed barrier: Lack of awareness among users

As mentioned in section 4.3.2 the awareness of energy saving potential and its perceived importance is far from optimal. Employees with an own workplace decide themselves how they use their computer, and thus also when they shut it down and/or to implement energy saving measures. It is therefore essential that the issue is also taken care of and ICT departments raise awareness about sustainable user behaviour. This can be done by informing them about the available options and the benefits for the university.

7.2 Bottom-up solutions

Nonetheless, not only top-down measures will cause the transition to take place. Also bottom up approaches can have a positive effect on bringing sustainability and realizing energy savings on the agenda. We therefore propose to form a permanent student task group that will raise awareness on the particular issue, contacts stakeholders and helps accelerating the transition to a more energy efficient ICT.

7.2.1 Organise a workshop

Addressed barrier: Lack of awareness of saving-potentials

With support of the Green office, the student task group can invite the important actors in the decision making process. Namely the ITS department and the information/demand managers from all faculties. In such a workshop the importance of sustainability, in general as well as at the level of UU, could be discussed (see Appendix II for proposed topics). Furthermore the actors could be informed of the economic aspects and potential of energy saving measures in ICT. In this setting the currently available knowledge can be shared between actors.

7.2.2 Communication

Addressed barrier: Sustainability consciousness

Bottom-up awareness raising can also be very effective, especially when it is done through personal communication among fellow students and colleagues. Here, also the idea of flyers and stickers becomes relevant. The combination of bottom-up and top-down awareness raising will result in a larger consciousness about the amount of energy we waste in the daily use of ICT devices. The consequences of wasting energy should be made clear and visible and should be incorporated in the awareness raising process.

8. Implementing energy saving measures

8.1 Proposed energy saving measure

From the review of the previous reports, currently the most effective way for achieving energy savings is by focusing on workstations. Firstly, workstation measures can easily be implemented without requiring an infrastructural or institutional change. Secondly, implemented workstation measures immediately lead to lower electricity consumption and thus costs. And finally, implemented energy saving measures are directly visible to users - students and staff - thereby increasing awareness for energy savings as a part of practical sustainability. We propose the implementation of the following two energy saving measures for workstations:

1. Default monitor brightness of all monitors at UU is set to 50. This shall be applicable to all existing monitors and future procurements.
2. All computer pool workstations at UU are automatically turned into standby mode after 20 min of inactivity once a user has logged out.

During the first stage, the proposed measures are targeted at student workstation only, the so-called study spots. Although being principally applicable to all computers at UU, employees have differentiating working routines, primarily because they work with one personal workstation or laptop.
With the implementation of these measures at all 2000 student workstations and assuming the same operational hours as the Geosciences and Social Sciences buildings (Appendix V), approximately 314 MWh electricity and €38,000 savings per year can be realised. This is equivalent to a reduction in electricity consumption of 65% compared to the current situation. These are moderate estimates that assume an average electricity price of 0.12 EUR/kWh, an average computer usage of five hours per day for 50 weeks per year and do not include one-time costs for implementation (man-hour). An estimate for the approximately 8000 staff workstations and laptops is more difficult as employees do not have a generic usage pattern and could revert back the energy saving measures. This highlights the importance of information campaigns to raise awareness on the efforts for energy saving measures.

The costs for monitor brightness adjustments are estimated with 460 EUR for all thirteen buildings[10] (for the calculation see Appendix VI). For practicability two students should be assigned to each single building who get a lump-sum between 20-60 EUR, depending on the size of the building[11].

The costs for the configuration of the Windows 7 power saving measures, i.e. automatic standby after 20 minutes of inactivity, cannot be fully assessed. We do not have sufficient information on the man-hours used by the executive Information Technology Service (ITS) to calculate project viability. However, to keep implementation time and thus costs low, we recommend the ITS to invite the student task group (STG) to join the implementation process.

[10] Not all student workstations are available through studyspot.uu.nl, such as the computers from Utrecht University College (UCU). These buildings are excluded in the costs calculation.
[11] The lump-sum assumes an hourly wage of 20 EUR.

The STG[12] is a voluntarily formed group of Energy Science students who have a dedication for increasing energy efficiency at UU.

