Ministry of Foreign Affairs

GreenServe Impact: Process, findings and lessons learned

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GreenServe Impact:
Process, findings and lessons learned

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1. About this document

The document is the conclusion of the GreenServe project, from the methodology adopted to the collection of results from the case studies. In this document you will be able to find the process and approach undertaken by the project team, the findings of the different case studies and lessons learned generated throughout the project's run. The report is complementary to the Market-potential report provided by Certios.

This report emphasises the knowledge we have gained from our engagements with different stakeholders to understand current practices with the aim to initiate additional case studies. The project's undertaken activities coalesce into identified lessons and needs for further energy management improvement efforts. An outline of four specific case studies in combination with a guideline roadmap can be used to replicate or translate adoption of similar good practices for other organisations.

The overarching goal of this document is give motivation to organisations to take actions. The document has been written in an intuitive way to inform the reader, supplemented with a consolidated lessons learned inventory.

2. About the GreenServe project

The current trend recognises the importance of optimising energy efficiency of an ICT facility. We need effective alignment of hardware, middleware and applications of ICT environments with a view to their energy consumption and performance. Several practice-oriented initiatives have been undertaken in the Amsterdam region on this topic, such as:

- The report Zervers: An exploratory research into energy saving potential in ICT environments
- The project Greening the Cloud: Measuring the influence of software on the energy use of hardware

However, the results from these projects have not yet been validated in an operational setting, limited trust in the discussed good practices, and thus, potential gains of application of the discussed good practices is limited.

This project was commissioned by RVO (Rijksdienst voor Ondernemend Nederland) to understand what is the state-of-the-art situation of the ICT used by public organisations and potential case studies and to assess opportunities to enable energy and power management measures. The collected results will be used to communicate on these related opportunities enabled by the project.

For this, the project needs understand the current situation and practices within the target groups in relation to power and energy management. Aspects such as: where does the organisation stand, and what are the commonalities of the technical environmental and organisational of the practice. This requires answers to questions such as what practices do they use, how do they manage the IT environment now, etc.

The project identified the main stakeholders and drivers of current practices by looking beyond the most obvious. This brings into scope those (previously) invisible and helps to strengthening the case for more balanced decision-making. This will simultaneously act as a threshold-lowering incentive to encourage others to adopt similar improvement measures.

3. GreenServe Team & role

The project leverages the partnership that was formed during the Greening the Cloud project, which aimed to collect good practices in energy efficient software development.

GreenServe combines organisations with different areas of expertise: knowledge sharing, research, consultancy and policy making.

Green IT Amsterdam was responsible for the engagement of the target groups, supporting the parties involved through communication activities, and developing and disseminating communication material.

The **VU Amsterdam** had the task to design and carry out case studies according to well-thought-out, well-coordinated principles. Specific measurements and analysis took place in the Green Lab at the VU.

Certios has carried out the analysis of the (market) potential of energy saving through energy management options, including bottlenecks, drivers and business cases.

The **Steering committee** was composed of RVO (the client), the Ministry of Economic Affairs, the municipality of Amsterdam and trade organization Nederland ICT, who supported the GreenServe team by engaging case study candidates, creating opportunities for validating and presenting the (intermediate) results, and discussing how to overcome the project's challenges related to convincing decision makers and influencers to support the energy efficiency actions of the case studies.

During the work done over the past 20 months the project collaborated with organisations on nine case studies and delivered additional market research. GreenServe combines the results and impacts of these efforts in this report. The information provided can be used freely by any organisation interested in improving the energy efficiency of their IT environment by means of energy and power management measures, whether this is related to in-house ICT or by involvement of their ICT suppliers.

The GreenServe project started in Februari 2015 with a kick-off meeting with the initial partners Certios, Software Improvement Group, the Vrije Universiteit, Hogeschool van Amsterdam and Green IT Amsterdam. The goal of this kick-off meeting was to define a plan of approach and timeline.

4. Project Approach

Work plan for the development of case studies

GreenServe evolves around the development of Case Studies for improving an organisation's current situation. The approach aims to combine both collecting common and more universally shared insights – which asks for a similar, uniform way of working – and investigating case specific aspects that need flexibility to adjust to the nature of individual case study topics. There are several key aspects to take into account for this:

- What can be seen as existing knowledge and assumptions as a starting point?
- What are the possible improvement directions that could be explored?
- Know your main stakeholder groups.
- Be able to explain the process of participating to an interested stakeholder.
- How can you ensure you can capture and document the information needed to evaluate a case study and share the gained knowledge with others?

Existing knowledge and assumptions

The GreenServe project is a continuation of former initiatives focusing on energy consumption improvements within IT environments, mainly afore mentioned Zervers report and Greening the Cloud project. From these initiatives and additional experiences and available knowledge the GreenServe project started with a set of basic assumptions, which are derived from the earlier initiatives:

- There is an increased willingness and desire to improve the energy consumption of ICT from both a cost and sustainability perspective.
- Yet, ICT departments often do not have to pay for their part of the electricity bill; known as the split-incentive.
- On average the energy efficiency of equipment doubles roughly every 18 months (known as Koomey's Law), which means replacing old models can result in significant energy consumption improvements.
- For new environments energy efficiency is often part of procurement considerations, but relevant measures and features often go unused despite availability of good practice knowledge provided by vendors and independent research.
- Moving an IT (or specific application) environment to Cloud is not always considered an option or desirable due to the nature of the environment or privacy and security considerations.
- There are still a significant number of legacy IT environments within organisations for various reasons.
- There is an ongoing general perception that power management leads to performance issues and because service delivery contracts between (internal or external) customer and provider are crucial anything that is perceived to negatively affect this is avoided.
- Many applications still run on dedicated environments due to legacy designs, ease of separating management responsibilities and the need to accommodate peak-use moments resulting in overcapacity and under-utilisation of hardware.

Main improvement directions

GreenServe aims to provide the state-of-play and opportunities related to optimising alignment between hardware, middleware and applications for the purpose of reducing energy consumptions without compromising on performance and reliability. Because of the existing and combined knowledge and experiences of the project's partners regarding energy management related to ICT environments the possible improvement directions were clear from the start:

1. Adoption of power management in existing environments.
2. Refresh and consolidation opportunities.
3. Application specific improvements of software.

Engaging stakeholders

GreenServe puts extra emphasis on investigating the stakeholder landscape, since the earlier projects noted diverging beliefs and motivations across the different stakeholder groups. The project identified the following stakeholder groups for whom the participation in and / or outcomes of the case studies would be of value and interest:

- Application managers
- ICT / Department managers
- Trade Organisations
- ICT providers
- Sustainability/Energy Managers
- CxO level
- Buyers

The project paid particular attention to understanding diverging perspectives and their relation to stakeholder interests, with the aim of overcoming what appear to be contradicting assumptions and beliefs. Engaging specific stakeholder groups to start a dialogue on the topic of energy management improvements within ICT while ensuring all key stakeholder interests are also considered along the way is fundamental to the case study development process – and to achieving energy efficiency improvements in practice.

Based on the existing network of the GreenServe partners, the preferred (group specific) organisations and their contacts were inventoried. We engaged with datacenter co-locators as well as their end-users customers, such as public sector application managers, IT managers, procurement officers etc., and their ICT service providers. This initial approach involved pitching the project, its aims and activities and promote the value of participation in a case study.

The process

The partners and the initial case study participants agreed to apply a new and unique method, the Sustainability Impact Assessment Method (SIAM). It focuses on evaluating impact and trade-off decision making within individual situational context. The approach for GreenServe and its case studies was formulated around this method as well. SIAM has been developed by the VU Amsterdam and Green IT Amsterdam with the specific aim of assessing potential good practices and identifying opportunities to facilitate their implementation in practice. See paragraph on SIAM for more details about the method.

