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1.0		Final version	Esther van Bergen; Rabih Bashroush	1/12/15

Table of Contents

Table of Figures

1 EXECUTIVE SUMMARY

1.1 General

The key objective of EURECA is to support energy / resource efficient and environmentally sound procurement actions within the European Public Sector for data centre and related products and services.

This report is produced as part of WP1 DC Procurement Analysis. The aim of this deliverable is to report on the project's analysis of the impacts of making new procurement choices. Building on the initially performed analysis, including a SWOT and GAP, of current (best) practices, the project has performed a public sector needs and ambitions assessment related to bridging the identified GAPS to meet the particular public sector targets related to carbon emission and energy use reduction, sustainable energy action plans and other related national of EU goals they are committed to.

This deliverable provides insight into the efforts taken to understand the effects of these (technology) procurement choices and their impact on social, environmental, legal and economic aspects (organisational drivers) which allows the project to identify the mechanism and data needed for the cost / benefit calculations that will enable the creation of business cases which address the aspects mentioned above. This also allows for the baselining of economic life cycle data needed for the validation and evaluation of EURECA framework and tool itself (work package 5).

1.2 Findings and conclusions

With the increased focus on energy efficiency and sustainability in recent years there are some good examples to be found and substantial gains have been made through procurement of new data centre products and services. However, there are still disconnects that prevent the uptake of new technology and/or take advantage of viable opportunities.

We can conclude that the main needs for the public sector to meet their ambitions (possibly driven by national, European or global ambitions) lie with:

- support in identifying the most relevant targets and criteria that align with strategies and derived objectives of the entire entity
- subject-matter awareness and understanding (DC/ICT and environmental/sustainability)
- enabling group involvement that reduces reliance on the persistence of an individual employee, and to counteract conflicting interests or end up with solutions that do not work on overall level
- reduction in time and effort needed

The landscape of impact of new procurement choices exists both inside and outside the public sector organisation. There are several (interconnected) levels from a procurement perspective we need to look at that influence and determine the eventual impact; the procurement scenarios themselves, the product / service life-cycle and the organisational drivers (which are consequently also the areas impacted).

To understand these choices the CBA for Business cases should include monetary figures (TCO for life cycle costing) and other weighted values for environmental impacts and improvement benefits (LCA-based, with DC /product-specific use stage data and common production and end-of-life data.

Finally, each KPI intended for use in (public sector) procurement needs to be applied in exactly the way they are intended and not in ways where they create distorted (false) results. As such the intended use of KPI's will be reflected in the way they are incorporated in the EURECA framework and tool.

2 Introduction

2.1 Purpose of this document

This document is to describe the approach to an inventory of needs and ambitions for bridging the aforementioned gaps, primarily in the target countries (UK, The Netherlands and Germany) and to describe the mechanism and translation towards impact evaluation for business cases. The main target of exercise is to create the foundation that will allow for the development of comprehensive business cases that address the main identified organisational driver aspects through use of the EURECA framework and tool.

2.2 Objectives

The DoW (Description of Work) specifies the following activities to be performed for the 'Impact analysis of green data centre procurement choices report' within work package 1:

- Identify ambitions and needs indicators from actual procurement tender examples and specific business cases with the policies and targets used in those cases, particularly those that endeavoured to use KPI/metrics and other criteria which EURECA has identified for the framework and tool in D1.1.
- An analysis of the areas affected when evaluation of procurement choices are targeted towards environmentally sound data centre products and services.
- Arrive at a conclusion of the method and mechanisms beneficial for relevant cost-benefit assessments towards creating business cases within the EURECA framework and tool that allows for effective impact evaluations of various solution avenues and maturity levels.

2.3 Deliverable Scope

In order for EURECA to develop a framework and tool that can be used to bridge organisational drivers and (innovative) industry best practices by facilitating the procurement of the best fit solution for any public sector organisation, we must understand the effects on a variety of aspects that may be impacted. Based on the analysis performed in D1.1 and the analysis as outlined under Objectives, we will be able to identify the landscape of where impacts may be expected in relation to environmental, economic, social and legal aspects.

Due to the fact that there are a large number of variables per individual procurement choice it is however not possible to calculate any specific impact, for instance in quantifiable numbers, at this stage. We do provide a foundation towards enabling reliable cost/benefit calculations for life-cycle inclusive business case formulation. Thus also shaping the method used to help evaluate a procurement choice and similarly how to evaluate the impact of EURECA as project and tool. Hence this deliverable has strong links with deliverables D2.1 (DC EURECA Framework and Specification) and D5.1 (Evaluation method for measuring the energy savings and environmental benefit of the project) that will develop the more detailed and comprehensive approaches to quantify those aspects.

3 Definition of Terms

EURECA means the Datacentre EURECA Project

CBA stands for Cost Benefit Analysis.

Commission means the European Commission.

Dissemination level **'PU'** means Public

C3IT means Carbon3IT Ltd

CBA stands for Cost Benefit Analysis

DC stands for Data Centre

D2.1 means the Deliverable identified as number D2.1 within Work Package 1 of the EURECA project

DCMM means the data centre maturity model of The Green Grid

Deliverable means a formal contract deliverable item under the EURECA project

DoW means Description of Work. The EURECA project signed a project agreement identified as project number 649972 for a project under the call H2020-EE-2014-3-MarketUptake. This document contains a table with work plans, and it is this information to which this table refers.

Environmentally Sound stands for *"A low overall environmental impact per provided Data Center service (computation/data services) based on present day available solutions." This 'environmental impact' includes impacts such as climate change, acidification, particulate matter, etc. but also primary energy consumption and water scarcity* (see D1.1 for context determining the definition of this term).

eLCC stands for environmental (or external) life cycle costing

EoL stands for End of Life

EU CoC means European Code of Conduct for energy efficient data centres

GITA stands for Green IT Amsterdam

Green stands for: see 'Environmentally Sound'

GPP stands for Green Public Procurement.

GHG stands for GreenHous Gas(ses)

(Procurement) Scenario(s) provides an indication of the scenario the Public Sector body should initiate a tender for that meets the actual procurement need (related to data centre products or services). By providing an assessment to determine the actual needs, the EURECA framework and tool can help establish the right Procurement Scenario for tendering.

ITT stands for Invitation to Tender (also used to indicate 'general' procurement, i.e. non PCP or PPI)

Industry stands for data centre and related ICT industry

LCC stands for Life Cycle Cost

LCA stands for Life Cycle Assessment

maki stands for maki Consulting

PCP stand for Pre-Commercial Procurement (PCP)

PPI stands for The Public Procurement of Innovative solutions

Practice stands for the use of a standard, framework, guideline, specification or KPI/metric

RFI stands for Request for Information

RFQ stands for Request for Quotation

RFP stands for Request for Proposal

Task 1.1 stands for the first task as described in the EURECA project's DOW under WP1, consisting of a Regional analysis of green data centre procurement

Task 1.2 stands for the second task as described in the EURECA project's DOW under WP1, consisting of a SWOT analysis of existing procurement of environmentally sound data centres and of related products and services

Task 1.3 stands for the third task as described in the EURECA project's DOW under WP1, consisting of a GAP analysis between existing procurement and environmentally sound procurement

Task 1.4 stands for the fourth task as described in the EURECA project's DOW under WP1, consisting of a public sector needs and ambitions assessment inventory for bridging the gaps to meet relevant targets with procurement choices

Task 1.5 stands for the fourth task as described in the EURECA project's DOW under WP1, consisting of developing an understanding of the impact of such procurement choices which allows for the development of cost / benefit data needed for business case creation

Work Package 1 (or WP1) of the EURECA project covers 'Green DC Procurement Analysis'

Work Package 2 (or WP2) of the EURECA project covers 'Procurement Framework & Tool'

Work Package 3 (or WP3) of the EURECA project covers 'Knowledge Sharing'

Work Package 4 (or WP4) of the EURECA project covers 'Training'

Work Package 5 (or WP5) of the EURECA project covers 'Validation & Evaluation'

Work Package 6 (or WP6) of the EURECA project covers 'Dissemination'

4 Assessing needs & evaluating impact

4.1 General

This section describes the content of Deliverable D1.2 which has been implemented in accordance with the contract requirements.

4.1.1 Approach and methodology used

In this deliverable we build upon the analysis performed in D1.1 and the contacts made with stakeholders from public sector bodies. From these contacts the project further researched specific elements relevant for effective translation of public sector (organisational) ambitions and targets in procurement exercises and which areas may be impacted.

This deliverable focuses on carrying out a targeted analysis of a number of public body tender examples in their efforts to bridge the gaps which enable(d) them to contribute to their objectives, primarily in relation to the organisation's environmental and economic drivers and the effects / impact of these examples in the context of the findings and conclusions of D1.1 for the benefit of the EURECA framework and tool.

The project researched (in further detail) and reached out to public sector bodies that have (relatively recently) undertaken a procurement of data centre products or services and analysed their approach as case examples. Where (made) available the project specifically looked at formulated Business Cases to better identify key contributing factors of how a good business case correlates with achieving objectives set by the public sector organisation that initiated the procurement.

Using the findings (practices framework and analysis conclusions) from research done in D1.1 in combination with the analysis of the procurement process and business case examples for this deliverable, the project can develop a clearer understanding of internal and external areas affected by various aspects of procurement exercises that aim to procure more environmentally sound data centre products or services.

This provides key information which can then be used to develop a cost-benefit calculation mechanism that caters for the selection of a 'best fit solution' for a varying number of situations, maturity levels and objectives.

4.1.2 Stakeholder groups involved

For the activities within WP1 EURECA engaged with the following stakeholder groups (in line with those defined in the initial DOW and refined in WP6 (DEL6.1)):

- (External) The **Public Sector managers and decision makers** The Public Sector in the regions of UK, Germany and The Netherlands form the initial starting point of the project.
- (External) **Public procurement organisations and groups** EURECA also aims to engage with bodies or groups that influence or operate services on behalf of groups of Public Sector organisations.

- (External) The **Policy Makers** Government organisations that represent and influence procurement of Data centres and has a large overlap in general.
- (External) **Public Sector IT Managers** Stakeholders who influence the services that data centres support are taken into account as a separate target group.
- (External) **ICT Suppliers and Service Providers** The EURECA tool depends on support from suppliers and service providers, which are needed to both demonstrate and to respond to procurement procedures for high energy efficient performance products and services.
- (External) **Standards Committees and Best Practice Communities** The ultimate aim of DC EURECA is to develop the EURECA tool to support the uptake of energy efficient and environmentally aware methodologies. Therefore, it is essential to ensure relevant input and liaisons are in place to support the EURECA tool development and its future relevance.