As mentioned before, all introduced energy saving measures should be accompanied by awareness raising campaigns to support behavioural changes of users. We designed two desktop wallpapers (see Appendix VI) that can be installed by the ITS alongside to increase the visibility of the introduced measures:

- User instruction how to adjust the monitor brightness
- User information about the introduced measures and their benefits

8.2 Roadmap

To assure the successful implementation of these measures at workstations, we developed a road map that could be used to guide the implementation process.

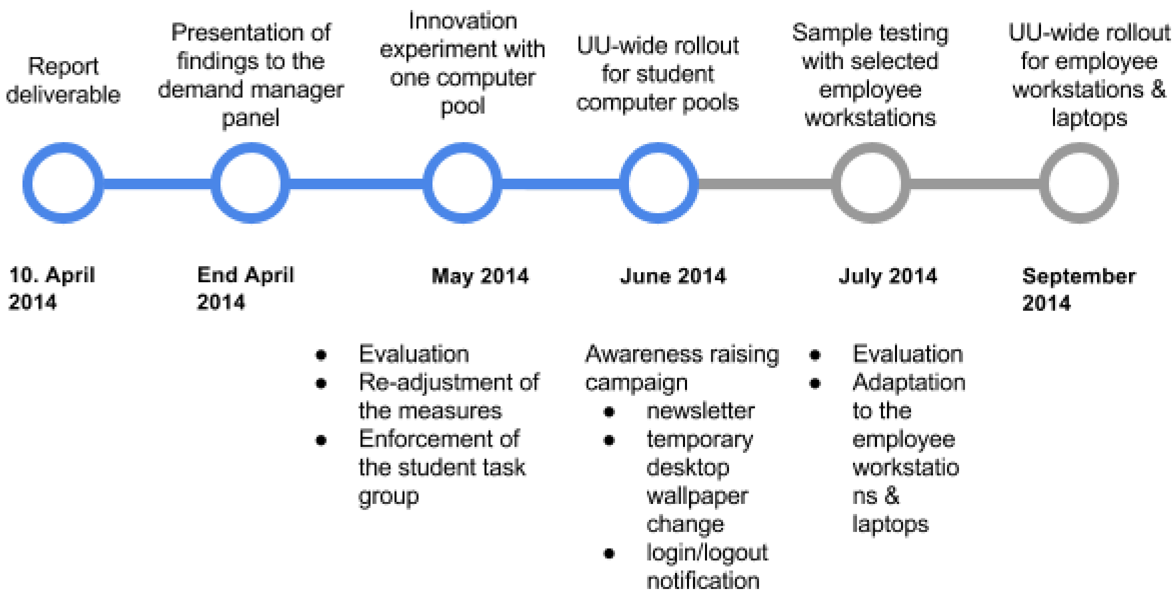

Figure 8: Roadmap for the upcoming 6 months to implement energy saving measures (Source: own illustration).

Following the delivery of the report, the main findings on impeding barriers and measures for effective implementation will be presented to the panel of demand managers of the faculties (ICT) and representatives of the Information Technology Service (ITS). Subsequently and with the agreement of the panel, a voluntary student task group is assisting a practical experiment with one computer pool room to test the long-term effects of adjusted monitor brightness and standby feature. In May 2014, these effects will be evaluated, both from a view on user impact and electricity consumption. The main premise will remain that any energy saving measure should not conflict with a positive user experience. Thus re-adjustments of the measures will be done where required. The impacts of the measures on electricity consumption can be monitored and measurement through a second control room that does not have any measures

[12] For information, please contact the Green Office Utrecht which is the direct facilitator of the activities of the STG: greenoffice@uu.nl

in place. Furthermore consumption before and after implementation can be compared to highlight the effectiveness of the measures. Technical expertise and software are available at the Information Technology Service (ITS) to assist in monitoring individual uptimes of computer workstations (Iseger & Deuzing, 2014).

In June 2014, a UU-wide rollout is followed by the successful completion of the controlled experiment. Users are informed about the measures through their faculty newsletters and by specifically designed desktop wallpapers (see Appendix VI). If the overall effect reaches satisfaction, in July 2014 a first sample testing with selected staff workstations can be conducted. The summer break can be used to adjust and optimise both, the student and the staff schemes, to release the optimised settings for the beginning of the new semester in September 2014.

9. Discussion

During the research the calculations for the savings were made. Even though the previous reports (Voorneveld et al., 2011; Bernhard et al., 2013) had presented calculations regarding the same issue. It was found that the calculations in these previous reports were sometimes not transparent and assumptions that were transparent were rather optimistic resulting in very high potential savings. The new calculations are more reliable, although not all information about the use of workstations could be gathered and therefore assumptions still had to be made.