The overall process, from the engagement of the target groups to the knowledge sharing approach is a process that needs time, both because the steps during the process need to be carefully implemented by practitioners who mainly aim to guarantee uptime and performance, and because each individual step relies on understanding of various stakeholders across the value chain. To do justice to this complexity, the following four individual project phases have been designed:

1. Engagement and defining case topic
2. In-depth context analysis and case execution
3. Evaluation and documentation
4. Translate into knowledge sharing material

This translated into the following 'roadmap' of the participation process which also incorporates the aspects of SIAM needed to capture and document the information needed in relation to the decision-making process and the eventual results. This process proofed to be a valuable strategy in enrolling potential candidates in energy efficiency improvement processes.

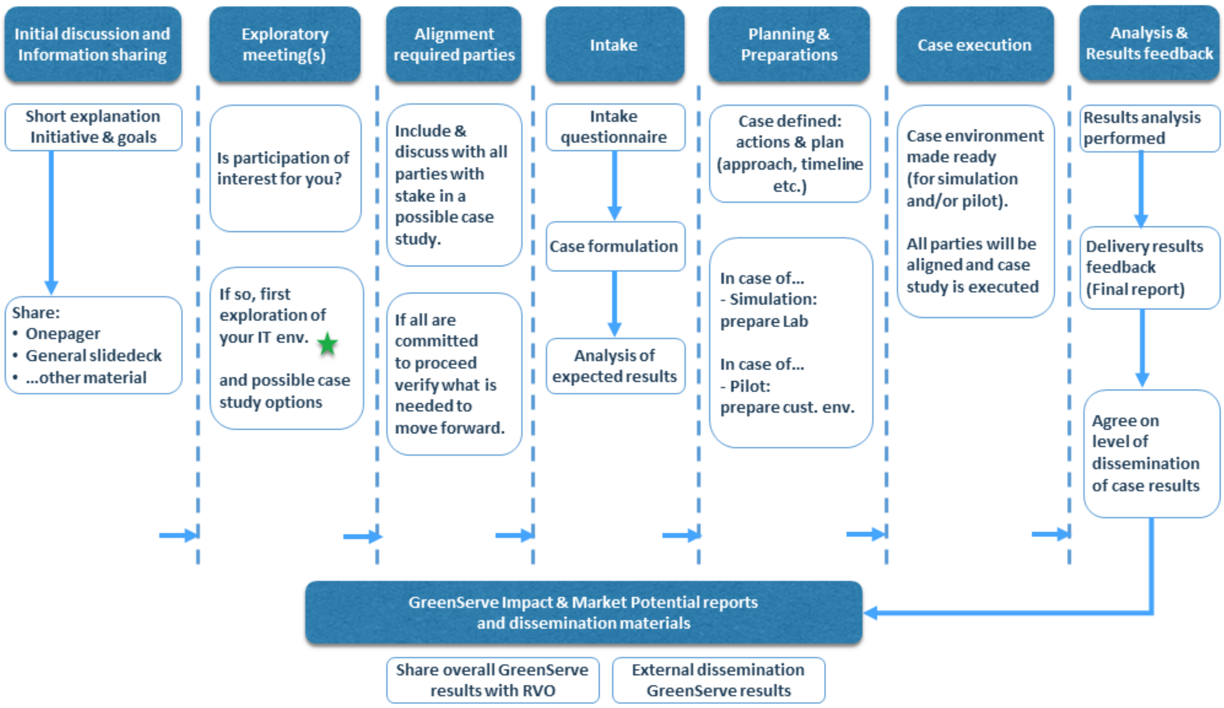


Figure 1 - Approach to engagement and participation in case studies

The ***first phase*** is where the case studies are initiated by going through an approval process within the case study candidates. Key activities are engaging the target groups, combined with the development of dissemination material aimed at creating awareness and generate interest. Each stakeholder may have different benefits or concerns. For example, for the application manager, the goal is to get insight into energy performance of its own application. For a CEO the value may be in strengthening the relationship with their clients by contributing to their clients' sustainability objectives. For an ICT manager, participating in a GreenServe case study can answer the question: can I improve the energy efficiency of my ICT without negatively impacting performance?

When there was interest expressed in the topic during the initial engagement, the project would explain the process (see next paragraph), do a first exploration together of the current situation and possible avenues and, as a next step to a potential case study, include additional relevant stakeholders for an intake.

The intake with the primary participating organisation had to answer a simple core question: "Which application or platform do you want to focus on for the case study?". The project team therefore focused on the end customer, preferably, a public organisation. The transfer of knowledge and the replicability of the results among public organisations are considered more impactful. Their ICT provider would preferably be a MJA3 participant as for them participation would provide the additional benefit of contributing to the MJA3 energy efficiency gains. We used a questionnaire to gather information about the energy use of their environment. This questionnaire would also serve as a trigger to identify and subsequently involve other stakeholders.

When initial interest is triggered, a joint exploration of possible the Case Study options relevant to their specific IT environment. This would result in a plan for executing the case study which includes ensuring the capturing of the current situation and the eventual results so that actual impact can be determined. This is the key element for identifying what makes a good practice and which lessons are learned for the purpose of wider knowledge sharing and good practice adoption.

The ***second phase*** concerns execution and analysis of the Case Studies. The SIAM method is used to ensure we are able to capture the information needed from those who have a stake in or are impacted by any actions taken. This also allows for investigating certain key questions to the scope of GreenServe, such as:

- Who are the stakeholders and what drivers or concerns motivate them?
- How much energy does the application use?
- Which Energy Management options are used / can be used?
- What are the potential benefits and limitations for performing an energy efficiency intervention? What is needed to commence the case study?
- Once going ahead, can we and how do we measure results and impact? Is additional specific expertise to analyse results needed?

If and when key questions are successfully addressed and the decision is taken to test the selected energy management improvement option, the case study is executed and results are captured and analysed.

The ***third phase*** consists in capitalizing on the results that are collected throughout the development of a practical guideline. This part focuses on two main target group perspectives, namely the supply (ICT provider) and demand (ICT customer) perspectives. In other words: organisations that manage their own ICT facility and those using ICT service providers such as a (colocation) datacenter or a cloud provider. Within these two types, there are several relevant audiences that we can identify, and who need to be included in the process.

Finally, as the aim of the project is to describe the case studies to identify opportunities and lessons learned to help and stimulate others to adopt similar practices, the ***fourth phase*** consists of translating this into useful guideline of the best approach to take which is supported by facts and tips. This new communication material is created for the purpose of wide and continued sharing through available channels to maximise its impact of increasing awareness and knowledge exchange.

The initial timeline for the project's plan and relevant milestones was as follows:

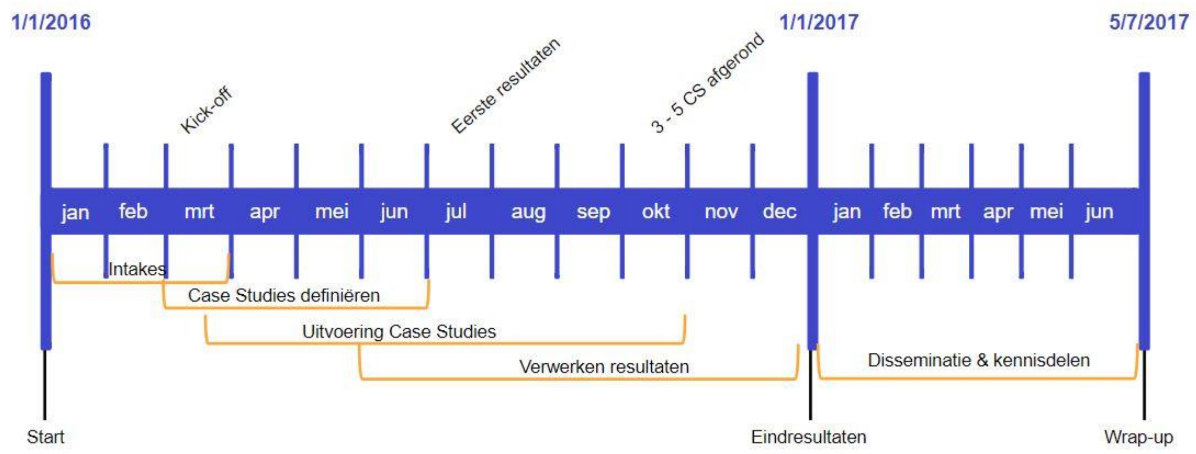


Figure 2 - Figure 2 - Project's initial planned timeline

During the project we gained additional insights about the process of initiating these types of case studies itself which resulted in an extension of the project's timeline. This is addressed more specifically in the chapter lessons learned.