The project has engaged in the following activities with stakeholders:

Table 1- Engaged Stakeholder Groups

Activity	**Stakeholders**	**Type of engagement**
Articles Industry sites	• ICT Manager • DC Manager • ICT Suppliers	Dissemination: create visibility, create awareness of EURECA, invite to website
Articles Public Sector / Procurement sites	• Public Sector procurers • Public Sector Groups • Public Sector Managers	Dissemination: create visibility, create awareness of EURECA, invite to website
Face to Face interviews	• ICT Manager • DC Manager • Public Sector procurers • Public Sector Groups • Public Sector Managers • Policy Makers	Extensive set of questions (and follow-up) in interview form.
Procurement and public sector fora	• ICT Manager • DC Manager • Public Sector procurers • Public Sector Groups	Become forum member, create posts to inform about EURECA, request for input.
Survey	• Public Sector procurers • Public Sector Groups • Public Sector Managers	Extensive set of questions (and follow-up), some in yes no, some multiple selections, some free text.
Knowledge Sharing events	• Public Sector procurers	Short outline EURECA

	• Public Sector Groups • Public Sector Managers • Policy Makers	project; interactive discussion sessions current procurement practices, ambitions, needs et all.
External events	• ICT / DC Industry • Standard bodies/committees • Public Sector procurers • Public Sector Managers	Presentations, networking, short input conversations.
Standard Body committee sessions	• ICT /DC Industry • Standard bodies/committees	Active participation in ongoing standard development; input conversations

4.2 From ambitions to decisions (tenders and business case examples)

The selected procurement exercises and business case examples in this chapter were real live public procurement based ones and were initiated by public sector bodies that have (relatively recently) undertaken a procurement of data centre products or services.

The contacts with most of these public sector bodies had already been established during the stakeholder activities for D1.1 and under WP3. The project has further engaged with several public sector organisations in these procurement examples and analysed their approach as case examples. This allowed the project to develop a deeper insight of how and to what extent public sector bodies include the organisation's ambitions on environmental targets and other relevant drivers, what they came across during this exercise and to what extent they were able to address certain 'gaps'. Each example is discussed shortly based on the analysis performed. These examples may be exemplary to cases that can be found everywhere.

Each example will contain the following information if (made) available:

a) Organisation name
b) Procurement triggers and drivers (operational, environmental and economic, such as specific policies, targets, objectives, use of KPI/metrics)
c) Procurement scenario (what 'scenario' (i.e. new built <-> cloud) and the selected solution)
d) Success factors (why is it deemed successful, do we agree?)
e) Constraints, challenges, bottlenecks (can be indication of 'needs')
f) Improvement (what could they have done to make it an (even) better example to show the potential and added benefit of using EURECA)

Note: The detailed format specification of case examples that are used for the EURECA Directory which provides the 'case studies' functionality of the tool will be provided in D2.1.

4.2.1 Organisation: University of Brighton, UK (England)

Procurement triggers and drivers

The university's ambition is to become a centre of excellence in building sustainability into research and teaching and learning and work with local, regional, national and global bodies to help build sustainable learning communities. Their aim is to embed it into all the work they undertake. This is made visible in several ways, such as the c-change programme, where opportunities for carbon saving are identified by both students and staff, and the Carbon Management Plan. This plan included the following goal regarding ICT:

"The university will implement strategies that employ technology to bring savings such as a new centralised data centre replacing existing localised centres; server virtualization, and automated shutdown of desktop computers."

For the procurement of the new data centre this resulted in the primary drivers of energy efficiency, improved resilience and the ability to support high density computing.

Procurement scenario: Retrofit (M&E and Data floor - complete refurbish)

In this example the procurement consisted of a complete refurbish within the existing Watts Building - a 400 sq. metres' main data centre on its main Brighton campus. The scope included the provisioning and commissioning of a standby generator, UPS, IT cabinetry, air conditioning, power distribution, fire detection and suppression, environmental monitoring, flooring, ceiling and light structural work, but excluded structured data cabling. In effect almost a new build but with the added complexity of maintaining uninterrupted services to the existing IT equipment. Specific requirements were

- to approximately Tier II standard,
- adhere to current best practice and EU CoC,
- include Variable Cabinet power densities
- design PUE 1.22 for Full Load and 1.45 for Partial Load

Success factors

The selected solution is designed to flexibly adapt to the real time live IT load in the facility that aims to maximize energy efficiency at all times, housing 28 cabinets that can support up to 25kW each, and is remotely monitored and maintained. For the cooling requirement rear-door heat exchangers were selected in combination with dry air coolers and chillers. The dry air coolers provide 100% free cooling when external ambient air is 16°C or lower, while partial free cooling starts at 21°C. The resulting PUE at full load is said to be 1.18, while at 25% load reaching 1.41.

Though over longer term the results will need to be validated, this achievement can be considered successful. The organisation has a strong and visible sustainability ambition and has translated this into a more concrete plan spanning different departments of the organisation. As such the element of energy efficiency was set as a priority from the start. There was also some level of awareness regarding best practices and standards, such as the EU DC Code of Conduct, however it is unclear whether this proactive knowledge development is as a result of from the organisation's strategic sustainability ambitions or awareness of developments in the ICT sector.

Constraints, challenges and bottlenecks

The facility consisted of a 24/7/365 operation that required continued live services of business critical IT system (financial, IT/Estates personnel knowledge) where no downtime could be accommodated. Any impact and general nuisance, particularly regarding noise, on directly adjacent areas had to be kept to a minimum due to the facility's position. There was also little external space to make use of. Attention to health and safety and access control during the construction phase was also a strong requirement.

Business case improvements

A more comprehensive evaluation and technical tender documentation, for instance exploring the possible use of renewable energy systems, would have likely resulted in a more inclusive business case. As would a wider approach to environmental life-cycle costing, looking beyond energy to include other resources and impact during use phase. More extensive training for IT/Estates personnel would have likely triggered a consideration to include a wider view of 'sustainability'. Using a supporting framework such as EURECA could have facilitated this. However, it must also be said that the translation from the university's ambition into the Carbon Management Plan has contributed to the primary focus on energy.

4.2.2 Organisation: University of St. Andrews, UK (Scotland)

Procurement triggers and drivers

Triggers for this procurement consisted of the fact that their facility consisted of multiple sites resulting in maintenance Issues (IT/M&E), poor financial control and overall expensive management. The university's sustainability vision has been followed through with the formulation of the objective for staff to actively pursue lowering their building's carbon footprint through using less energy and changing behaviour. In addition, St Andrews has pursued its 'e-enablement programme', which focuses on the use of technology to make business processes more efficient and effective. Another ambition and desire of the university is to be seen as delivering innovative IT delivery, energy efficiency.

Procurement scenario: New build

In a desire to mitigate the issues of the existing situation in combination with energy efficiency and innovation objective, the decision was made to opt for a new build facility that aimed at Free Cooling 340 days plus per year, Hot-Cold Aisle containment, optimised UPS, CRAH's, energy monitoring and Waste Heat Reuse (Generator Blocks & Heat Exchangers for proposed new build adjacent student accommodation/School). The initial design PUE was less than 1.45, which resulted in an actual PUE of 1.2x

Success factors

Though the initial triggers were finance related and matches the objective to reduce cost and save staff time, the university has actively looked to contribute to the university's strategic ambitions and related objectives regarding sustainability and innovation. There were several factors that contributed to the success of the implemented solution. To begin with, the university has campus wide energy efficiency and improvement policies and ambitions regarding innovation. This triggered the aim to procure a new build data centre to latest design concepts.

The solution has received much recognition, which in turn has contributed to general awareness within both the data centre industry and the public sector for the potential of achieving results while pursuing more environmentally sound solutions. The case has won recognition with a CEEDA Gold Award, EU DC Code of Conduct participation, DCD innovation award & Uptime Institute special recognition.

Constraints, challenges and bottlenecks

As with the University of Brighton the campus has a 24/7/365 operation that needed to maintain live service support. Unfortunately, direct Free Cooling was soon determined as not possible due to high saline content in the air (situated within 100m of the sea). Limiting noise coming from the data centre facility was a priority because of its location next to the university's library. Also due to its location there was the factor of space constraints, the facility made use of two disused squash courts.

Business case improvements

More extensive training would have likely triggered a consideration to include a wider view of 'sustainability'. Using a supporting framework such as EURECA could have facilitated this. Also, as we see with many examples - both successful and less so, the focus has been primarily on energy efficiency. No doubt largely driven by objectives for cost savings due to the fact that their energy bill was the most visible and directly achievable savings opportunity. However, herein also lies the reason for successfully achieving a big improvement.

St. Andrews is currently in the process of procuring a new facility for expansion and income stream purposes and has offered to be a EURECA pilot site, the use of EURECA technical expertise and the tool will assist the new build to be an exemplar of the procurement of environmentally sound data centre products and Services. St Andrews will be providing assistance to the team in the design of the tool and other non-technical aspects.

4.2.3 Organisation: Queens University Belfast, UK (Northern-Ireland)

Procurement triggers and drivers

The Queens University Belfast, by means of the University's Estates Team, maintains a campus wide strategy that looks at any and all areas of potential improvement regarding energy efficiency and carbon emissions. It is in this light that a request was done to carry out a data centre optimisation assessment of the existing physical infrastructure. Three main areas were assessed: power provision, environmental control and flexibility for future expansion. It also evaluated the current energy use, identify areas of inefficiency and potential risks.

The energy consumption was reduced because of the reduction of the overall number of servers when the university's IT Team invested in high-density blade servers, but this resulted in hot spots in certain parts of the facility. As there was no air segregation within the data floor itself, the hot and cold air was mixing which reduced the potential return air temperatures within the system. These lower temperatures returning back to the air handling units caused the system to operate at a less efficient level than possible. It became clear that there were opportunities for improvements regarding the data centre's energy efficiency and airflow.

Procurement scenario: Retrofit (M&E and Data floor)

The solution the university selected was a combination of several elements. For once, an aisle containment system was introduced, segregating the supply and return air. Cooled air can only return to the air handling units after travelling through a server. This increases energy efficiency as all the cooled air is effectively applied to cool the servers before returning to the air handling units. Aisle containment is only part of the solution as the new airflow paths and increased return air temperatures means the entire system of floor and thermal management needed to be reassessed to ensure the very best performance can be achieved by the cooling system. This resulted in a combination of high-density computing, airflow management with hot/cold aisle containment, control upgrade and calibration to cooling system.

Success factors

Before deciding on a specific procurement scenario the university researched different companies and spoken with other educational institutions, and then opted for an assessment to capture all opportunities that could be taken into consideration. This then formed the basis of the combination of improvements advised. The university selected a provider with proven experience in delivering while maintaining live services, which was set as a requirement.

The solution itself can also be considered successful. Before the improvements the PUE was 2.0, which was then reduced to 1.5 and the cooling system improvements by approx. 50%. This resulted in energy saving approximately £60,000 per year that translates into a Return on Investment of approximately 315 tonnes reduction in Carbon footprint and a financial return of only 12 Months.

Constraints, challenges and bottlenecks

As the improvements took place within a live data centre environment it was important to reduce any risks to the ongoing services. The university opted for an organisation that could provide a track record in this respect.

Business case improvements

The university has CHP system providing heating and power to the PE Block and Voltage optimisation equipment. It is not clear whether this was considered, but it there may have been an opportunity to connect the data centre to this system.

Both the assessment and the technical solution implementation was done by the same solution provider. This makes it more difficult to evaluate if the best fit solution was presented. An objective check, possibly via EURECA training and available functionalities (within the tool) for IT/Estates personnel, could have triggered a more comprehensive evaluation and accompanying technical tender documentation.