Students and employees (the users of the workstations) were identified as one of the stakeholders, however, partly because they have relatively low power and interest regarding the implementation of energy saving measures they were not studied for this report. Nonetheless, in the steps towards implementation this group should not be forgotten and their experience with the energy savings measures should be evaluated.

The theoretical framework that was developed was derived from several different sources also applicable to other settings than the current institutional setting. Furthermore several other frameworks have different categories. It is however believed that the used framework will suffice and that all barriers are identified and solved.

A large portion of the information was gathered through interviews. The semi-structured interview was chosen as the appropriate form for these interviews. Due to this setting the questions and information presented to the different stakeholders might not be identical resulting in slightly differing responses and thus less reliable results. On the other hand the form of semi-structured interviews created an open atmosphere which could have resulted in more honest and informative answers. Furthermore there was still space for additional comments from the stakeholders which would not have come forward in a strict questionnaire setting. Unfortunately, not all stakeholders could be interviewed and therefore some relevant information might still be lacking while other information might not be correct for the whole UU.

It is believed that when the solutions to overcome the barriers are implemented not only the energy saving advice from this report is implemented, but also that new energy saving measures will find their way to implementation. This can be ascribed to the fact that sustainability will be institutionalised (or: have become part of the mind set) in the organisation of UU.

10. Conclusion

In this report a contribution is made to make Utrecht University more sustainable. The ICT domain has still a large potential for reducing energy consumption as was concluded from two earlier student reports. However, only few of the given recommendations have been implemented and therefore our objective is stated by the main research question: *How can existing energy saving advice be implemented in the ICT domain at Utrecht University?*
The previous reports concluded that most saving potentials are achievable at the workstations, the servers and the procurement standards. To stimulate the implementation of these savings and to generate more savings in the future, the organisational structure and behaviour of people should also change. In the current research, it was found that some recommendations from the previous reports were already implemented. However, this was not done because of the previous reports, but for other reasons. Furthermore, most stakeholders never received the reports and did not know about the recommendations. Currently, a new data-centre for all servers is being built which has been optimized for energy consumption. There are also minimum procurement standards for energy consumption and all workstations have Windows 7 which can enable more energy saving options than the previously used Windows XP.
Identification of the barriers was done by using a framework proposed by Dieperink et al. (2004) on the adoption of energy saving technologies. For each barrier a solution is given.

The following barriers were identified:

- No technical barriers were found but the fact that the measures should not have a significant negative impact on the usability. Communicating the necessary changes for the users would help to overcome complaints.
- An economic barrier is the lack of direct incentives for the faculties to implement saving measures on their own, because the energy and other facility costs are divided on all faculties based solely on the type and amount of space used by each faculty. A new way of accounting the energy costs should be implemented to overcome this problem.
- Regarding macro developments, sustainability is an issue with increasing concern at UU but it has not had much impact yet on the ICT domain. More specific awareness on this issue has to be raised by the university board, both to the ICT departments and the users. Also workshops can be given to the stakeholders related to this topic.
- Institutionally, there is a barrier of responsibility. The faculties own the workstation pools, but the ITS has the task to maintain and control them. Therefore there is a decoupling of ownership and control for which both parties do not take the responsibility of implementing energy saving measures. Also regarding the stakeholders, in the monthly meeting between the faculty ICT managers and the ITS the issue of energy savings has never been discussed. Somebody in the ICT domain should be made responsible for implementing energy savings and binding policies and targets for energy savings have to be set by the board.

To help the implementation of energy saving measures, a plan is proposed of actions that can immediately be taken. This plan consists of two measures for student workstations:

1. Default monitor brightness of all monitors is set to 50. This shall be applicable to all existing monitors and future procurements.

2. All computer pool workstations are automatically turned into standby mode after 20 min of inactivity once a user has logged out.

Implemented on 2000 workstations these measures will save approximately 314 MWh electricity and 38,000 EUR per year, which is equivalent to a reduction in electricity consumption of 65% compared to the current situation. The investment costs of these measures will be marginal, because no investments (apart from the information campaign) and only a small amount of man hours is required to introduce and maintain these measures.

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Appendix I - Interview Guide

The following questions were used for the interviews with relevant stakeholders as identified by the stakeholder framework (Table 4).