SIAM explained – a Sustainability Impact Assessment Method

The SIAM analysis is based on assessment method developed by VU (SoSA, Software Sustainability Assessment[1]) to evaluate the impact of software improvements from 4 sustainability dimensions: social, environmental, economic and technical. With the realisation this fundamentals of SoSA can be translated to a wider context (not just software), this resulted in SIAM. It enables the creation of trade-off insights between benefits and concerns from different relevant stakeholders within the specific organisational relevant context.

This approach ensures that, while assessing the possible adoption of a practice or solution, the organisation's (strategic) objectives are identified and considered during the decision-making process. In the case of GreenServe, the decision of whether or not the implementation of a specific energy or power management action is 'worth it' when considering the main stakeholders and their drivers.

The analysis consists of taking the following steps:

1. Get to know the stakeholders - Get a feel for their possible information needs and wishes, establish a relationship.
2. First inventory of drivers and possible data to consider for KPI's and metrics.
3. Identify the 'impact category' (based on PESTEL-GS) for each driver - by categorising drivers we can better identify the context of the most important drivers of relevant stakeholders of specific practices (i.e. case topics).
4. First rough evaluation - initial assessment of the results related to the identified aspects to help underpin trade-off decisions.
5. Trade-off overview → Decision-making
6. Assess results: Final report / Case Study and derive the lessons learned.

The PESTEL-GS is an acronym based on a well-known marketing method. It is a tool traditionally used by marketeers to analyse and monitor (external) factors that have an impact on an organisation. It is often used to identify threats and weaknesses. The acronym is based on the abbreviation of Political, Economic, Social, Technical, Environmental and Legal. The GS has been added for SIAM to identify those aspects in relation to Governance (means of steering and control) and Space (the physical or geographic environment).

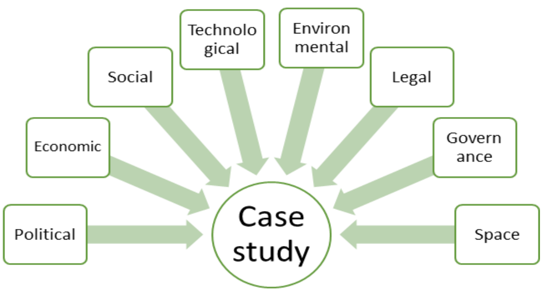


Figure 3 - Representation of the PESTEL-GS impact categories

[1] SoSA:
https://nddho.surf.nl/binaries/content/assets/subsites-evenementen/nddho/presentaties-2017/3---2017-0519-nddho-plago.pdf
https://www.slideshare.net/patricia_lago/designing-software-with-a-sustainability-intent-the-software-sustainability-assessment-sosa-method

For SIAM, the PESTEL-GS analysis has been developed to identify and map the relations between the stakeholders, their underlying drivers and the potential benefits and concerns for an intended action that requires insights on its expected impact before deciding to proceed.

KPI's and other indicators need to be identified during PESTEL-GS. Subsequently, they will be used to determine the (expected) impact of the action and how the contribute to the identified drivers of the different stakeholders. This approach will also ensure that the impact is assessed from all four sustainability dimensions.

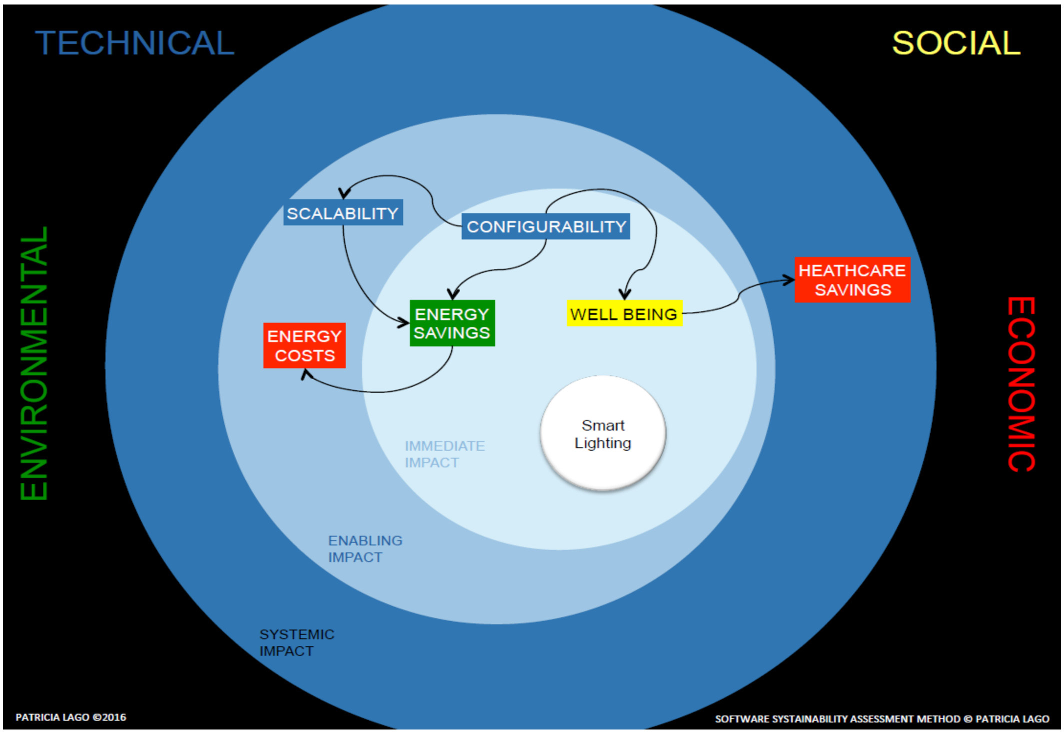


Figure 4 - Example of a SoSA mapping by Dr Patricia Lago

5. GreenServe Case Studies specifics

The analysis is based on 6 case studies that have been performed by the VU Amsterdam and by Certios. The topics range from optimization of software applications through enabling power management settings to performing hardware refresh activities. While this chapter describes the activities performed during the case studies, the results achieved, and the trade-off analysis that characterises each specific case, the later chapters refer back to them as they are the source for the conclusions, lessons learned and guides.

Case A – CMS vs. HTML for websites

(with Cobra Systems)

Case specifics

Summary

Content Management Systems (CMS) are amongst the widely adopted solutions to publish content on the web, as they simplify the creation and modification of digital content. However, they also introduce a significant overhead on the server side, in terms of available features and resource usage and efficiency. How would that effect the energy consumption impact? This case study focused on comparing the energy usage of a simple blog implemented in 2 different versions, one based on CMS and the other based on static PHP, both using the same underlying architecture (hardware and VM software layers). The experiment used fully scripted execution of varying actions which was run 30 times and took measurements from several system components. For this case study we opted for WordPress as CMS because is the most popular content management system, used by over 27% of all websites on the internet and by 59% of all websites using a known CMS.

SIAM – Stakeholders, drivers and metrics

For this case study the following were identified as main *stakeholders*:

- Application manager
- ICT manager
- Managing Director

The main *drivers* for participating in the case studies were:

- What is the impact of using off-the-shelf content management systems (CMS) on the energy efficiency of web applications?
- Is there any impact or difference in performance?
- What considerations can be identified regarding web application strategies?

For the case the following *metrics* were used to evaluate results:

- Energy consumption (Joules, Watthours)
- Power consumption (watt -total, CPU, Memory, Disk)
- Resource Consumption (CPU, Memory, Disk - also at virtual machine (VM) level)
- Performance: Total benchmark time (seconds), Average Time and Requests per second, Average Data Transfer Rate (Kbps/s)

Results

- Performance: 34% increase of execution time; 73% decrease of requests served per time; a 38% power consumption increase.
- Resource use: CPU usage is increased by WordPress, while memory and disk usage are actually reduced.
- Energy consumption: The experiments run in this case study demonstrate it is possible to save almost 45% of energy consumption, especially in virtualised (Cloud) environments, by using static pages over CMS to serve the same content.
- The experiments also demonstrated that the CMS loads a significant amount of software components that are not necessary when presenting the website content to a visitor.