4.2.4 Organisation: University of East Anglia, UK (England)

Procurement triggers and drivers

It is unclear what the exact triggers and drivers for this tender were, but it is likely both the outdated system, a high PUE, carbon and cost saving opportunities were the underlying arguments.

Procurement scenario: Retrofit M&E cooling system upgrade

The selected solution exist of a combination of direct fresh air free cooling coupled with DX (direct expansion) air handling units. It included the use of EC (electronically commutated) fans which are far more efficient at part-speed than conventional fans because their speed can be adjusted using air pressure sensors and software which links all the fans in all the air handling equipment across the entire cooling infrastructure. This means that only the required amount of air is delivered to the IT equipment as is needed, reducing the cooling overcapacity in the facility's environment.

The electrical system, cabling and distribution boards and cooling were changed to deal with the additional system capacity. Large apertures had to be created above the data centre and in the ceiling of the floor above to allow adequate airflow for the associated free cooling capacity. By refurbishing the existing cooling units and condensers costs were kept low while making the units much more efficient.

Success factors

The university has formulated an extensive sustainability strategy which is translated into an environmental programme and the creation of a sustainability management structure within the organisation and conscious effort to create awareness, education, visibility and group involvement while carrying out plans. There is a particular primary focus on carbon reduction.

The Design reduction in PUE went from 2.08 (60kW IT Load) to 1.15 (Full Design Load 138Kw) and 1.3 at 50% Load. However, the Actual reduction in PUE 1.13 at full load, 1.22 at 50%. Both reduction indicators provide valid arguments to label this case as a success of energy efficiency. Amongst other success factors we can identify achieving a greater cooling capacity; 100% Free Cooling up to 24°C Ambient, Partial free cooling up to 32°C Ambient and a 30-70%RH Humidity range and a projected Return on Investment of 5 years.

Constraints, challenges and bottlenecks

Five key challenges were identified during the feasibility and design phase, namely;

- UEA is a world renowned research institute working 365 days per year. With the data centre located on campus, this meant the work had to take place in a live environment;
- The legacy cabling under the raised modular floor needed to be accommodated within the design;

- The facility is located very close to student accommodation and teaching facilities so the solution needed to comply with limited noise emission standards;
- The entire project from initial survey to delivery had to be achieved within three months;
- A large hole needed to be cut in a live data centre's roof. With the very poor weather, with excessive snowfall, added an additional risk to services.

Business case improvements

As this case was specifically targeting the climate management - cooling system of the data centre, the energy reduction was a logical focus of the tender. It is unclear whether a wider improvement opportunity was investigated, but it is possible the use of renewable energy technologies might have been an opportunity. In addition, there was no mention of specific standards or processes used to guide this solution selection, nor whether there was a targeted (e)LCC assessment performed.

4.2.5 Organisation: City of Amsterdam, NL

Procurement triggers and drivers

The Triggers and drivers for the city of Amsterdam are always economic, tax income has to be spent wisely and cost reductions are always a goal, as they are in most organizations. However, environmental drivers were prioritised at least at the same level. Amsterdam has around 60 data centres scattered over the Amsterdam area. In order to be able to enforce a stricter policy on the energy efficiency of data centres in the Amsterdam area, in combination with Amsterdam's ambitions to cut the emissions of CO_2: -40% CO_2 emissions compared with the emissions of 1990, it was decided to start the projects that led to energy reduction of Amsterdam's own public data centres.

The included environmental ambitions as were presented to the city council and primarily expressed in energy saved (KWh), was then compared to the amount energy used annually in homes. The decision to take this approach was to make the opportunity to save energy more tangible and as such create awareness and stimulate understanding amongst both the public and the city's employees and council. To further convince the city council of the business case, the calculated CO_2 reduction was used to bring the business case in line with Amsterdam's CO_2 reduction targets. The main KPI's used were data centre capacity (and security) and a design PUE of less than 1.3. The annual savings on the energy bill was an important KPI as well, in combination with the annual CO_2 reduction.

Procurement scenario: New built or extend life of the existing data centre

Amsterdam had several data centres. One data centre that played an important central role had to be decommissioned for several reasons. This 'old' location proved to be very inefficient and was used and analysed in a scenario 'doing nothing'. This scenario described the expected growth of IT and how this data centre would not be able to cope with this growth. Next to the existing huge cooling problems and general waste of energy in this old facility, it would never

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been able to facilitate the staggering IT growth. There were more issues, but these were the triggers to build the different scenarios on, in the business case.

Success factors

One of the important success factors in this case example is the decision to put environmental drivers on par with economic drivers. However, key for the actual decision-making was the conscious choice to link these drivers to the city's own environmental targets, and to translate them into cost and other saving values, using metrics that help create awareness and understanding.

During the development of the new data centre new and previously unforeseen solutions were included. Innovative solutions like the use of an existing ATES (Aquifer Thermal Energy Storage) installation, enabling the reuse of data centre heat for the heating installation of the City Hall and the Opera of Amsterdam, and the free data centre cooling with the help of the water flow of the nearby river Amstel, were introduced. This proves a willingness to re-evaluate earlier decisions based on new available information. The saving opportunities appeared to be greater than previously assumed and many publications and presentations were held to inspire other organizations and the data centre community. At the time (2010) it was the first data centre solution known in The Netherlands to reuse and store heat as well as use free cooling, as an answer to reduce the unnecessary use of energy (see Dutch presentation movie: https://youtu.be/9H_DOprUVJU).

As such the success factors included a willingness to try new and innovative techniques, a focus on energy efficiency, experience with and an existing installation for underground hot and cold storage and the geographic location of the data centre, in the centre of Amsterdam.

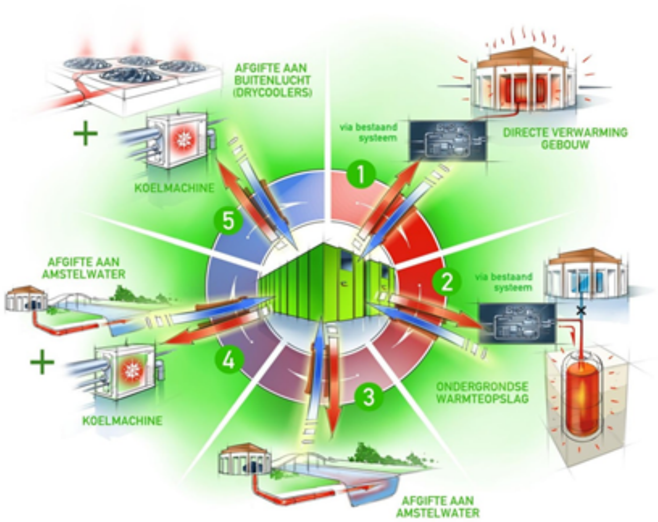

Figure 1- Visual of utilizing ATES

Constraints, challenges and bottlenecks
In public governmental procurement processes, the need for an excellent stakeholder analysis is paramount. Decision makers tend to be tied in very closely with politics. Since the acquisition of this new data centre involved many new and innovative ideas, explaining these and associating business case KPI's, namely cost and energy implications, was difficult.

Business case improvements
More attention could have been given to the many different decision makers in the process to decide to execute a business case. More effort to describe the business case on different levels: political gains, cost reductions, increased IT quality, energy savings, CO_2 reduction, and compliance with the laws (Milieuwet) would have been helpful. This all had been done to a certain extent, but a better indication of the involvement of public relations and other ways to gain from an energy efficient data centre were not explored upfront. Also, a comprehensive LCA could have made the business case even stronger. At the time it would have helped the decision making and to increase the speed of it.

4.2.6 Organisation: Hoogheemraadschap van Delfland (HHD), NL

Procurement triggers and drivers
HHD was considering to move out of its office building and move to another facility. One of the roadblocks in the decision-making process whether or not to move its office facilities was the presence of an in-house data centre. In order to convince decision-makers that relocating its data centre should be considered as an option (even a good one), a business case for several scenarios was requested. As a starting point for these scenarios the existing data centre was analysed.

The existing data centre was built in 2006 and was built for future growth. Due to an increasing rate of server and storage virtualization the amount of racks had instead been dramatically reduced since. The analysis of the existing data centre proved a very inefficient use of energy (several big cooling installations) and a very unsecure data centre. The dependency of a performing data centre for its critical applications had grown overtime. The continuity could not be guaranteed anymore. The most important drivers for the business case and the decision making were

- Operational: quality, flexibility, scalability;
- Economical: costs;
- Environmental drivers were not deemed as important but since energy use is a large part of the operating costs, it was considered indirectly.

The tender process of this public organization was entirely focused on 'the bottom line': costs. The potential cost savings on energy however turned out to be very important factor in the final decision making.

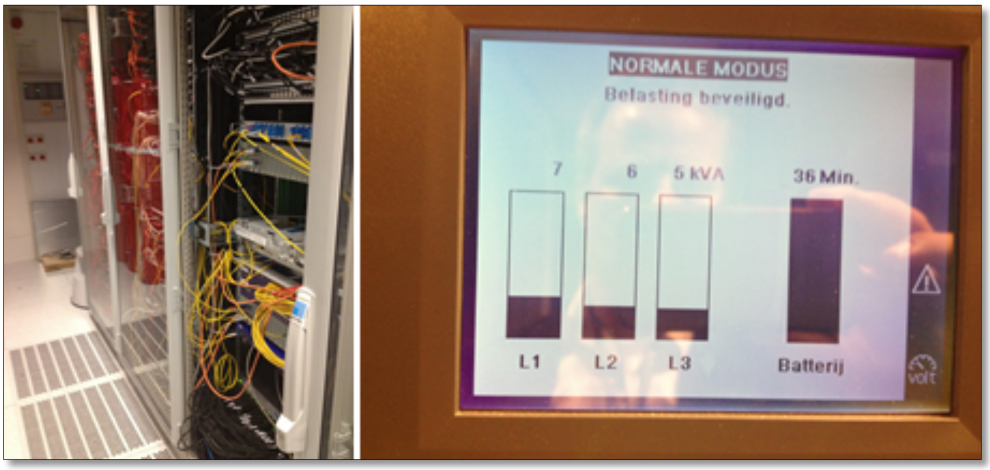

Figure 2 - Old data centre (messy and underutilized).

Procurement scenario: Outsource co-location

The business case was calculated with all the projected costs of 4 scenarios: 1 for continuing the current data centre and no relocation of its office. The others were based on the quotations of 3 alternatives, external and commercial data centre facilities.

Success factors

Primarily focused on quality and costs (value for taxpayer's money) it became obvious that the cost of energy would be very deciding. PUE was introduced after an awareness presentation by Certios to the management of the organization. On request of the management, other environmental factors were included, such as the impact of travel in both direct and environmental costs.

The decision was made for a modern data centre where HHD could outsource to. Also see https://youtu.be/PKAhQ9IOWn0. This data centre won because of its very low design PUE of 1.16 (due to a scalable adiabatic cooling system) and subsequent low operational energy cost component. The environmental as well as the cost aspects went hand in hand. It proves that often "greener" solutions are more cost effective when actively including environmental objectives. By opting for the solution to switch to the external data centre based on this business case approach, HHD is saving 146 t CO_2 and 244.404 KWh annually. Critical to the success was the access to knowledge, breakdown of the cost factor into the constituent components provided the inside to go for the most energy efficient solution.