Table 4: interview questions framework

Nr.	Question	Type of question/ barrier	Type of barrier	ITS department	UU board members	Facul-ties
1	What is your role at Utrecht University?	Introduction		X	X	X
2	Are you aware of the previous reports from students on energy savings in ICT? (show table)	Introduction		X	X	X
3	Have these reports led to any actions that you are aware of?	Introduction		X	X	X
4	Have other energy saving measures for ICT been proposed in the past? By whom and what actions have been taken?	Introduction		X	X	X
5	How many workstations are there at UU (student + staff)?	Current status		X		X
6	Are the computers controlled centrally via the network? Can group policies be used to implement energy saving measures?	Current status		X		X

7	Who is or would be responsible for the implementation of energy saving measures?	Current status		X		X
8	Are there already energy measures in place on computers? Who is using these measures? Are these measures promoted to the students/staff? Have users asked for or against certain measures?	Current status		X		X
9	Is the actual energy consumption of the computers known/monitored?	Current status		X		X
10	Is it possible to test certain measures on UU computers? Have such measures been tested before?	Current status		X		X
11	What are the economic aspects for energy saving measures that you consider? For instance, do you have payback period criteria for energy saving investments?	Main question	Economic aspects	X	X	X
12	Who has control over the purchasing budget?	Main question	Economic aspects	X		X
13	Who has control over the energy costs budget?	Main question	Economic aspects		X	X

14	How do new energy saving measures fit into the existing IT infrastructure?	Main question	Technical aspects	X		X
15	Are there any difficulties with operating and maintaining energy saving measures?	Main question	Technical aspects	X		X
16	Are energy saving measures competing with other options of implementation, such as specific applications, etc?	Main question	Technical aspects	X		X
17	What are the energy consumption criteria for newly purchased hardware?	Main question	Technical aspects	X		X
18	Do you see any difficulties regarding the ability of the ICT domain to implement energy saving measures?	Main question	Characteristics of the ICT domain of the educational institution	X		X
19	Is the age/type of computers currently in use a problem for energy saving?	Main question	Characteristics of the ICT domain of the educational institution	X		X
20	Is the electricity consumption of computers in use a perceived problem?	Main question	Characteristics of the ICT domain of the educational institution	X	X	X
21	What are the focal points for expected future investments of the ICT domain?	Main question	Characteristics of the ICT domain of the educational institution	X		X
22	How open do you perceive the ICT domain to be	Main question	Characteristics of the ICT domain of the	X		X

	regarding changes and new technologies?		educational institution			
23	Do you have an energy consumption management system? How would you characterise it?	Main question	Characteristics of the ICT domain of the educational institution	X		X
24	How do you perceive the awareness for sustainability on campus?	Main question	Macro developments	X	X	X
25	What impact does the price for electricity have on the ICT domain and on energy savings measures?	Main question	Macro developments	X	X	X
26	Is there something in recent developments at UU's ICT domain that could impact the implementation of energy savings measures?	Main question	Macro developments	X		X
27	How would you characterise the role of regulation, incentive programs and subsidies introduced by UU or on a local/national level in the recent years? What was their impact on your domain?	Main question	Institutional policy	X	X	X
28	What demands does the computer user have that you are trying to meet?	Main question	Stakeholders	X		X

29	How do you perceive the extent of cooperation between different departments at UU and external actors such as supplying software companies?	Main question	Stakeholders	X		X
30	What role do supplying software companies play? Do they impact decision-making in your domain?	Main question	Stakeholders	X		X
31	Are there other staff members who have more information on this topic?	Main question	Stakeholders	X	X	X
32	How would you describe the decision making process & assessments in the ICT domain?	Main question	Decision making process & assessments	X		X

Appendix II - Organise a workshop

Discussion of energy saving measures at an organised workshop

- Screen brightness
- Centrally shut down computers overnight
- Measures in Windows 7 (sleep/hibernate mode)
- Power management software (such as PowerMAN, Plugwise)
- Notifications or education raising awareness
- Use idle computers for doing research computations

Appendix III - Information from email conversations

Full email transcripts can be requested at one of the authors (N.B. the e-mails are in Dutch)

Jeroen Schipper - Project manager data center facility

Email conversation summary (March 14, 2014)

In the previous report bij Bernhard et al (2013) The following conclusions were drawn: With respect to the tendency towards a more energy efficient and thereby more sustainable data centre on the Uithof, generally speaking, the center should be developed as a dense computing systems where:
1. Software technologies control data growth and shrink capacity demands
2. Managers use Service Level Agreements to manage energy usage
3. Energy efficient computing infrastructure optimizes performance and utilization levels
4. Physical plant is engineered for maximum energy efficiency"

The previous report were never received by managers of the data center, therefore none of the previous advices could be followed. However, the data center works with maximal virtualisation and, for example, blade-servers. Furthermore the data center is engineered as economical as possible. Advices 1,3 and 4 are implemented with these measures. Advices 2, focused on working with SLA's on energy usage is under the attention but not implemented yet.