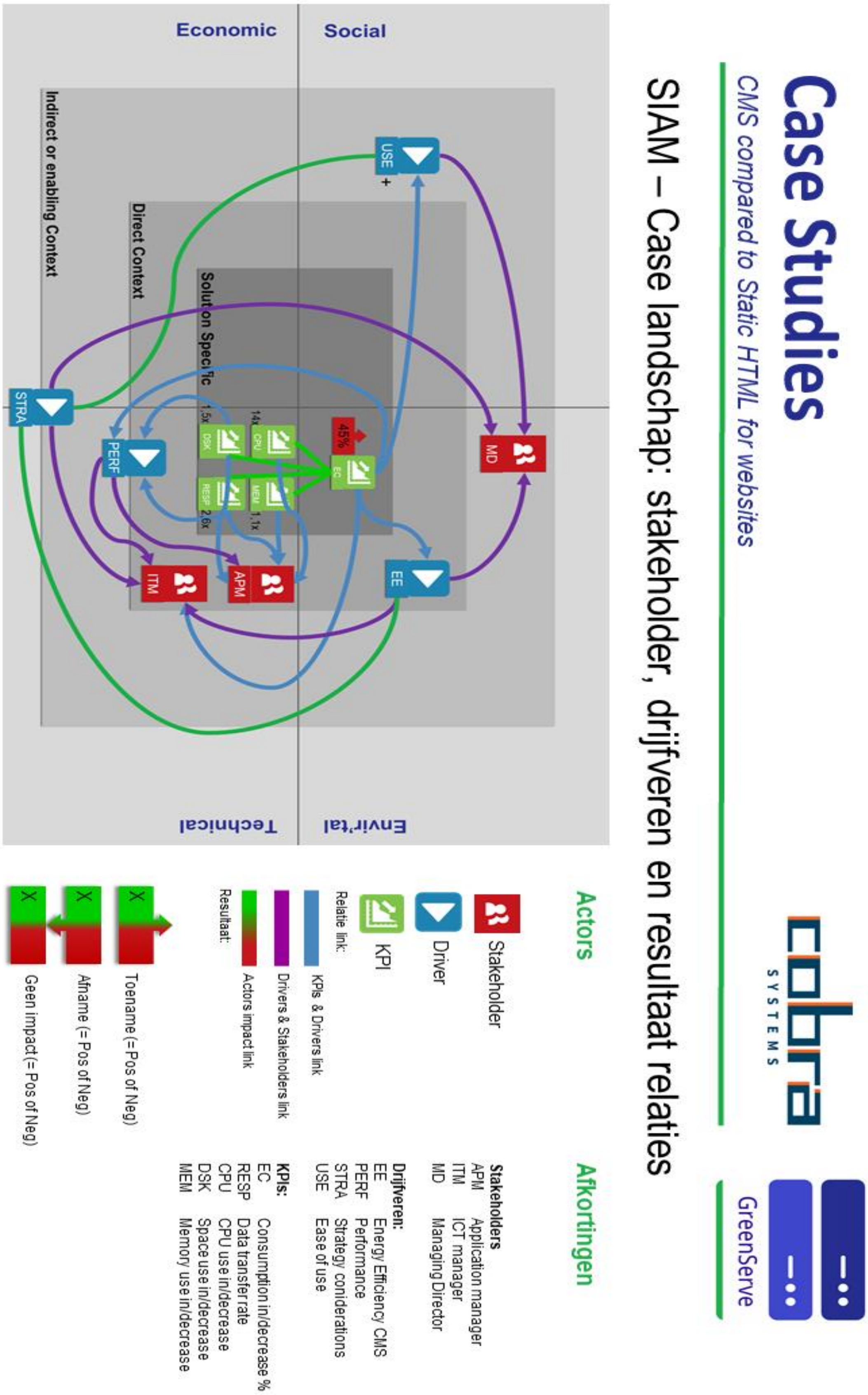
Decision Trade-offs

The impacts for decision-making is the evident trade-off between the increased flexibility and ease of use granted by CMS and the simplicity and performance offered by static websites. Simpler solutions such as web portals, simple forms or common webpages that do not require or use the advanced features offered by CMSs can be realised by using simple static webpages to save a relatively significant amount of energy and also provide better performance to their users.

This information can be adopted into an organisation’s strategy towards web content development. It allows and enables web developers to make conscious and informed decisions about which technologies to adopt for (individual) web products, which knowledge and skills are needed to do so.

The trade-off analysis is described with the SIAM map on the next page.

Case A SIAM Map



Case B – Software update deployment strategies impact

(with KPMG)

Case specifics

Summary

For this case study, measurements were made for the analysis from 'static code' and 'dynamic load' perspective to be able to assess specific aspects of the application. In particular, we looked at characteristics in different 'releases', software quality attributes and deployment strategies and their impact on the energy consumption of the application.

SIAM – Stakeholders, drivers and metrics

For this case study the following were identified as main *stakeholders*:

- Application managers
- ICT / Department managers
- Sustainability/Energy Managers

The main *drivers* for participating in the case studies were:

- High energy consumption of business applications
- The need for high-performance applications
- Increased quality and maintainability of software code
- The need for insight into characteristics of Qubus: difference between releases and deployment strategies
- Time to market of the software and applications
- Time and effort spend on developing the applications

For the case the following *metrics* were used to evaluate results:

- Static source code metrics
- Dynamic load test
- Power consumed (Watts)
- Execution Time in milliseconds (ms)

Results

- Different releases of the application have different energy profiles in an often intuitive way
  - Refactored, smaller code corresponds to lower energy consumption
  - Multithreading results in higher power consumption
  - Increased duration of recurring actions results in higher energy consumption
- Because the relative limited impact of frequency scaling, higher load during a shorter time results in lower energy consumption than lower load during a longer time.
- Different deployment strategies result in different energy profiles
  - Distributed deployment of Qubus corresponds to lower load and higher energy consumption
- Qubus' power consumption does not vary as drastically as the energy consumption of the load tests. Its power consumption is not directly proportional with the total energy consumption of the experimental load tests.

- The energy performance of a release is modulated by the deployment strategy: it is not defined by the deployment strategy.

Decision Trade-offs

- Time to market defines how much time and resources can be spend on increasing the quality of the code of an application. Higher quality takes a longer time to market, but results in better maintainability and lower energy consumption.
- Distribution of an application increases maintainability of an application, but can negatively impact its energy performance.

Case C – Applying Green Cloud Model (GCM) in practice

(with Rabobank)

Case specifics

Summary

GreenServe aimed to validate the Green Cloud Model (GCM)[2] created under the Greening the Cloud project and to identify opportunities for improvements of the model in relation to the practicality of its use. In addition, Rabobank already has its own developed Energy Efficiency model (REL) with a similar intention. Both parties wanted to use this case study to compare and evaluate the models to identify their individual strengths and suggestions for improvements related to their applicability.

SIAM – Stakeholders, drivers and metrics

For this case study the following were identified as main *stakeholders*:

- Application managers
- ICT / Department managers
- Sustainability/Energy Managers
- CxO level
- VU Amsterdam and Amsterdam University of Applied Science (as primary developers of the GCM)

The main *drivers* for participating in the case studies were:

- Assess the GCM model in real live application
- Assess the REL model in comparison
- Increase energy efficiency of ICT
- Comparative analysis of various ICT applications deployed within the organization

For the case the following *metrics* were used to evaluate results:

- Hardware Efficiency (CPU Cycles divided by Rack Energy Consumption)
- Virtualization Efficiency (Virtual CPU Cycles divided by Physical CPU Cycles)
- An application's Relative Efficiency (Its Minimal Clock Cycles per Transaction divided by an Average of Clock Cycles per Transaction)

Results

- The bare metrics show differences in stability between the various applications.
- The bare metrics indicate shortcomings in specific deployment, such as significantly decreased Relative Efficiency of an application during night-time.
- The four indicators of the GCM could only partially be calculated as we encountered a number of challenges when trying to apply the model. However, most of these

[2] Greening the Cloud project: http://www.hva.nl/urban-technology/publicaties/publicatiereeks/publicatiereeks/publicatiereeks/content/folder/greening-the-cloud-copy.html

challenges can be realistically addressed. In doing so, the GCM would be feasible to apply.