Constraints, challenges and bottlenecks

The criteria in HHD's request for a business case were mostly cost and quality of service based. This was due to the fact that the general regulations for procurement of these services are prescribing a certain protocol and criteria.

Knowledge, albeit the lack thereof, was certainly a bottleneck during the first stage of the procurement process. Correcting this caveat by requesting a scan of the existing facility by a knowledgeable third party proved very beneficial for the procurement process and final acquisition.

Business case improvements

It would have been better to include energy efficiency from the start. Awareness sessions had to be held in order to convince management of the importance of including energy efficiency. In the end, it turned out well. It would be better if there would be more energy efficiency awareness in business cases, and better tender criteria based on better knowledge of the energy implications of data centre products and services (and how to operate them, e.g. temperature, energy use, etc.).

4.2.7 Organisation: TU/e - Technical University Eindhoven, NL

Procurement triggers and drivers

The University of Eindhoven (TU/e), the City of Eindhoven and the Summa College all used the data centre facilities on the TU/e University Campus in Eindhoven. The existing data centre facilities were in many ways becoming obsolete. Adding urgency to these operational triggers was the fact that the data centre was located in a building that was listed for "re-development" either to house a different faculty of the university or to be sold off for commercial use.

Care for the environment is deeply ingrained in the organization of the TU/e as well as with the other participating parties. This commitment is underpinned by the fact that the TU/e is one of the participating organizations in a so called multiple year agreement (MJA-3) in which the TU/e commits itself to a 2% yearly improvement in overall energy efficiency.

Operational drivers: *Capacity of cooling, power and space; quality, risks.*
Economic drivers: *Cost*
Environmental drivers: *Energy efficiency*


TU/e Technische Universiteit Eindhoven University of Technology

Inhoudsopgave

Titel
Aanbesteding Housing

1 ACHTERGROND VAN DE AANBESTEDING 5
1.1 Opdrachtgever (hoofd) Opdracht 5
1.2 Opdrachtgever Optie 6
1.3 De Opdracht 6
1.4 Penvoerder 8
1.5 Aanbestedingsprocedure 8
2 BEKNOPTE BESCHRIJVING AANBESTEDINGSPROCEDURE 9
2.1 Aankondiging 9
2.2 Planning 9
2.3 Beoordelingsprocedure 9
2.3.1 *Toets op (procedurele/administratieve) eisen en compleetheid* 9
2.3.2 *Toets op uitsluitingsgronden en (minimum)eisen* 10
2.3.3 *Beoordeling op gunningscriteria* 10
3 ADMINISTRATIEVE EN PROCEDURELE VOORWAARDEN 11
3.1 Inhoud van de Inschrijving 11
3.2 Toepasselijkheid voorwaarden voor deze aanbesteding 11

Figure 3 - Snapshot of the contents of the European tender.

Procurement scenario: Outsource co-location

It was quickly realized that in order to obtain both the flexibility of scaling as well as superior energy efficiency, the capacity need of three parties was not sufficient to warrant a new build under the flag of the TU/e.

Success factors

It was tempting to use other tenders for data centres of other public organizations. After a while Eindhoven decided not to do this. A fresh approach was chosen. In order to make an inventory of what the three parties in Eindhoven really wanted, a workshop was conducted. What the workshop made clear was that the functional requirements of the facility were to be the foundation for the tender. Instead of asking: "we require a PUE of less than 1.3" the question was formulated into "we want a state of the art, modern data centre that is very energy efficient…" which was accompanied by indicators such as "with energy efficient, we (Eindhoven) thinks of a PUE of.." and "think of re-using waste heat". This made the mentioned KPI's indicative, not directive and left room for vendors to suggest alternative solutions that met the fundamental requirement. The tender left a lot of the ideas with the vendors of data centres. Exactly there where the innovative power is to be found.

Due to certain constraints (mentioned below), formulating the tender proved difficult. The constraints, time and location, could very well have limited the interest from vendors. However, to accept the criteria for a successful tendering process, at least 3 quotations were needed. Eindhoven was prepared to invest time and money in their new data centre facilities. Allowing existing and Greenfield databases to fight for the bid. It would also be generous with helping potential candidates to lighten the usual administrative and bureaucratic burdens associated with, for instance, building permits.

The more functional approach worked out well. The data centre that has been chosen out of 4 open presentations, stunned everyone in the selection board by their willingness to invest in a CO_2 negative (!), first TIER IV data centre in The Netherlands, offering a lower operating cost than the other bidders. The vendor decided to build a very energy efficient data centre in Eindhoven and it was realized within 8 months. It reuses its data centre waste heat by providing a business park block heating system with heat. It uses 100% green power (wind and solar energy) and was built on cradle-to-cradle principles. Also see https://youtu.be/fy51LfTeIAk.

The public bodies of the University of Eindhoven (TU/e), the City of Eindhoven and the Summa College were happy with the outcome and could start using this facility, months before the required September 2015.

Constraints, challenges and bottlenecks

Time was one of the major concerns, the planned redevelopment of the building in which the data centre was housed created a hard deadline for moving into the newly acquired data centre space. Distance was also a factor. Technical limitations dictated that the data centre needed to be either in, or very near to Eindhoven.

Business case improvements

The business case could have been even stronger with introducing more diverse life cycle analysis (LCA) items. The tender could have mentioned the LCA requirements. It was very energy efficiency focussed. The outcome of the comparisons in the business case however, would (in this case) have likely been the same.

4.2.8 Organisation: Dutch Central Government, NL

Procurement triggers and drivers

The Dutch central government with its constituting ministries had over 64 locations from which data services were delivered. This situation was extremely complex, costly and hugely inefficient. In 2010 a program was started to consolidate these 64 location into 4 regional data centres.

The goals of the consolidation are amongst others to improve on cost effectiveness, security, availability and also sustainability. Care for the environment is an integral part of Dutch domestic policies, and although the primary drivers for this project are operational and economic, environmental drivers are always prominently featured in any of the tenders put out by the Dutch government. The business case created for this project is only partially published, but in the communications surrounding the project the PUE is often mentioned as one of the leading indicators of success.

Procurement scenario: Mix - retrofit existing facilities, co-location and new builds

As the expected capacity need for these 4 new locations is tremendous, no scenarios were initially excluded.

Success factors

In the case of the DC consolidation project, extensive external support and expertise for business case creation and analysis was used. A major part of the business case consisted out of the determination of the capacity need in terms of physical rack and floor space, servers and storage. For the housing of this equipment, a relatively simple sustainability criterion, the PUE was chosen. During the course of the project, the initial requirement of a PUE < 1.5 quickly became obsolete and was later adjusted to < 1.25.

As revealed in a recent presentation at the "Symposium Groene ICT en Duurzaamheid" (29-5-2015, Leiden NL), Dennis Kerssens of the Ministry of internal affairs published the most recent numbers on this consolidation project (Kerssens, 2015)[1] :

[1] Kerssens, D. (2015, May 29). Smart sharing van ICT infrastructuur - kan het duurzamer?. Retrieved from http://www.surfsites.nl/duurzaamheid/symposium/presentaties

	Before	After
Energy use	235 GWh	128 GWh
PUE	2.3	<1.25

As can be seen, a simple criterion, but an astounding effect resulting in a saving of a 107 GWh annually. The success of the business case can be largely attributed to two factors, the improvement in the energy efficiency of the housing (PUE), another important contributing factor however is the ongoing virtualization and renewal of the ICT infrastructure.

This success can be largely attributed to the effort put into the creation of the tender and the initial business case. Setting clear goals and adjusting the values during the course of the tender to reflect the ongoing technological advances have resulted in challenging but achievable demands. Determining the capacity need was also essential, a major source of inefficiency is underutilization of resources, correct need determination created the opportunity for supply and demand matching.

Constraints, challenges and bottlenecks

In any project of this magnitude there are many challenges, not the least of which is time. During the 5 years that this program is under way, technology especially in the ICT equipment has made tremendous progress. Keeping the requirements and capacity demand figures up to date in order to reap the benefits of these technological advances has been a challenge.

Business case improvements

The business case could have been stronger by introducing life cycle analysis (LCA) items. The success shown is partly attributed to the improved PUE and partly to a much better space utilization. Including ICT life cycle analysis requirements would have included the evolution of ICT equipment in the business case, helping in an accurate allocation of the efficiency gains. The current tender was very energy efficiency focused. The outcome would however, in this case, most likely have been the same.

4.2.9 Organisation: Omgevingsdienst Noordzeekanaalgebied (ODNZKG), NL

Procurement triggers and drivers

ODNZKG is a local government body that monitors adherence to the 'Dutch Environmental management act' in Amsterdam and the surrounding regions. The region of Amsterdam belongs to the top 3 of European data centre hubs, a large part of European internet traffic passes through this region. As a result of this concentration, data centre energy use in the region is high. The ODNZKG has focused its attention on the 40 largest locations in the

Amsterdam region. The combined energy use of these 40 data centres together is 460 GWh, 11% of commercial electricity use of the region. The Dutch government and the municipality of Amsterdam have ambitions to lower overall energy use and such concentrated usage offered a perfect opportunity for large savings with limited resources from the ODNZKG.

Procurement scenario: external expertise (alternative scenario)

The case discussed here does not involve the acquisition of data centre capacity or services, instead knowledge about the industry was obtained by hiring various experts on data centre and ICT technology and requesting research reports from them. Several publications resulted from these engagements (in Dutch) such as:

http://www.ce.nl/art/uploads/file/Presentaties/2013/20131126_Energie-efficiente-nieuwbouw-datacenters_MA.pdf

https://www.amsterdam.nl/publish/pages/444422/energygo_brochuredatacenters_20sep_2.pdf

The only environmental category included here was energy. As a KPI, the PUE was chosen. Basis for this choice is found in the Dutch Environmental Management Act. The act states that any energy efficiency measure with a ROI of less than 5 years MUST be taken.

Success factors

All 40 locations submitted and effectuated plans for improvement of their respective PUE's. As detailed in a recent publication on the savings in Amsterdam data centres (Gemeente Amsterdam, 2014) [2] these plans resulted in savings of a 68 GWh annually:

	Before	After
Energy use	460 GWh	392 GWh

A large part of the success can be attributed to the freedom of choice left to the data centre operators. Rather than dictating certain measures, the operators could use their own knowledge and that acquired by the ODNZKG to improve energy efficiency and with it the competitiveness. Through the system of building permits, the ODNZKG enforced a design PUE of <1.2 for newly build and <1.3 for existing installations.

Constraints, challenges and bottlenecks

An important constraint in the operation of the ODNZKG is the fact that they do not have direct influence on the implementation of energy efficiency measures in commercial data centres.

[2] Gemeente Amsterdam. (2014). *Amsterdam Datacenters Save Energy!*

The Dutch Environmental Management Act states that energy efficiency measures must be taken, but business cases are greatly influenced by commercial factors such as depreciation and energy pricing. As such it is the willingness of the data centre industry to cooperate that the program currently depends upon.

An important bottleneck is also the business model of the data centres. Many (co-location) data centres have no direct influence on the IT equipment of their customers, any inefficiencies resulting from inefficient IT hardware due to bad placement of this hardware is very hard to remedy.