Servé van Rijt - Project Controller at Building and Campus

Email conversation summary (March 18, 2014)

The energy costs are recalculated divided over the faculties by Building & Campus (B&C). Annually a budget for the housing costs is determined. In this budget a forecast on space use (in square meters) of the buildings per faculty is made. All energy costs will be determined on the basis of this space use. While determining the costs, three distribution codes will be used:

1. Depreciation costs and rents are determined per building and subsequently evenly distributed on the basis of space use over the faculties
2. The total energy costs are weighted (e.g. high weighting factor for laboratory, average weighting factor for offices and education spaces and a low weighting factor for storage space) and distributed on the basis of space use over the faculties.
3. All other costs are then distributed over the used square meters.

For energy costs this implies that the energy costs are determined on the basis of a budget, not on the actual energy costs and the energy costs per building are not in relation with the actual energy use of the building because all spaces with the same type have the same weighting factor and thus the same energy tariff per square meter.

This methodology was partly chosen by Utrecht University to keep the energy costs as easy as possible. Furthermore the consequence that users (faculties resp.) will not suffer from a higher energy bill just because they're 'by coincidence' located in an older building, was weighted heavily in this decision.

This methodology was partly chosen by UU to keep the energy costs as easy as possible. Furthermore the consequence that users (faculties resp.) will not suffer from a higher energy bill just because they're 'by coincidence' located in an older building was weighted heavily in this decision.

Appendix IV - Interviews

Full audio recordings of the interviews can be requested (unless stated otherwise) at one of the authors (N.B. the interviews are in Dutch)

Peter Scheeren & Shashi Yadav (ITS)

Interview summary (March 12, 2014)

Interview Peter Scheeren and Shashi Yadav
Head of Basic Services and computer support at ITS
15:00 Wednesday March 12 2014
Bestuursgebouw 3.78
Joep Weerdenburg, Axel Roozen and Robert Orzanna

Introduction

May we record this conversation?

- Yes

What is your role at Utrecht University?

- Peter is head of the Basic Services that supports all computer workplaces at the UU, Shashi works at the support staff of the ITS for the computer workplaces.

Are you aware of the previous reports from students on energy savings in ICT?

- Peter knows there are such reports, but has not seen any of them. Also can not remember he was interviewed by them.

Have these reports led to any actions that you are aware of?

- Apparently not as far as he knows.

Could you give some feedback on the proposed measures that were advised in the previous reports?

- Shashi says that the currently with W7, sleep/hibernate mode can be activated, but the faculties do not want that. Staff members can activate it themselves on their computers, but do not know how much that is being used. W7 itself is fine, no other programmes are needed. Within a current programme, it is possible to measure which computers are active, but they do not use that and it requires a separate licence. Monitor brightness can only be manually adjusted which is not very practical. There are monitors on the market that automatically adjust brightness according to the time of the day, which might reduce energy use. Current new monitors are LED monitors and therefore consume less energy than the old ones.
- Procurement of hardware is the responsibility of Aloysia Kluck, and CSR is important for choosing the suppliers (for four years). There is no explicit standard on energy efficiency that new hardware have to meet, Peter thinks. Faculties can choose from the list of the supplier what they want.
- There are no people in ITS responsible for energy use. There is contact with SURF, but not specifically about energy savings. The energy department of V&C is responsible for energy use, but they do not have contact with ITS about this.

- Using idle computers for research is possible, but staff have to do that themselves. Student computers maybe through the faculties.

Current status

Are there already energy measures in place on computers?

Who is using these measures?

Are these measures promoted to the students/staff?

Have users asked for or against certain measures?

- There are options in W7 to activate sleep/hibernate mode. Also computers are centrally started up and shut down (faculties decide on that). They do not seem to be actively promoted. Think users misunderstand the measures for broken PCs.