- On the virtualisation layer, we tested the indicator on a non-virtualised system. This means there is no loss of computing power due to virtualisation, but there is also no virtual utilisation in that case.

Decision Trade-offs

- Identification of a suitable location to capture data is hard. Deriving the actual data from the systems is time consuming. Moreover, many of the reporting mechanism are underutilized, and as a result the ICT managers need to spend significant time on configuring the systems that need to produce and report the data.
- When the data is produced, there are large energy savings and performance increase opportunities to be identified.
- Experience with capturing the data significantly decreases the effort it takes to apply the Green Cloud Model.

Case D – CPU Power management for Cloud-based storage

(with SURFsara)

Case specifics

Summary

This case study describes the implementation of a power management feature related to CPU settings in the BIOS). This feature is called Demand Based Switching and automatically reduces the clock speed when the demand decreases and automatically increases when demand increases. Its functionality is widely available but is still little used. SURF wanted to know what the savings potential is when the setting is changed from Max Performance (MP) to Demand Based Switching (DBS), whether this has a noticeable negative effect on the performance and what it does with the capacity utilisation of the servers. The study concluded that the change from MP to DBS resulted in a significant increase in energy efficiency, with no noticeable decrease in performance.

The application that was tested for this case study was SURFdrive: a file storage system used by higher education institutes serviced by SURF. The case was carried out in a production environment on a representative part of the servers for this storage service.

SIAM – Stakeholders, drivers and metrics

For this case study the following were identified as main *stakeholders*:

- SURFdrive Application manager
- ICT manager
- Sustainability/Energy Managers
- SURF member decision makers, Sustainability/Energy Managers and their ICT managers - as (potential) customers of the SURFdrive service

The main *drivers* for participating in the case studies were:

- Develop more knowledge towards identifying new improvement opportunities
- Demonstrate their exemplary role as Sustainable ICT leader and Center of Expertise to their members (in the higher education sector)
- Reduce power consumption of their ICT services

For the case the following *metrics* were used to evaluate results:

- Response times in ms
- Power consumption in KWh
- CPU utilisation %

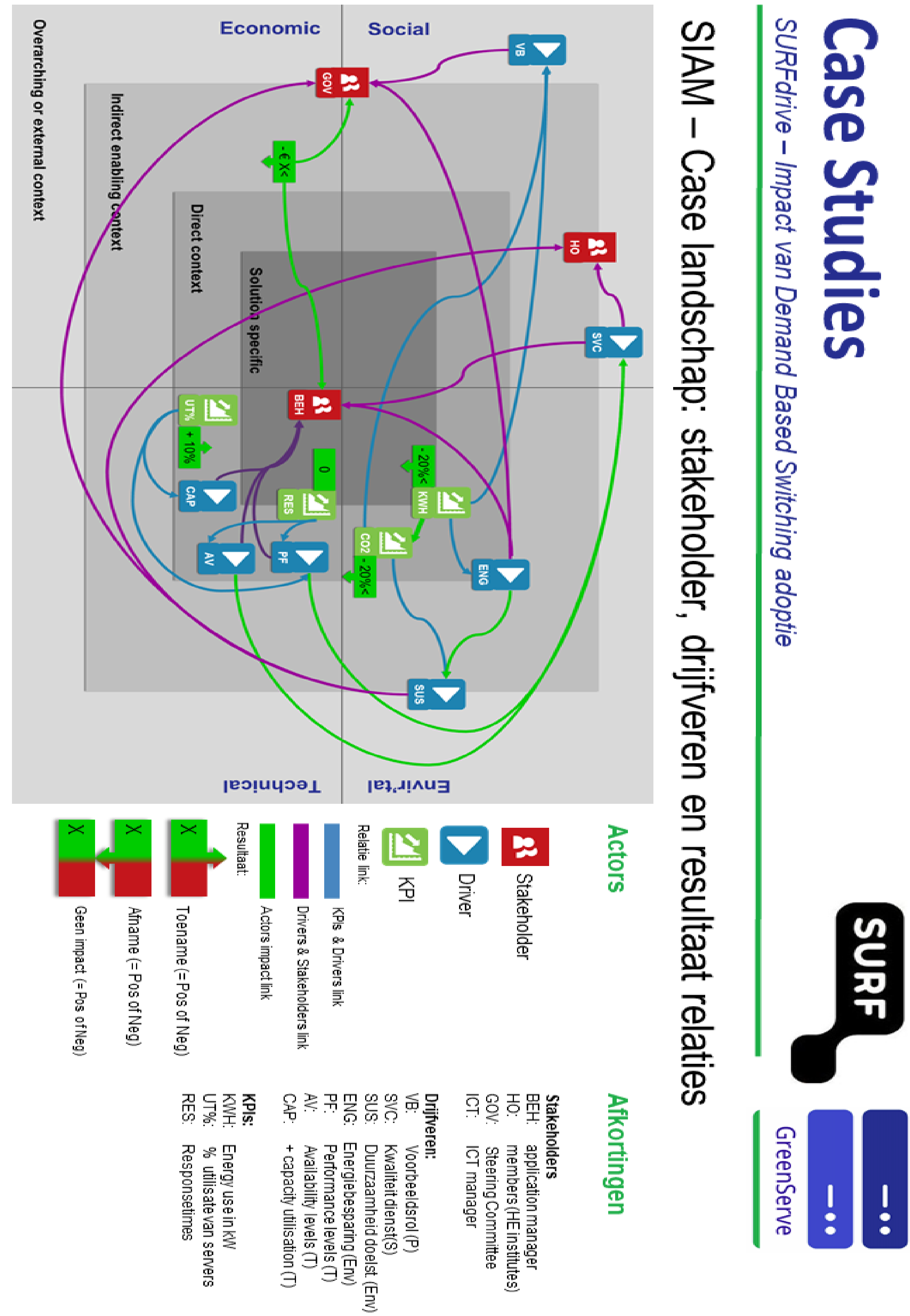
Results

- Power consumption of servers set to DBS decreased by 20%.
- Average server CPU utilisation increased from 10% to 20% and utilisation peaks from 20% to 30%, resulting in a general 10% utilisation increase across the board.
- No measurable impact in response times / performance was detected.

Decision Trade-offs

The trade-off consisted of the willingness to dedicate employee resources versus the possible identification of energy consumption gains. Based on the results SURF plans to expand the adoption of this measure across SURFdrive and other services.

Case D SIAM Map



Case E – Energy efficiency measures at municipalities

(with several Dutch municipalities)

Case specifics

Summary
This case study describes processes within three midsize to large municipalities in the province of North-Holland. All three preferred to be mentioned anonymously in public documentation. For this reason, we will refer to them as municipalities A, B and C. All three responded positively to exploring the identification of improvement opportunities, partially triggered by the awareness of their municipality's sustainability agenda. The timeline of the GreenServe project did not lend itself to monitoring the actual implementation of these policies in either enabling power management functionality or procuring an application environment with advanced power management functionality. However, all three municipalities explicitly incorporated the lessons learned of the case studies into their updated policies. The results are captured below.