Business case improvements

The current business case is entirely focused on the PUE, not on a reduction of carbon emission or a reduction in total energy use. Although much more complex to enforce, including a life cycle analysis on the ICT equipment installed in these data centres, improving its average efficiency and utilization would have a huge effect on overall energy use. As detailed in the report "zervers" (Harryvan, 2014) [3]; the possible decline in installed equipment and increase in utilization and compute efficiency could impact overall energy use by as much as 90%.

[3] Harryvan, D. (2014, May 21). ZERVERS. Retrieved from https://www.amsterdam.nl/wonen-leefomgeving/duurzaam-amsterdam/publicaties-duurzaam/rapport-zervers/

4.3 Procurement choices: Understanding Impact

4.3.1 Background

To understand the impact of making new procurement choices we must understand the areas that are potentially affected for the different procurement scenarios we have identified, i.e. from new build to cloud service. For the EURECA framework and tool to be effective we will then translate this to mechanisms that enable the use standards and metrics/KPI's from a life-cycle approach that will support procurers in their decision-making.

This chapter follows the reasoning behind the process of developing and selecting for the framework and tool's functionalities for cost/benefit calculations and creation of business cases to evaluate solution options for procurement choices. It provides an overview of the landscape of different aspects that may be impacted by such choices. This leads into next chapter where we outline the design elements necessary for the impact calculation method for the EURECA framework and tool under WP2. An in principle identical and compatible method will be used to calculate impacts of EURECA itself (of the project and of the tool-use), in WP5.

To understand the effects of (organisational) choices one must take into account that there will be both internal and external aspects that are impacted. Together, they form the landscape of potentially affected areas. There are several (interconnected) levels we need to look at that influence and determine the eventual impact.

Note: For the scope of EURECA the project will have to make choices on which internal and external elements to include in the framework and tool, while not excluding the possibility of inclusion at a later stage. Additionally, those using the EURECA tool also determine the eventual impact of their procurement choice which depends on the maturity level and the ambitions of the public sector body and the procurers involved.

Procurement choice itself - scenarios

Depending on which scenario is determines the level the impact of the other categories. The identified scenarios are:

1. [Improve with existing IT environment only]
2. [Hire external expertise]
3. (In-house) new build
4. In-house retrofit M&E
5. In-house retrofit data floor
6. In-house new equipment and/or software
7. In-house new service
8. Outsource co-location
9. Outsource hosting / private cloud / government cloud
10. Outsource public cloud service

Product / Service lifecycle

- Development/manufacture
- Use / operation
- End-of-life

Organisational drivers and topics

- Economic (financial)
- Social
- Environmental
- Legal /policy targets
- Technical

4.3.2 Impact landscape per topic

Procurement choice itself - scenarios

Improve with existing / hire expertise

Although these scenario options are aimed to be a possible recommendation from EURECA, it does not require a tender process and related full cost-benefit (Business case) calculation. They will often relate to low-hanging fruit improvements that require relative small investments. Though certainly not unimportant, these will equally result in small impact from a public sector procurement perspective, and very unlikely to be PCP or PPI based.

(In-house) new build

When a new data centre facility is to be build, one must take into account that usually a new physical site is needed. Realising this new facility will impact its surroundings *and vice versa*, the land, the neighbourhood (people, businesses) and the infrastructure. Many aspects are involved, such as the location of the building itself, the security of the facility, accessibility of local infrastructures (transport, grids etc.), the design of the facility, managing the building process (logistics of materials supply and waste, building regulations) and compliance to existing planning policies and regulation, etc. Building a new facility that includes innovative design may also be a trigger to challenge existing policies and regulation.

In-house retrofit M&E

For the retrofit of mechanical and electrical facilities within an existing data centre facility one is limited by the constraints of the existing building and its immediate surroundings. However, these limitations can also work as an advantage. Just as with the build of a new facility the local infrastructure of the grids (and sources) for energy and water, i.e. the supply and demand on those grids may influence the business case for potential solutions. When retrofitting M&E components of the facility it can be recommended to also evaluate the design of the data floor (see following).

In-house retrofit data floor

As with a retrofit of M&E mentioned above a retrofit for a data floor is limited by the constraints of the existing building and its fundamental structure. Re-designing the data floor or a server room or full scale data centre can have significant impact. The data floor consists of the design of the combination of the positioning and kind of server-racks, the cabling design, airflow and other elements such as access. It is also strongly connected to the climate control system and M&E in general. As such, when considering a retrofit of the data floor, it is often advisable to also consider evaluate its interaction with M&E of the facility.

In-house new equipment and/or software

Over time, due to organisational or technical changes or general growth and expansion needs the kind of equipment, be it networking or server equipment or related, may become diversified and outdated. Additionally, it is possible a system was once developed by a person or persons no longer employed.

When relevant documentation and management of those systems is incomplete, has become outdated or otherwise unclear there is a tendency to leave it running 'just in case' due to fears of interrupting business services. With monitoring software such as DCIM it may be clear that systems can be decommissioned or can be replaced with new, more efficient equipment; software for virtualisation is another important variant here. If this can be done at a larger scale it may be advisable to reconsider the entire design of the data floor of the facility to make use of the full improvement opportunity there.

In-house new service

Due to technical (software or hardware) advancements or the desire for new ICT services (or new business functionality) it is possible this impacts the ICT infrastructure as a whole. One such example is the fast adoption of virtualisation and private cloud that results in new internal services delivered by the ICT / DC to the public sector organisation. Such developments may result in not just the development of a new service, but the purchase of new (or replace old) equipment. This in turn may impact as a domino effect on the data floor requirements, the M&E requirements and possibly even the space requirements of the facility in its entirety.

Outsource co-location

Taking on board all relevant considerations, requirements and objectives (partially) outsourcing to a co-location provider may be the scenario that is the best alternative to the existing in-house solution or as an alternative to prevent having to expand the existing facility (which can have a knock-on effect on all the facility's components, from available space to the data floor configuration to additional climate system demands). Co-location offers more flexibility for future expansion while maintaining full control over the organisation ICT infrastructure but not having full responsibility to the facility's M&E systems, security and building maintenance etc.

Outsource hosting / private cloud / government cloud
The impact of outsourcing to a hosting provider can be considered similar to outsourcing to a co-location, with the addition that managed of the ICT infrastructure is also provided and paid for as managed services. This may provide benefits of more efficient management and continued improvement of the underlying ICT infrastructure, however in return there is no longer full control over its design. From a EURECA perspective, i.e. environmentally sound procurement of data centre services, procuring such services requires the inclusion of relevant criteria and possibly the opportunity to request improvements in environmental impact areas. Private cloud services and government cloud are more similar to hosting, as the (typically only 2 to 3) data centres can be known, their environmental and energetic performance hence be considered, in contrast to public cloud services.

Outsource public cloud service
Outsourcing to a public cloud service lies in the same line as with co-location and hosting / private or government cloud but goes another step beyond: The entire ICT infrastructure, including its software layers are included in the service provided and is based on cloud and virtualisation technology up to the application at end-user level. Benefits of outsourcing to cloud services over traditional applications (and related underpinning infrastructures) lie in the flexibility of pay-per-use, high utilisation / IT loads etc. which often makes it much more energy efficient and cost-effective of the infrastructure compared to private cloud or even traditional applications' design and delivery. The actual data centres that provide the cloud service are typically however not easily knowable, hence their specific energetic and environmental performance cannot be considered. It also has its limitations regarding application design influence (and software efficiency targets), control over data security etc. Engaging in dialogue with the provider and/or setting tender criteria on which to evaluate is recommended.

Note: As can be read in above one possible pre-perceived scenario may impact other areas of the facility. Particularly when the public sector organisation is looking for a holistic evaluation of environmentally sound improvement and to capture all viable opportunities for its decision-making. This is makes it imperative to perform the self-assessments of both the current situation in context of the relevant objectives.

Product / service lifecycle
While in the 'old times' only the up-front capital costs or procurement price at time of purchase was considered, in more recent times this was expanded with additional expected costs throughout the use of an asset. Following the European Procurement Directive of 2004 the use of life cycle costing became a requirement, and its use has been strengthened in the new Directive of 2014. Life cycle costing (LCC) is a concept and method to determine the most cost-effective option among different competing alternatives to purchase, own, operate, maintain and, finally, dispose of an object or process, when each is equally appropriate to be implemented on technical grounds. There are three types of LCC:

- Total cost of ownership (TCO): taking into account all cost related to analysed product except for externality cost and society cost.
- Environmental life cycle costing (eLCC): taking into account all cost related to analysed product including externality cost e.g. LCC in the European Clean Vehicle Directive.
- Societal life cycle costing (sLCC): taking into account all cost related to analysed product including externality cost and social cost.

Building, operating and decommissioning data centres (or their products components and services) has a range of cost, environmental and social implications – for the DC owner or user, but also for the society including for future generations, through the price they pay for dealing with today's emissions. For procurement by public sector bodies we can identify the following aspects of the impact landscape:

Economic (financial) implications

On average, economic impact assessments related to the public sector looks at the expenditure versus tax revenue generated and evaluates the effect for society. In the context of EURECA however, the economic implications will focus on financial costs and benefits related to the procurement of a data centre related product or service that are considered applicable under TCO calculation.

While a quantitative life cycle based approach will be used in EURECA to calculate the overall cost impact over the life cycle of the data centre or other procured goods and services (a continuation of the approach determined for impact of EURECA project itself as described in D5.1), the financial implications of 'externality cost (savings)' due to reduced environmental impacts are further described under the 'environmental implications'.

By taking into account the whole life cycle of data centres, it will be assured that all relevant costs of data centre are considered – investment cost (hardware and other capital costs, data centre operation electricity costs, Software Licensing Costs, and Personnel Costs (Facilities/IT)), annual operation cost (during use-stage), end-of-life management cost, i.e. in a TCO approach. The life cycle cost-benefit calculation details of the data centre production, use and end-of-life are further developed under EURECA framework (D2.1) and tool (D2.2). Examples of areas where financial impact may need to be taken into account for the various procurement scenarios are:

Costs / Benefits areas

- initial investments
    - product development (in case of PCP)
    - (end)product manufacture
    - product testing (in case of PCP)
    - conformity testing (in case of PPI)
    - solution purchase price

    - procurement staff
    - knowledge development / training
- operational use
    - warranties, insurances and licenses
    - maintenance of the equipment, device, or system considered
    - staff
    - knowledge development / training
    - energy
    - water
- end-of life
    - decommission (building, infrastructure, floor space)
    - reuse / recycle (resources, services, taxes)
    - knowledge development / training

For example, for a datacentre new build, in addition to the initial development and construction costs, the LCC approach to total cost of ownership takes into account all the user costs, (e.g., reduced capacity at work zones), and agency costs related to future activities, including future periodic maintenance and rehabilitation, as well as projected costs-benefits for possible decommission and reuse or recycling of materials. All the costs are usually discounted and total to a present day value known as net present value (NPV). This example can be generalized on any type of material, product, or system. More details on LCC of data centre services can be found in D5.1 and D2.1.

Social implications

While social impacts are not (or very limited) within the scope of the EURECA framework, this chapter will give some understanding into social impacts of procurement choices for data centre products and services.