Have other energy saving measures for ICT been proposed in the past? By whom and what actions have been taken?

- Not explicitly asked, but they did not say that anything was proposed either.

Is the actual energy consumption of the computers known/monitored?

- No, probably only the energy use per building is known by V&C (all electricity).

Do you have an energy consumption management system? How would you characterise it?

- Apparently not.

Perception

Is the electricity consumption of computers in use a perceived issue?

- Not asked, but seems more relevant for the faculties who use the computers.

How open do you perceive the UU (ICT domain) to be regarding changes and new technologies?

- N/A

How do you perceive the awareness for sustainability on campus?

- N/A

Organisation

Who has control over the purchasing budget?

- The faculties buy their own computers.

Who has control over the energy costs budget?

- The faculties pay their own energy bill to the V&C.

Who is or would be responsible for the implementation of energy saving measures?

- The faculties (for students) and staff for themselves. But with the procurement and installation, the ITS plays a facilitating role.

How would you describe the decision making process & assessments in the ICT domain?

- The faculties decide everything themselves, they do have contact with the ITS.

Is there something in recent developments at UU's ICT domain that could impact the implementation of energy savings measures?

- The new hardware supplier is currently being chosen and W7 is being installed on all computers (old computers that cannot run W7 will be replaced).

How would you characterise the role of regulation, incentive programs and subsidies introduced on a local/national level in the recent years?

What was their impact on your domain?

- N/A

What is the policy of the board/energy department regarding ICT savings?

- Only general CSR standards, not explicitly about energy savings in ICT.

Procurement

What are the energy consumption criteria for newly purchased hardware?

- Probably no hard criteria.

Is the age/type of computers currently in use a problem for energy saving?

- Some old computers cannot run W7 but they will be replaced, ITS does not want to work with old computers and therefore ‘forces’ faculties to replace them. Some computers have to be on all the time (research). Also some special computers faculties use, run other OS and are not supported by ITS.

What role do supplying software companies play? Do they impact decision-making in your domain?

- Faculties choose the software, although some licences are (supported?) through ITS (via SURF). Hanny Daniels is responsible for that at the ITS.

How do you perceive the extent of cooperation between different departments at UU and external actors such as supplying software companies?

- Peter has a meeting with all information/demand managers from the faculties every month, which is currently going well (some trouble in the past, because faculties wanted to do everything themselves). Also contact with V&C, but mainly about the WiFi connection in buildings. External is through procurement.

Economic aspects in ICT

What impact does the price for electricity have on the ICT domain and on energy savings measures?

- N/A, better ask V&C and faculties.

What are the economic aspects for energy saving measures that you consider?

For instance, do you have payback period criteria for energy saving investments?

- N/A, ask faculties.

What are the focal points for expected future investments of the ICT domain?

- New supplier should provide multiple brands, old only supplied HP. So there will be more choice for the faculties to supply the most suitable.

Technical information

How do new energy saving measures fit into the existing IT infrastructure?

- No problems expected here.

What demands does the computer user have that you are trying to meet?

- N/A, faculties decide this.

Do you see any difficulties regarding the ability of the ICT domain to implement energy saving measures?

- Should be no problem.

Are there any difficulties with operating and maintaining energy saving measures?

- Should be no problem/unknown.

Are energy saving measures competing with other options of implementation, such as specific applications, etc?

- N/A.

Are the computers controlled centrally via the network?

Can group policies be used to implement energy saving measures?

- Yes, via a programme (LanDesk?)

How many workstations are there at UU (student + staff)?

- Around 9000, 2500-3000 students PCs. Actual list is available, but changes every day.

Ending

Who in the ITS can we contact for (additional) information (you could not give to us)?

- Aloysia Kluck about hardware procurement.
- Hanny Daniels about software licences via SURF.
- We can ask Shashi technical questions.
- Peter is available for other questions.
- Peter is looking forward to our report and is willing to (let us) present it to the information/demand managers of the faculties during their meeting when the reports is finished. Having concrete figures of how much can be saved (also money) will help to persuade the faculties to implement the measures.

Is it possible to test certain measures on UU computers?

- N/A.