SIAM – Stakeholders, drivers and metrics

For this case study the following were identified as main *stakeholders*:

- Application manager (A, B and C)
- ICT / department managers (A, B and C)
- Municipality employees (A, B and C)
- Current ICT and datacenter services provider (A, B)
- Unknown / yet to be determined datacentre service provider (B)
- Consultancy firm: providing new ICT architecture design (B)
- Citizens (B)

The main *drivers* for participating in the case studies were:

- Reduce energy costs of ICT (A, B and C)
- Reduce CO2 footprint (A, B and C)
  (with 2020 to 2030 as target years to meet specific goals towards eventual carbon or energy neutrality)
- Performance levels for business applications (A, B and C)
- Performance levels for the (ICT based) services offered to citizens (B)
- No new changes for now because of just completing a recent move (C)

Results and lessons learned for decision-making trade-offs:

- Municipality A is undergoing an extensive and lengthy transition of multiple years which involves a complete refresh and redesign of their ICT infrastructure in stages. Partners from the GreenServe project collaborated with (European) project EURECA (with a scope of the entire datacenter facility) in the municipality's wish for an external intermediate evaluation. The eventual energy savings potential of these combined improvements are set to 11 Gwh per year. Although currently there was no opportunity for a case study for the adoption of power management, the municipality participated in a monitoring exercise to gain insights in capacity demand based on actual use trends. The result was received as positive useful information for next steps and they do plan to incorporate the exploration and testing of implementing active power management.

- Municipality B is currently undertaking a tender procedure. GreenServe engaged with them at a time when a 3rd party was just commissioned to design their future software-defined datacenter infrastructure using Cloud-based solutions and included attention to energy efficiency. Based on dialogue with the project the municipality re-engaged the firm who confirmed active power management would be considered for the design unless there are indications of performance impacts. The design is being finalized in the second quarter of 2018.
- Municipality C engaged in dialogue to re-evaluate earlier experiences with power management causing performance issues. This experience was over 5 years ago, but created a lasting impression. The municipality was happy to learn that in the issues they experienced are solved in later versions. However, the current hardware was not suitable to accommodate these newer software versions. It is expected that when current hardware is refreshed the municipality will also update their virtualisation software which include the power management features.

Ensuring good performance levels of the ICT services (either for employees or citizens) is key to both the application and ICT managers, as well as their external ICT providers. Understandably these stakeholders are determined to avoid any risks that are perceived to negatively impact this. The association of active power management with performance issues still exists and is sometimes reinforced by service support parties' first response to reports of performance issues to ask if power management is switched off.

As can be seen, all three municipalities' drivers relate to the municipality's strategic objectives alongside the need to ensure performance levels of its ICT services. It was their knowledge of the municipality's sustainability agenda and aim to reduce costs that generated the interest to engage in dialogue with GreenServe.

None of the municipalities had formulated specific targets for the ICT department with regard to the sustainability agenda. For all three the energy bill of ICT is (for at least part of the ICT environment) still part of the larger energy bill, creating a (partial) split-incentive situation. This is why it was not possible to determine the actual current energy use (and its related expenditures) for ICT specifically.

Both the lack of an energy-consumption 'baseline' and no specific sustainability targets make it difficult to assess the achievements that will be made once measures are completed. Regardless, there was a strong awareness that ICT contributes to the municipality's energy and CO2 footprint and a willingness to look for possibilities to improve.

The primary resulting from the dialogues between GreenServe and municipalities are:

- Updated knowledge regarding the current state of power management
- Increased awareness of the value of measuring the use trends of the ICT environment's applications
- Increased awareness of the value of measuring energy consumption.
- Validating ICT's potential for contributing to a municipality's sustainability agenda.

Case F – Refreshing equipment with high average age

(with a Dutch Water Authority (DWA))

Case specifics

Summary

For this particular regional Dutch Water Authority a number of servers were already planned to be replaced. Combined with an existing wish from the DWA to look for wider energy improvement opportunities, the option for full evaluation of its server park was considered as most valuable and the quickest and easiest option that presented itself. There were no plans for moving to Cloud or outsourcing due to the nature of the ICT environment. Within the server park each server was assessed on age, model and related energy specs.

SIAM – Stakeholders, drivers and metrics

For this case study the following were identified as main *stakeholders*:

- ICT / datacenter manager
- Sustainability/Energy Managers

The main *drivers* for participating in the case studies were:

- Reduce energy consumption of their ICT services
- Lower footprint
- Reduce energy costs
- Easier maintenance and support
- Considering adopting an earlier refresh rate strategy for equipment

For the case the following *metrics* were used to evaluate results:

- Age of existing equipment
- Energy efficiency specs per model in use
- Energy efficiency specs for possible replacement model
- Standard for 'CO2equivalent' to translate energy savings into GHG savings.

Results

- Replacing 28 physical servers with an average age of 5.1 years equals to annual savings of 61 MWh (6.625 KWh (old) - 1.568 KWh (new) * 12 months) in energy consumption.
- This translates into approximately 30 – 32 metric tonnes CO2 (equivalent) of GHG emissions avoided based on Dutch electricity grid [3]
- This DWA is considering a strategy for more regular evaluations for refresh-candidates, taking into account energy savings and costs.

Decision Trade-offs

Although energy costs were not made available for this case study, it can be assumed that this would also result in the desired energy cost savings. Had this focus on energy savings for

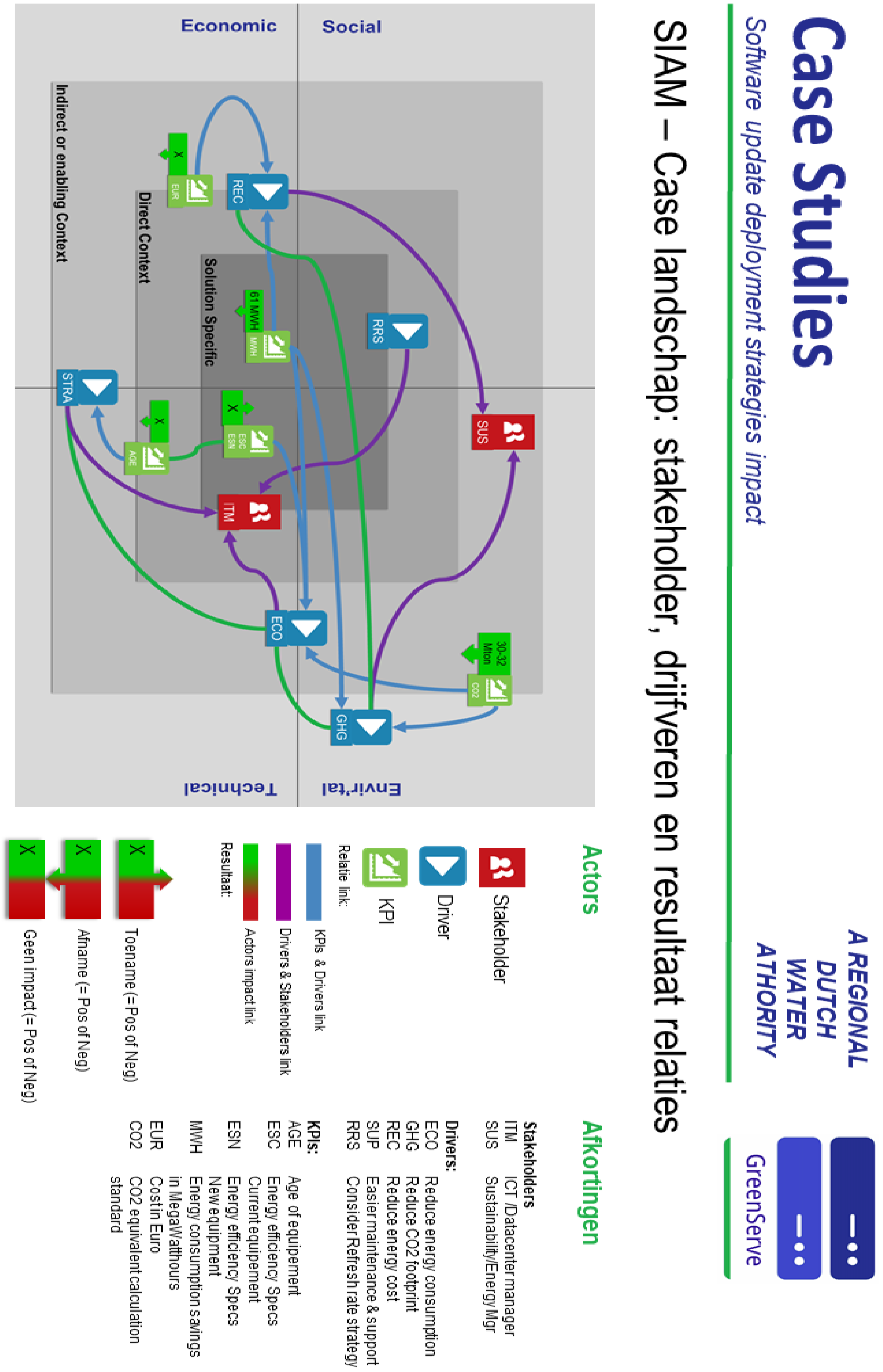
[3] http://www.carbon-calculator.org.uk | https://www.klimaatplein.com/gratis-co2-calculator

ICT been adopted at an earlier stage, for example 2 years earlier, the savings achieved would have already paid for half the investment needed for new equipment.