The following groups of persons can be distinguished that are affected by data centres: directly, this is the staff at the DC facility that is building, operating, maintaining or upgrading, and decommissioning it. However, also the whole supply-chains behind e.g. server production is related, up to questions of manufacturing of electronic components e.g. in China (where Apple has recently decided to force their suppliers to use benzene-free manufacturing in the interest of worker's health). Downstream the data centre, this is the staff that is recycling the hardware – with big differences whether this occurs in environmentally sound processes in Europe, or via the other extreme of open burning of hardware and extraction of gold with mercury, as found still ongoing in large scale in e.g. China.

Then, there is the staff at the public sector who is using the services and citizen that consume the public web services. However, these last two user groups are argued to be only very limitedly affected, as the services will differ little – if at all - between different data centre concepts and providers (leave aside different services quality and availability, what is however not captured here). However, the increase in e-services or technical improvements could over time impact the number of staff needed. It is also possible that the uptake of innovative technology and with it a demand for new skills and expertise through new procurement choices can increase job demand in these areas. This in turn will impact the need for training and education for both students (new generation professionals) and staff.

Another more indirect impact that could be a consideration is when it concerns the decision of a possible development of an e-service, for instance for the purpose of better helping people with a distance to the job-market, it may very well have societal effects. The e-service will have an environmental footprint which could be outweighed by the social benefits. Calculations of impacts for such considerations are complex and currently outside the scope of EURECA.

How are the relevant person groups affected and how can this eventually be considered in future efforts on the social implications of data centres:

DC staff

While the staff that works at the DC facility is most directly affected, it is argued here that – aside the aspect of the extent of human employment per provided amount of service and qualification of staff – is relatively little affected by negative social impacts. There are issues of noise and heat, but such are managed by e.g. noise protective equipment as part of good EHS practice. Other roles in e.g. administration, etc. are also among those with a lower social impact.

DC supply-chain

It is hence argued that the main social implications occur within the supply-chains. Main aspects that can be functionally related to data centre supply-chains, are: employment and qualification of staff, meeting of relevant ILO conventions (such as on freedom to negotiate payments, right to organise in trade unions, equal remuneration of men and women, child work, severe forms of child work, forced labour, corruption), accidents and other incidents [Wolf et al. 2002]. Such can be expected to be specifically relevant in countries with less EHS legislation and implementation/enforcement in companies, such as in part manufacturing in South East Asia and China, or in mining e.g., in African nations, also South East Asia, South and parts of middle America.

Measuring social and societal impacts

Should such issues be considered for future expansion for EURECA, the following approaches can be used to quantify and manage such issues:
Life Cycle Working Environment (LCWE) is the oldest and most advanced approach to capture social, product-production related aspects in life cycle perspective, in fact since the 1990s [Wolf 2014]. One solution that was developed already under a previous FP4 project and implemented into a professional Life Cycle Assessment software is the LCWT approach [PE

International 2003-2015], that is in between also available as a background database. Recent work on the topic is being carried out by several authors on employment aspects and child work and by [Wolf 2014] on the already mentioned accidents and incidents.
Other topics of more recent attention are conflict minerals. Also some aspects of critical raw materials are social / society related in nature, although more indirectly, as they affect the availability of materials to meet the needs of consumers. Different commercial solutions are available, including as plug in into one of the main worldwide PLM software teamcenter by Siemens.

Environmental implications

As the most relevant area of environmental impacts of DCs, typically the use phase electricity consumption is at the centre of attention. This is understandable for a number of reasons:

- it is also economically very relevant,
- it is indeed the single most relevant contributor to GHG emissions / climate change impacts, for most data centres and for the time being
- the information about electricity consumption during use is (mostly) easily available

However, there are two dimensions that would be overlooked, should the focus be exclusively on the electricity consumption: one dimension is the production of the goods, both of the electricity and of the capital goods of the data centre – from servers to UPS, from cooling to fire suppression systems, from UPS to the building itself. The second dimension are other environmental topics next to energy, while actually energy itself is not even an environmental issue, but a society issue, the emissions that arise with the energy production are. How important is it hence to look also into these two dimensions:

Capital goods production, EoL

There are a number of studies that have looked into the production of the various data centre capital goods, and of the data centre as a whole. The following two studies that looked at the whole data centre and that had access to better quality data, have found a considerable relevance of the production of capital goods to the overall energy consumption of about 50% [Meza et al. 2010] and carbon footprint of 33% [Honee et al. 2012], respectively. It is hence argued to be necessary to consider to a suitable degree also the production of the capital goods in the quantitative analysis, next to operational electricity consumption. This also to avoid a shifting of burdens from improving use phase electricity consumption, while causing higher impacts in the production of the capital goods required to achieve the improvements, and to not miss out hardware-related improvement potentials. The latter is also a key finding of the work of [Meza et al. 2010] that found big energy and environmental improvement potentials from rethinking DC conception from a hardware perspective (instead of from use phase electricity perspective), plus achieving relevant use stage electricity savings as side-benefits.

In contrast to capital goods production, which per se causes environmental impacts next to consuming energy resources, the end-of-life management of the capital goods often yields some (however small) net benefits of environmental savings, due to the recovery of valuable secondary material (e.g. copper, gold) and energy (e.g. from polymer waste incineration) that bring environmental credits back to the system. Such net benefits however require that recycling and landfilling of any remaining waste takes place in environmentally sound processes, avoiding shipment of 'recycling" 'in overseas. Such should be captured as well, by considering those benefits and possibly by considering take-back-schemes and sound-recycling schemes, should they be in place.

Environmental impacts beyond electricity consumption and primary energy

It is known from other studies on the individual hardware that the relative relevance for other environmental topics such as from toxic emissions, participle emissions is higher even for the production of the goods along the supply chains, because they either take place in countries with less good environmental legislation and/or in countries where enforcement is not stringent or fines are too low. The most important such environmental impact categories have been identified as follows in the ongoing Product Environmental Footprint (PEF) pilot projects of the European Commission, in the draft Product Environmental Footprint Category Rules (PEFCR) for a number of data centre relevant product groups:

- UPS: Human toxicity - carcinogenic effect, Freshwater eco-toxicity, Mineral, fossil & renewable resource depletion (the latter mostly due to metal resources)
- Hard disks: Mineral, fossil & renewable resource depletion (mostly metals), climate change, acidification, particulate matter
- Batteries: Climate change, Ozone Depletion, particulate matter, ionising radiation/human health, photochemical ozone depletion, acidification, eutrophication- terrestrial, eutrophication – freshwater, eutrophication – marine
- Metal sheets: Climate change, Ozone Depletion, particulate matter, ionising radiation/human health, photochemical ozone depletion, acidification, eutrophication- terrestrial, eutrophication – freshwater, eutrophication – marine, water depletion, land use

The primary energy consumption plays actually a less prominent role, what points to the necessity to explicitly look into the most relevant other impacts as well. Limiting the scope to the direct energy or primary energy are not very good proxies here. Already the use phase electricity can come from sources of a very different environmental profile, thinking of e.g. coal or natural gas power stations vs. hydropower or geothermal power. In fact, the carbon footprint of the supplied electricity is one criterion of the German procurement guidelines on efficient data centre services [UBA 2015].

In conclusion, a more comprehensive environmental profile needs to be considered. For practicality reasons, it is good to understand that the underlying life cycle background data can be the same as would be used if the focus would have been exclusively the carbon footprint: the relevant and updated databases cover all relevant environmental impacts. The foreground data at the DC design and build will be identical in any case, as the environmental impacts happen in the supply-chain, where in the initial step of EURECA development it will be necessary, but also sufficient, to use common background data. However, wherever more product-specific supply-chain based data collection has been established and is consistent, it should be possible that such will be used. The above list of data centre relevant impact categories is finally also roughly reflected by the list established by the Green Grid's in its high-level framework on Life Cycle Assessment for Data Centres [TGG 2010] (in brackets the main contributors): Energy consumption (during operation), Raw material depletion (construction of the data centre structure, manufacturing of IT and facility equipment), Land use (facility), Water consumption (operation). It also lists – not an impact category, but sources of emissions – the mix of energy-generating sources used to support operation and Reuse, recycling, and/or disposal of IT and facility equipment and materials.

There are even more impacts that could (and eventually should) be considered, such as forest /landscape destruction, biodiversity destruction, loss of ecosystem (services) from activities such as mining and waste disposal etc. Though it must be said that possible values and calculation mechanisms for these 'external costs' are still under debate and therefore not yet fit for the purpose for EURECA cost-benefit analysis.

Legal implications

Though legal and compliance requirements (such as for insurances) are labelled as constraints with which the organisation must adhere to and as such define the boundaries in which to operate, it may also be possible that looking for new procurement choices can be a trigger to challenge and change existing or to develop new legal policies or compliance rules. This may particularly be the case when embarking on PCP (and to some extend PPI) procurement initiatives. If a cost-benefit analysis can 'proof the case' of a new solution having large (environmental) benefits but is currently prevented of implementation by any legal or compliance matter, it can instigate a discussion to make changes that will allow it to be carried out (possibly under piloting circumstances).

In turn it is also possible new policies are developed stimulated by new technology that will enhance the market-uptake of more environmentally sound solutions, or policies are improved based on new insights.

Such adjustments or new policies may (need to) be evaluated on their impact, i.e. whether or not they have the desired effect. However, this is not within scope of EURECA.

Technical implications

When new procurement choices are made targeting more environmentally sound data centre products and services this results in both a higher market uptake of existing technology and the development of new technology and new services. From a technical point of view this will likely have an effect on all known areas within the data centre facility, the services that are provided, the information that is gathered and the day-to-day management.

Within the facility one can think of the design, maintenance and eventual decommission of the building itself, they monitoring and performance of all relevant components (from M&E to the office building interior to the (use of) software running on the servers). This in turn will increase the amount of data that is gathered. The gathering, storing and applying of this data uses ICT itself, but when used efficiently and effectively will create more (environmental) benefits than it costs. According to calculations done by GeSi this, on average, can for instance lead to "*emissions avoided through the use of ICT nearly ten times greater than the emissions generated by deploying it*".[4]

New information and insights can lead to changes regarding management, for instance in relation to availability, accessibility, the demand of new and different functional requirements. All this require new knowledge and skills by ICT / DC professionals.