Rob Iseger & Andre Deuzing - Information/demand managers at the faculty of geosciences

Interview summary (March 26, 2014)

Rob Iseger and Andre Deuzing
14:00 Wednesday March 26 2014
Van Unnikgebouw 4.12
Joep Weerdenburg and Robert Orzanna

Notes:

- No recording of interview
- Geo has around 900 computers, consists of staff and geolabs (GIS) in Unnik and Aard
- They also pay for using the student computer rooms and control the software
- Student computers are on when buildings are open
- All student rooms at UU must basically have the same settings/computers
- Workspace screens are already turned into standby after 20 minutes when logged out
- Printers already go into standby mode when not used after X minutes
- All information/demand managers and ITS decide on the computers/settings used
- There are no (additional) criteria on energy use of computers
- V&C Energy has detailed information on energy use per building (per time)
- It would help if the electricity was separately billed and there were more options to save energy for employees (control of lights and heating in office)
- ITS is able to see which computers are off or logged out

- Employees decide themselves on their computer settings and use (many do not shut down overnight), they have no incentive to save energy (money, time)
- They are in favor of reducing screen brightness (inform staff, include in installation protocol) and auto shutdown/hibernate computers that are logged out
- Do not like sleep/hibernate mode when logged in: too much time, danger of data loss
- Policy from university board would help to implement measures

Ron Mast - demand manager at the faculty of social sciences

Interview summary (March 28, 2014)

Social sciences:
Ron Mast
11:30 Friday March 28 2014
Sjoerd Groenmangebouw 3.30
Joep Weerdenburg, Robert Orzanna, Bas van Zuijlen

Notes:

- No recording of conversation
- Energy saving measures available on Windows 7 have to be applied university wide.
- 350 PC's from Geosciences are managed by ITS
- Hibernation after logout is a good plan if there are only acceptable negative side effects
    - Hard to distinguish computers that are turned of and computers that are in hibernation. How to go from hibernation to back on
    - Students and staff have to be informed about the new hibernation setting, so they'll cope with it in the right way.
- It is possible to test the hibernation settings in one computer room. Furthermore a reduced monitor brightness could also be tested here. Again if no, or acceptable negative side effects this should be implemented.
- Computers are switching on very soon to increase the availability of the computers, which was needed according to a survey among UU students.
- The demand manager from the University library is also important to approach, as the library has a lot of student workstations
- Policy from the board is not needed to implement these energy saving measures. It is likely that the board won't have time to make policy to this level, furthermore the demand managers are capable of implementing these measures themselves. However, all faculties should be approached and won over for the energy saving measures for the project to be successful.
- It is unclear if the saved costs will flow back to the faculty that implements measures, however, this should not be a reason to not implement these measures.
- It is not likely that the computing power of idle computers will be used for projects which demand high computing power. Lab already own supercomputers which can do these calculations.
- Ron Mast was also interviewed for the previous report and received it after completion. Only the measures in the report were not implemented because Ron didn't see it as actual advice, but more for the research/educational value.

Appendix V - Savings

Table 5: boot and shutdown schemes workstations UU (Niehoff, 2014)

Facility	UBU	FSW/GEO	BETA	UCU
Days	7 days (Mon-Sun)	5 days (Mon-Fr)	7 days (Mon-Sun)	5 days (Mon-Fr)
Start	7:30	7:00	7:00	8:00
Shutdown	01:30	22:00	0:00	22:00

Table 6: assumptions for saving calculations student workstations. Time: FSW/GEO, assuming an average usage time of five hours per day. Energy use desktop: Bernhard et al, 2013. Energy use monitors: Voorneveld et al, 2011.

Device	Energy use when on [W]	Time on, baseline [hours/week]	Time on, standby [hours/week]	Energy use in standby mode [W]	Time in standby [hours/week]
Desktop	44	75	25	2	50
Monitor 100	23	75	25	1	50
Monitor 50	18	75	25	1	50

Table 7: assumptions: 50 weeks per year, 2000 workstations, electricity price of 0.12 EUR.