Note1: Although there are no clear and uniform guidelines available yet on the optimal refresh moment when taking into account the sustainability impact, for both energy and materials related to disposal as well as the production of new. For refresh strategies it is always recommended to consider the fact of these impacts. The topic is gaining attention and it is expected in coming years more knowledge and good practice guidelines will become available.

Note2: The objective of making maintenance and support easier was not quantified.

Case F SIAM Map



6. Lessons learned

The results from the case studies are reformulated into lessons learned on three topics: technological implications of advanced energy and power management, organizational challenges, and contextual factors impacting adopting good practices.

Technology

LL1 - It takes time to collect relevant data for good decision-making. There is a need to consider multiple important drivers and stakeholders and to support arguments by facts. If it isn't measured, it cannot be managed. This data must often come from different areas of expertise across different roles within an organisation (or can even be assigned to an external party, i.e a supplier). **Engage beyond departmental and even organisational boundaries to address this so data can become available (and more easily) and simultaneously strengthen working relationships altogether.**

LL2 – External expertise or resources can play an important role in enriching, analysing and interpreting data into a comprehensive collection of actionable points. GreenServe benefited significantly from the analyses by the VU Greenlab. **Collaborating with research or educational institutes can provide you with the additional resources you need, and consultancies can act as a strong liaison towards this knowledge and expertise.**

LL3 - Many stakeholders involved in managing ICT environments of their organisation are aware of the existence of power management features, but are not always up-to-date on advancements made the past years regarding stability, robustness and performance. For example, the idea that using power management features in virtualized environments causes performance issues is still a widespread assumption while most, if not all, recent research and practical case examples provide evidence this is no longer valid. **Keeping up with recent developments on energy efficient ICT can help combine energy efficiency with increased performance and reliability.**

LL4 - Confirming existing papers, the GreenServe case on applying Demand Based Switching for SURFdrive, a cloud based storage service, resulted in 20% energy savings, combined with a 10% increase of server utilisation without any measurable negative performance impact. **Power management based on Demand Based Switching can save significant amount of energy for an application environment and does not impact performance.**

LL5 - Many organisations underestimate the gains that can be achieved by acting on insights resulting from measuring (and capturing) data. These insights allow management and operations to actively steer on energy aspects – something they typically do not have the tools readily available to do this. **In order for an organisation to self-initiate improvements and become proactive they will first need to address their capacity to collect and collate reports on energy consumption.**

LL6 - SMART your indicator-selection! **Make sure you select specific, measurable, achievable, realistic and time-bound relevant indicators.** You need to be able to calculate them in such a way that the information makes sense and reflects the correct context. F.e: the

Green Cloud Model case study showed that many data needed for indicators to apply the Green Cloud Model were not available.

LL7 – Simple software based optimizations can already create a large impact. The Cobra System case study compared the use of a Content Management System-based method versus static HTML method to build the same website. The experiments performed indicate significant energy consumption differences where applying HTML method consumed at least 45% less energy compared to CMS based method. **The trade-off between ease of use of the CMS and performance gain through automated code generation and optimization indicates that effort in reducing software overhead does pay off.**

Organisational involvement and motivation

LL8 - **It is crucial to know who your stakeholders are and to identify as many relevant ones as possible before consolidating and selecting your main stakeholders.** This ensures you will directly (or indirectly) involve those most relevant to the case study (and its specific topic). This is the only way to include and understand what drives your stakeholders (be it a benefit or a concern). This increases the chance of successful support and participation in performing a case study and implementing a good practice.

LL9 - **(Strategic) management support is crucial for an application and/or IT manager to get approval for energy efficiency improvement interventions.** We found this to be the crucial determining factor for an application and/or IT manager to move forward to actual execution and implementation.

LL10 – **The Green Cloud Model has been demonstrated to be a practical tool for identifying energy improvements in ICT systems.** However, its application across all four layers depends on an organisation's ability to measure and collect data. When aiming for wider application and adoption of the model it should take into account additional time and effort needed to ensure data can be made available or the application of the model can only be done within organisations that are mature enough.

LL11 - In many public sector organisations, IT related tasks and responsibilities are often spread across multiple roles, asking for explicit attention to stakeholder management. **Take into account any organisational decentralisation of tasks and responsibilities while planning your improvement efforts as this may be more time consuming than if tasks and responsibilities are more centralised.**

LL12 - The ambition from public organisations to participate in such project is often highly motivated by their need to meet sustainability targets, in addition to their need to lead by example. **Improvement proposals for the public sector should first stress the positive impact on the organization's sustainability policy, and describe how cost savings and reliability increase are a good side effect.**

Contextual and governance implications

LL13 **- Benefits of cost savings due to lower energy consumption are typically not an effective driver for those in (end-user) IT departments, as the split incentive exists in many situations.** I.e. the cost of energy consumption related to their ICT is not paid by ICT. If split incentive still exists, the bill is most often paid by the facility department. However, there is a noticeable trend that this is changing. There are more signs of organisations in the process of changing this (or have the intention to change this in the near future) by making ICT departments more accountable for their share in energy consumption.

LL14 - **There is an increased interest to gain more practical knowledge about the adoption of good practices and as a result a concrete interest to participate in case studies.** Therefore, an increase and diversification of documented (and shared) practical case examples that provide information on which practices were implemented, how it was implemented and what the situational context of the implementation was, will significantly improve the adoption potential of energy and power management improvements.

LL15 - **However, there is also still hesitancy to produce publicly available documentation as a case example for others due to information sensitivity issues.** This applies to both public and private organisations. For public organisations their main concern stems from the fact they handle information from and about the public (citizens etc.). For private organisations, which in this case are the suppliers of IT services, this is mostly related to the need for compliance with customer privacy agreements or competition-sensitive data.

LL16 - **The internal processes within (public) organisations requires the expertise, alignment and approval of multiple departments and (external) parties.** Aligning on these fronts is particularly time consuming and resource intensive. As a result, the initiation and approval phase were considerably more time-consuming than was expected and caused the implementation phase to be pushed beyond the time frame of the project itself.

LL17 - **The use of SIAM has proven to be a useful tool in ensuring the capturing of multiple and diverse stakeholders and involve them**, directly or indirectly in efforts such as the development of case studies aiming to both increase awareness and enabling the decision-making towards taking action. The use of this approach, however, is more time-consuming as organisations need to involve and align more stakeholders in the process. The more this approach is used, the easier its application will become.

7. Useful guidelines for (self) improvement actions

GreenServe identified distinct stakeholder groups that play a key role in increasing awareness and widening the adoption of good practices by providing practical example-based knowledge. The key to identifying the drivers for each of these stakeholder groups are the following questions:

Application managers

- How and why do efforts to improve the energy performance of my application benefit me?

ICT / Department managers

- How can I contribute to my organisation and/or customer's energy savings targets while avoiding possible undesired impact on, for example, performance and service levels?

Trade Organisations

- What is the savings potential of adopting energy management measures for the IT sector?
- How can the ICT sector support their customer(s) in improving energy efficiency savings?

Sustainability/Energy Managers

- How can our ICT department or provider contribute to our sustainability and/or energy targets? (added benefit = cost reduction)

CxO level

- Why and how should my ICT department contribute to my organisation's energy targets?

Procurers

- What can I ask of my ICT provider in tendering for ICT services?