[4] SMARTer2030 GeSi_Full_report - ICT Solutions for 21st Century Challenges (by Global e-Sustainability Initiative and Accenture Strategy)

4.3.3 Impact landscape visual

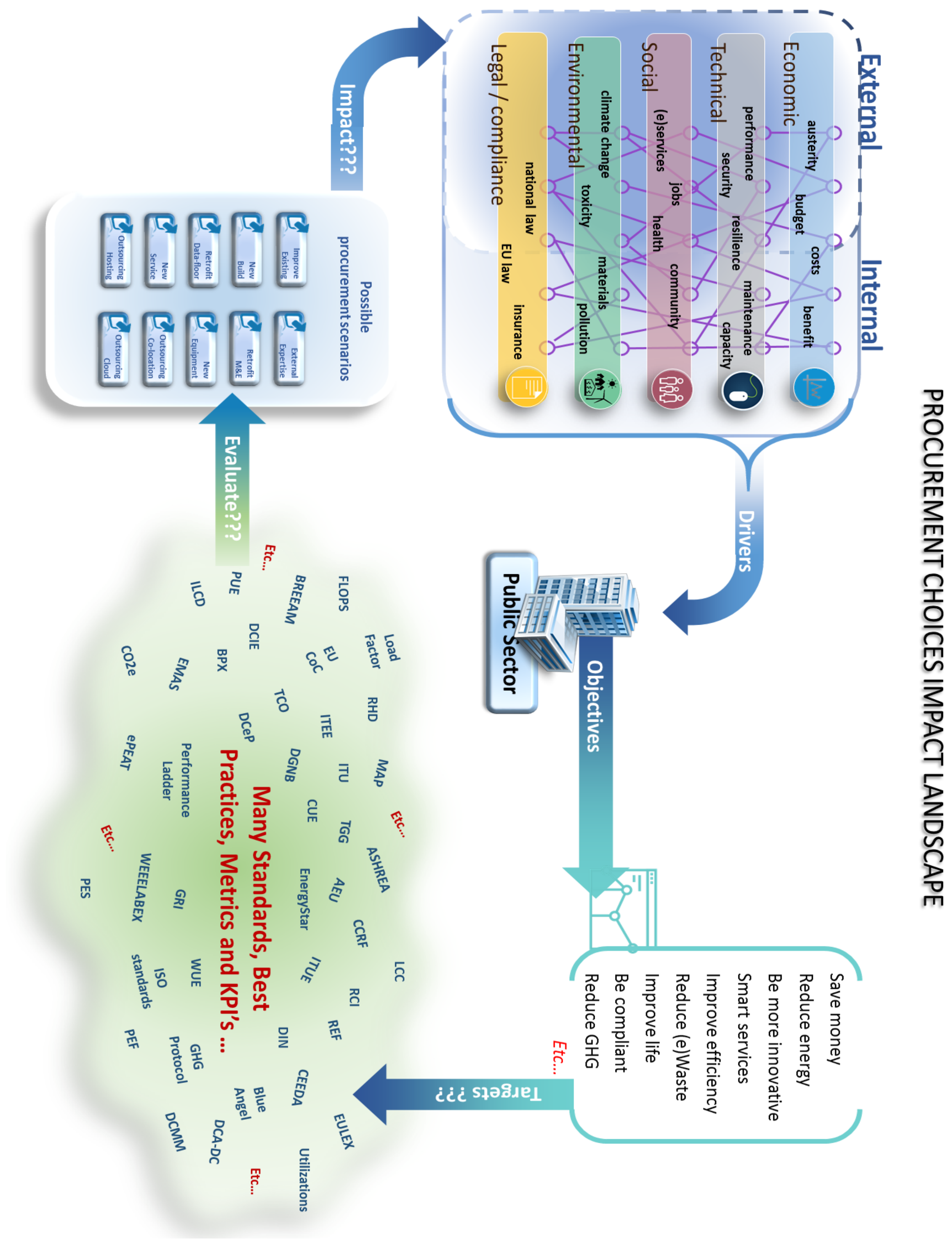

Figure 4 - Impact landscape Infograph (see Annex 1 for enlarged version)

4.4 Design elements for CBA impact calculation method

Based on research carried out during D1.1 tasks of Industry best practices and Procurement practices, followed by a SWOT and GAP analysis and the additional analysis performed for this deliverable under chapters 4.2 and 4.3, the EURECA project is now able to create a draft of the fundamental building blocks needed for EURECA framework and tool to be effective.

The elements (or building blocks) that we expect to use for the functionalities within the EURECA framework and tool will consist of the following:

Building upon a framework that incorporates a Data Centre Maturity Model (DCMM) in combination with additional key best practices/standards (such as the EU DC Code of Conduct) that are used for self-assessment and (ambition) road-mapping, the underpinning the method for cost-benefit calculation that are used for the creation of business cases of a procurement scenario will be the method of Life-Cycle Costing. The LCC method allows for calculation of quantifiable benefits by comparison of as-is (or 'status-quo') versus a to-be option as an intricate part of the creation of a Business case. It could also potentially be used by to compare option A versus option B.

Though, for the creation of a Business case it is not always possible to translate costs and benefits into monetary values. At this time there are a variety of different monetary values used for translating to different impact areas, therefore cost-benefit calculations for Business cases will include calculations of both monetary and other values to give weight to the different impact areas. This makes it possible for procurers to base their decisions not only on monetary values but also by weighing in costs and benefits of other values.

How this 'costing' approach works is explained in more detail in Deliverables D5.1 and D2.1. However, in its basics this approach will consist of a calculation of the Total Cost of Ownership (TCO), which is expressed in monetary value. For information purposes, we foresee to complement this by external costs (both jointly forming the overall eLCC) on selected emissions. This will be combined with benefits in form of $CO_2(e)$ and other environmental values.

For the Business case these calculations will be set within the frames indicated for technical, legal & compliance requirements. Also taken into account are the relevant best practices and standards in relation to the solution and the existing situation of the ICT / data centre infrastructure. This information is provided by the input given by the public sector procurer and the various databases / directories that are to be part of the EURECA framework & tool.

Because the 'social' drivers and objectives are largely outside of scope for EURECA, these are likely not to be included into cost-benefit calculations for the business case. However, we aim for the possibility to reference to any objectives related to standards and (best) practices that are commonly used in procurement in the Business case.

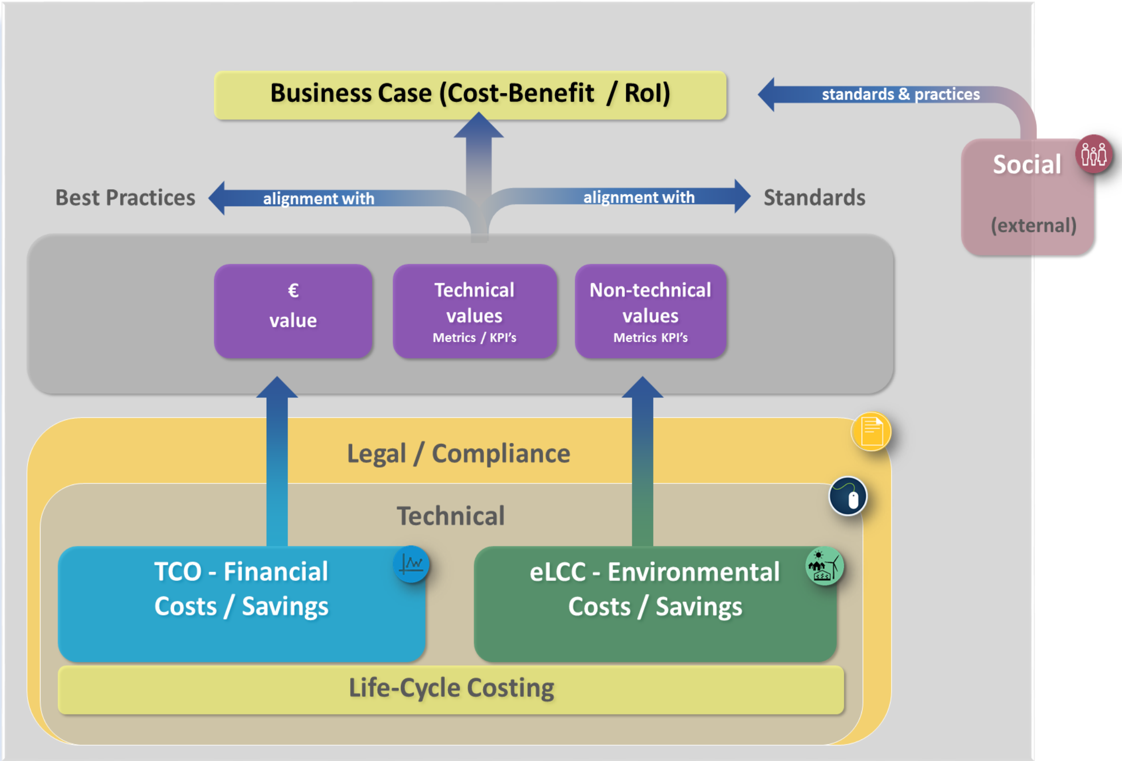

Figure 5 - Visual of cost-benefit calculation approach for a procurement scenario

This approach allows the business case to reflect the objectives that the organisation has provided. As a result, the decision-making process can be more closely aligned with those objectives and the underlying organisational (strategic) ambitions and drivers.

Using the EURECA framework and tool itself, supplemented with accessible training and awareness sessions to further understand the subject-matter and supporting guidance throughout the use of EURECA, will enable the public sector procurer to create a business case built on a situation specific foundation and allow themselves make better-balanced decisions.

Note: The above early design is indicative at this stage but can be considered as the fundamental direction for the further design and development of the EURECA framework and tool.

4.4.1 Method and rules life cycle costing and assessment

This paragraph is a description of the method and rules for LCA/LCC EURECA aims to use and include in the framework/tool. In this D1.2 we outline a general idea to that what is developed for D2.1 and D5.1 (which in turn is based on work already done in D1.1).

By taking into account the whole lifecycle of data centres, it will be assured that all relevant data centre related energy and environmental impacts are considered - from raw material extraction, component production, use phase until the end of life. This is necessary also to avoid a shifting of burdens from use phase, which often is the only scope of analysis of ICT products, to other product stages.

However, LCC scoping - which aspects of impacted areas are to be included and which are not? - is critical for the EURECA framework and tool. If the scope becomes too large, the tool may become impractical to use and of limited ability to help in decision-making and consideration of alternatives; if the scope is too small, the results may be skewed by the choice of factors considered such that the output becomes unreliable or partisan.

For data centre self-assessment and business case development, but also for eventually evaluating tenders for awarding a bid, it is preferable to calculate cost as TCO as baseline and calculate and present the externality costs separately:

- To avoid double counting as environmental figures are also presents using LCA
- As external cost data in use in other EU legislation are only covering four emissions (in the Clean Vehicle Directive) and hence to avoid unintended partial weighting due to transform only four flows to cost
- As the robustness of the external cost estimations is clearly less than that for the total cost of ownership

This still allows for the Business case to include calculations of a wider variety of impacted areas, but may be given weight by means of other values other than a monetary value. This would still provide public procurers with tangible means to evaluate these areas, such as organisational targets, objectives and goals, or for the awarding of a bid. This is also in line with the latest Impact Assessment Directive of the EU, which refers explicitly to using the developments of the European Platform on LCA, which are namely the ILCD Handbook, the ELCD database and the PEF guide. Sector-specific recommendations by ETSI, the green grid on life cycle assessment of data centres, as well as the GRI and GHG Protocol are used as guiding principles. At the same time, and given the complexity of ICT products and data centres and limitations of the availability of comparable life cycle guides for data centres, as well as to ease the effort for data centre goods and services vendors, some simplifications are made.

4.4.2 KPI/metrics and LCC values and capturing environmental benefits

Depending on the level of maturity and the ambitions set during the self-assessment steps within the tool, the most relevant metrics and KPI's and other relevant values can be selected to be used for the cost-benefit calculations. Also reflecting the aimed ambition level, the potential targets for tender criteria can be provided.