Situation	Annual electricity use [kWh]	Annual electricity cost [EUR]
Baseline **50% with 100 brightness** **50% with 50 brightness**	483,750	58,050
Standby **100% has 50 brightness**	170,000	20,400
Savings	313,750	37,650

Appendix VI - Implementation guideline

Table 8: time necessary to change monitor brightness

Monitor adjustments	Time estimate
Time per monitor adjustment	30s
Number of monitors	1392
Walking time per building	1h
Number of buildings	13
Total time	**24.7h**

Source: own estimates based on data from http://studyspot.uu.nl/

Table 9: number of monitors and costs to adjust monitor brightness per UU building

Building	Number of monitors	Required time (h)	Costs per building (EUR)
Kromme Nieuwgracht 80	207	3	60
University Library City Centre	143	2	40
Buys Ballot Laboratorium	160	2	40
David de Wiedgebouw	49	1	20
Educatorium	9	1	20
FEM HU	9	1	20
Hans Freudenthalgebouw	8	1	20
Marinus Ruppert	130	2	40
Martinus J. Langeveld	65	2	40
Minnaertgebouw	179	2	40
Sjoerd Groenmangebouw	42	1	20

University Library Uithof	222	3	60
Willem C. van Unnik	178	2	40
Total	**1392**	**23**	**460**

Source: own estimates based on data from http://studyspot.uu.nl/

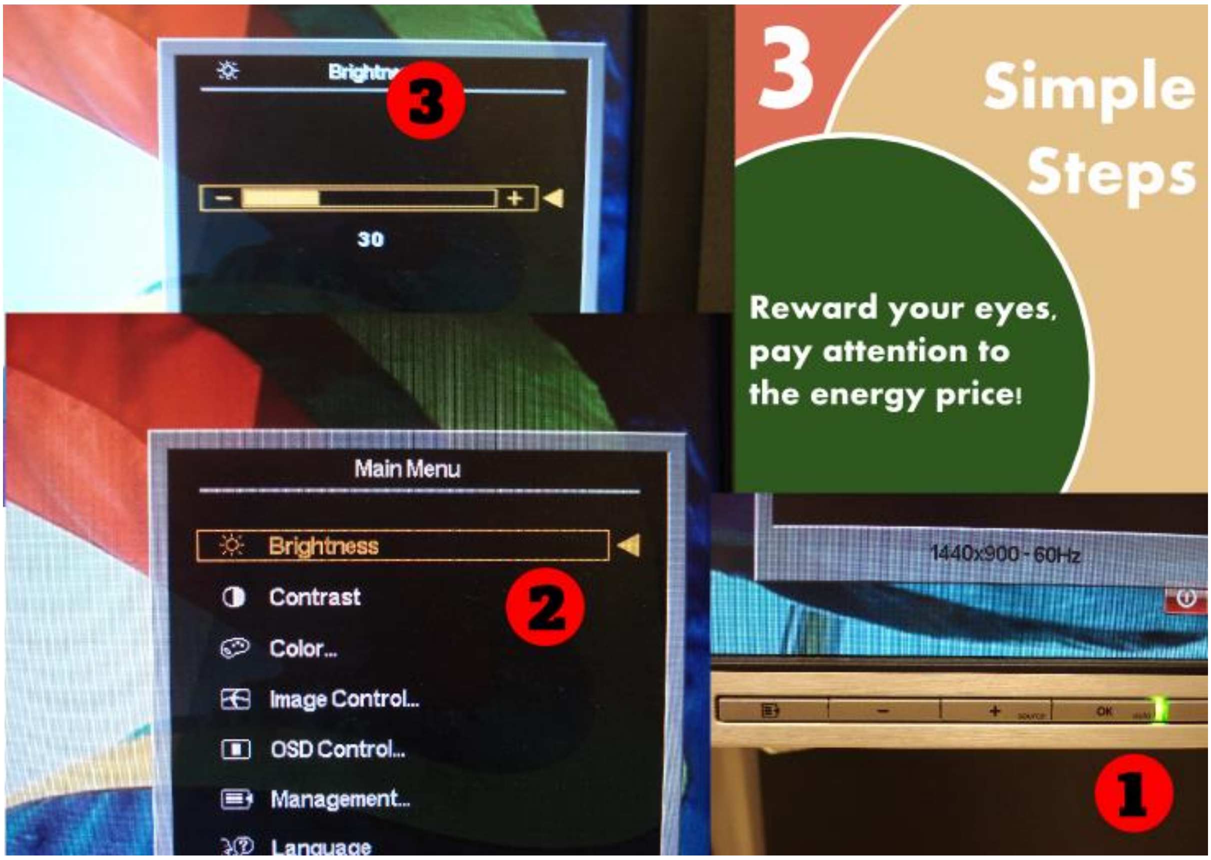

Figure 9: example of campaign poster to raise awareness to energy saving measures (source: own illustration)

Figure 10: example of campaign poster to raise awareness to energy saving measures (source: own illustration)