The GreenServe Infograph – A practical guideline

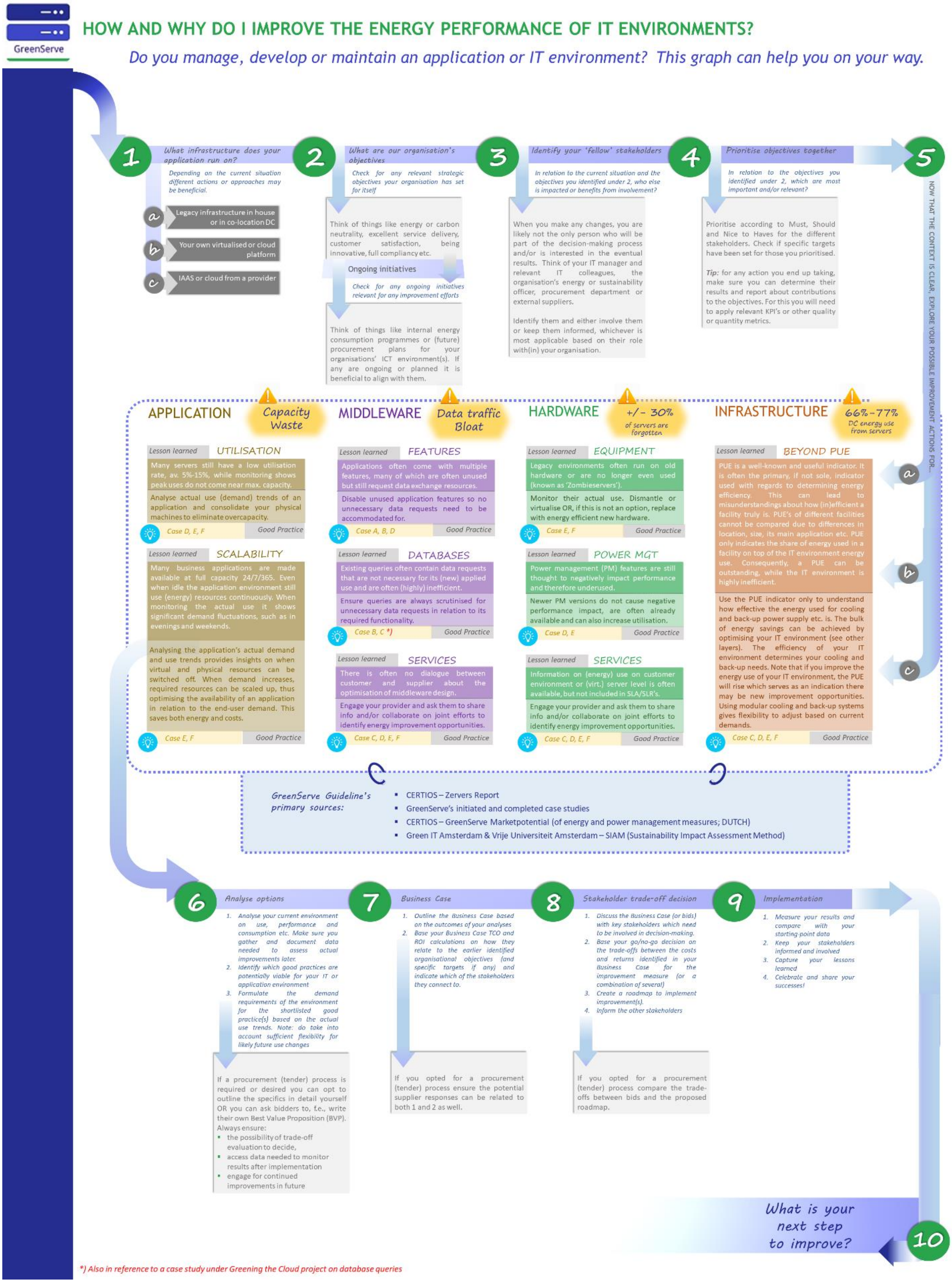


Figure 5 – GreenServe Infograph - A practical guideline (See separate pdf for full size version)

Facts & Tips sheet – What can owners of facilities, ICT and applications do?

Topic	SIAM connect strategy to operation	What data is needed	What to look out for	Potential improvement indications
Power management in BIOS or in Virtualisation Software features	Check what your organisation's strategic objectives are that the improvement measure can contribute to, make sure you understand for who within or outside the organisation the planned activity may be of importance (benefit or concerns) and determine how you will estimate and/or measure its effect. Tip: Also include relevant service support providers or even city planners, f.e. when a new facility is part of the plans. Create a support base within your department / organisation fromf the stakeholders by highlighting their specific benefits and acknowledge (if possible address or alleviate) their concerns. Determine how you evaluate its effects and what you will use to measure this. Select the right (combination of) metric('s). A quality indicator can also be used (f.e. a certain level of certification).	• Measure current use trends • Existing capacity of the target environment • Existing utilisation of the server(s) • Current energy consumption of the target environment • Measure response and execution times of current (and to-be in a test environment) situation. • Tariff to use for translating energy savings into cost calculations • Use the standard for 'CO2equivalent' to translate energy savings into GHG savings.	• Make sure the data covers a representative time period • Check for expected demand growth (or decline) or other changes. • Fluctuation patterns in use intensity, duration and peaks.	Depends on the type of environment and the use pattern (intensity and length/peak fluctuations). Expected Average of 20 – 35% Cloud-based storage example: Pattern = intensity during business hours and short peaks at midday and end of business Energy consumption savings = 20%. Utilisation = average 10% increase In theory for an application with an intensity and peak use during a smaller period of time the achievable % would be considered to be higher.
Query scripts		• Measure execution times of queries • Analyse and evaluate scripts and identify unnecessary data requests and bottlenecks • Tariff to use for translating energy savings into cost calculations • Use the standard for 'CO2equivalent' to translate energy savings into GHG savings.	• Also analyse ready-made queries from database frameworks as they are 1-size-fits all so not optimised for your specific environment. • Ensure you have access to resources with knowledge and skills to perform the evaluations and can optimise queries.	For queries this is difficult to say as there are many different types and complexity levels, Example case (from Greening the Cloud): Experiments encompassed 3 main variable factors, 4 different query types and 3 different table sizes. Energy efficiency improvement = Average 25% with corresponding reduction in execution times.
Equipment refresh		• Age of existing equipment • Energy efficiency specs per model in use • Energy efficiency specs for possible replacement model	• When equipment becomes more energy efficient, cooling and back-up power capacity needs may also decrease. In existing self-owned facilities this offers additional saving opportunities (or result in overhead and a higher PUE)	Example case of refresh of 28 servers of 5.1 yrs average age with 4 latest models = 61 MWh energy savings & 30 – 32 Mton CO2 per year.

		• Tariff to use for translating energy savings into cost calculations • Use the standard for 'CO2equivalent' to translate energy savings into GHG savings.	.	
Facility upgrade		• Measure current use trends • Existing capacity of the target environment • Existing utilisation of the server(s) • Current energy consumption (total/per location and more detailed such as for cooling, back-up, ICT (and/or per application environment) • Tariff to use for translating energy savings into cost calculations • Use the standard for 'CO2equivalent' to translate energy savings into GHG savings.	• Combine various improvement measures such as consolidation, adopting virtualisation and cloud design, equipment refresh, innovative cooling and back-up solutions, modular builds etc.) • Include flexibility to be able to adjust for growth or other adjustments	Examples that were explored in the Eureca project conclude that in practice the energy efficiency of an on-premise datacentre can be improved with 25% through adopting best practices in the datacentre facilities, and with 35% by moving to a colocation datacentre that has adopted best practices.
Application (individual, suite or platform) features		• Monitor use trends of your applications to identify un(der) used applications. • When in use: monitor use trends of specific features • Tariff to use for translating energy savings into cost calculations • Use the standard for 'CO2equivalent' to translate energy savings into GHG savings.	• Which features do you need? Which can be left out of or set to disabled in installed version?	The example of optimising a website by moving from a generic CMS to customized HTML resulted in 45% energy savings related to the case study website.

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