During the earlier research done for WP1 the best practices and standards, and the initial orientation on metrics and KPI's were evaluated against a variety of categories in the 'Evaluation Framework' (Annex I to D1.1), amongst them a rough RACER evaluation, which stands for Relevance, Accepted, Credible, Easy and Robustness.

For this phase of WP1 we have expanded this approach to determine the selection of elements to be potentially applied in cost-benefit calculations to evaluate the impact of a solution. For this we have used and referenced an approach used from an (as yet unpublished) paper on "KPI's for Green Data Centres" [5] developed for DG Connect which is written from the perspective of comparing the environmental performance of data centres.

The selection criteria used serve to evaluate whether a KPI and KPI/policy combination are suitable to evaluate certain environmentally related technical improvements. This helps to identifying the best options in a cost-benefit calculation. Also see Annex 2 - Analysis of potential KPIs for Data Centres, which includes a description of referenced indicators, the analysis overview and conclusion paragraph from the 'KPI's for Green Data Centres' report.

The criteria 'Practicality' (in D1.1 referenced as 'easy') and '(stakeholder) Acceptance' can moreover be expected to change over time, as more and better data become available, supporting software tools are improved, more experience is gained, and stakeholder understanding improved. The criteria used are:

- ***Relevance***

The indicator must closely relate to the problems being addressed: The KPI has to relate to the energy-efficiency and greenhouse gas performance of data centres. A support to wider EU environmental objectives is beneficial.

- ***Effectiveness***

The indicator must be pointing to the right direction under the selected policy instrument: The KPI needs to relate to the technical performance of the data centres in a system perspective (i.e. support a level playing field and not be distorted to favour less performing solutions), and consider the main contributing parts over the whole life cycle. To capture all relevant environmental and resource issues beyond energy and climate would be beneficial (i.e. to avoid a shifting of burdens).

Robustness

The indicator calculation must be sufficiently reliable in its broad application and for the intended policy instrument: The KPI must be scientifically sound / defendable, its calculation

[5] KPIs for Green Data Centres – Background paper for workshop; unpublished (Contract number 30-CE-0518625/00-10, European Standardisation Mandate and Lifecycle Inventory Databases) - Prepared for: European Commission, DG CONNECT. Prepared by: Marc-Andree Wolf, maki Consulting

involves no or acceptable / limited subjectivity (i.e. be reproducible) and limited / acceptable uncertainty (i.e. be sufficiently precise).

Practicality

The indicator calculation must be applicable with acceptable cost and duration and still meeting sufficiently well the method's potential: The following needs to be given: sufficient data availability (considering data quality, technological broadness and specificity, geographical coverage, age), limited complexity of implementation / needs for experts, sufficient availability of tool support, acceptable duration for development, and others.

Enforcement / market surveillance

The indicator / policy combination must allow for a sufficient enforcement in the market, limiting the share of free-riders to an acceptable level, to limit disadvantages for compliant companies and prevent underperformance of the KPI/policy achievements in terms of reduced environmental burdens.

Policy/legal issues

The indicator has to be suitable for the policy instrument. The KPI/policy combination has to be proportional to the expected benefits, be in-line with wider EU policy and society objectives, support EU policy coherence (i.e. avoid redundant, overlapping or contradicting policies), be in-line with international trade-agreements and WTO requirements, and meet other legal requirements (including the subsidiary principle).

Costs and admin burdens for producers and government

The indicator / policy combination must entail only acceptable costs and administrative burdens with the benefits clearly exceeding the costs (and being more efficient than alternative options). It needs also to be considered who bears the direct costs and burdens and who has the benefits. While ultimately these will always be the consumer / society, the cost transfer to them can be via the purchased products or via general or specific taxes or subsidies.

Stakeholder acceptance

The indicator method, the results and the form of communication / policy instrument must find sufficient acceptance by the direct users of the indicator and other, main stakeholders: the KPI/policy combination must have sufficient acceptance by ICT industry, trade organisations, green and consumer NGOs, and governmental bodies on national, EU and international level. Note: Stakeholder acceptance can also be understood as a meta-criterion that reflects on the integrated KPI-performance against all the others criteria as listed above, is here however used in the stricter sense as described above.

The analysis in the mentioned WS background report has shown that most of the KPIs that are used to steer data centre internal improvement (particularly PUE, WUE, CUE and further differentiated ones such as ITEU, ITEE, etc.) cannot and should not be used to express the data centre's overall environmental or energetic performance or even to compare different data centres. Despite the report's conclusions on 'shortcomings' of some of the analysed KPI's (some more so than others), these are mainly in reference to the risks of their potential faulty use, as can be the case in procurement. In short and focusing on the main problem, most of the indicators do not consider the technical performance of the data centre. I.e. two data centres A and B with the same e.g. PUE can in fact differ extensively in their actual environmental performance, as data centre A may have 5 years old servers, data centre B brand new ones with a many times higher performance, and the performance of several data centres like A. In other words, the risk in use in procurement is that PUE is used solely as a means to compare offers of two data centres with the intention of using it to determine their overall environmental performance without taking other impacting factor into consideration. At the same time, the PUE is a valuable means to assess and improve the effective use of energy in a data centre and therefore remains viable for use within specific procurement scenarios and for internal use for comparison of before and after internal improvements.

The summary conclusion here is that each KPI needs to be applied in exactly the way they are intended and not in ways where they create distorted (false) results. As such the intended use of KPI's will be reflected in the way they are incorporated in the EURECA framework and tool.

For our analysis of the benefits, we will hence need to go one step further, while basing it on the same relatively simple data that is used for calculating e.g. the PUE, but inject background life cycle data that can transform the electricity consumption into the whole environmental profile for producing and delivering this electricity, i.e. we obtain primary energy consumption and carbon foot-printing figures instead of only electricity. Similarly, we can inject life cycle background data on the hardware production, without requiring specific information from the data centre operators. Combining common hardware background data and product and data centre specific use phase data on electricity consumption and efficiency will yield a differentiated and much more accurate and complete picture of the environmental performance, and hence allow to quantify the net benefits of EURECA.

For assessing the environmental benefit, we will hence base this on the energetic and environmental life cycle performance of the options. These are related to:

- primary energy (renewable and non-renewable),
- climate change,
- acidification,
- eutrophication,
- ozone depletion,
- summer smog,
- particulate matter,
- ionising radiation,
- human and eco-toxicity,

- land use,
- water scarcity.

For tendering during procurement of hardware with award schemes to be suggested by EURECA, the approach will be even simpler, focussing on the use stage electricity consumption and efficiency, in conjunction with their technical performance that would anyway be documented by the producers (e.g. loss factor / own consumption of electricity of a UPS, power use at max and idle power of server), or be provided industry-wide as established benchmark data (e.g. SPECpower_ssj2008 server benchmark data).

4.5 Conclusions

From the evidence we have collected from our partners, beneficiary background knowledge and interviews with suppliers for more in-depth research on several specific procurement process and business case examples, a successful project always begins with a high level organisational wide strategy based upon energy efficiency and (environmental) sustainability that encompasses the entity as a whole and includes green power procurement, sustainable general procurement, waste recycling policies, sustainable building policies etc.

It is clear from our analysis that public sector organisations often already know that their data centre/server room/communications rooms are struggling to adapt to new technology (density) and often have poor environmental control systems, resulting in high energy costs and poor service delivery (patchy service delivery caused by infrastructure breakdowns), this is largely due to historical factors (rooms not being purpose built at the beginning) and a disconnect between those providing the service (IT) and those paying the energy bills (Estates/Facilities). High retrofit or new build costs often deter organisations from addressing the issues until events overtake them and expensive reactive solutions are sought.

The IT/Facilities & Estates disconnect also disguises the total cost of ownership (TCO) aspect and once this is identified, a new build or retrofit project is a more common result.

This has been the case in nearly all of our reviewed projects where a data centre optimisation survey, often undertaken by an (external) organisation produces a report which is independent, usually supports the commissioner of the report in highlighting that very real risks will result if no steps are taken to rectify the problems.

However, unless the external consultant is aware of the alternative solutions, the status quo will usually result. Clearly, our UK examples have been triggered by an external consultancy with very a high and wide arrange of expertise in data centre energy efficiency as with the examples from the Netherlands.

Our analysis of current and relatively recent projects indicates that current procurement policies actively discriminate against the procurement of green data centres and data centre services, but have resulted, despite the issues, in data centres that have achieved the desired results:

- Contributing to the organisational goals (partly)
- Reduction in Energy & Climate change related emissions (expressed in 'carbon')
- Delivering better resource efficient digital services

The procurement process clearly requires focus on the non-technical aspects of cost (in some cases difficult to ascertain given the poor statement of requirements), being the greater part of the evaluation criteria (70%) and technical aspects being only 30%.

The technical aspects can be broken down further but even with enlightened organisations such as St Andrews University, the energy efficiency and sustainability aspects only form 10% of the evaluation criteria. Unsurprisingly then, that public sector organisations rarely commission energy efficient new build data centres, or refurbish old ones to the latest designs and energy efficient concepts.

A thorough translation of strategic ambitions to tender criteria that ensure the best potential effect is often less comprehensive for environmental objectives, particularly due to complexity of combining multiple (strategic) objectives, conflicting interests, time constraints and limited understanding, awareness and collaborative approach. As a result, the environmental (or sustainability) related aspects of the formulated criteria and the eventual awarding of the tender carry considerable less weight than could be expected when looking at the organisation's strategic ambitions and organisation wide objectives. Relevant tender criteria and the selected solution tend to focus primarily on energy (and related carbon and cost) reductions in use-phase. This means that, despite being successful examples, there are likely opportunities missed. In any case, the cost of the services and the need to reduce operational costs were the primary driver in all cases.

The above highlights the needs for public procurement bodies to enhance their improvements on meeting their (next steps for) sustainability related ambitions and achieving a higher maturity while increasing market-uptake of relevant solutions (be it products or services). Regardless, the examples we researched more in-depth have shown considerable gains regarding energy savings, often in combination of cost reductions and mitigating initially foreseen problems, thus contributing to a wider range of (strategic) objectives nonetheless.

Our research indicates that substantial improvements have been made and that if all public sector organisations were to adopt a similar or even more comprehensive approach, even larger savings can be made across the EU. It is important to highlight that such consideration of environmental criteria should not and does not need to compromise the computational performance delivered. In contrast, as energetically and environmentally efficient data centres imply a sound planning, the quality of the final product can be expected to be rather higher.

Note: This does not only apply to data centre related products and services. Therefore, we would recommend that a similar procurement guidance and support will be developed also for office ICT in order to achieve improvements.

The landscape of the impact of new procurement choices exists both inside and outside the public sector organisation. From a procurement perspective, there are several (interconnected) levels we need to look at that influence and determine the eventual impact; the procurement scenarios themselves, the product / service life-cycle and the organisational drivers (which are consequently also the areas impacted).

For the creation of a Business case it is not always possible to translate costs and benefits into monetary values. At this time there are a variety of different monetary values used for translating to different impact areas, therefore cost-benefit calculations for Business cases will include calculations of both monetary and other values to give weight to the different impact areas, particularly to better enable environmental impact evaluation.

This makes it possible for procurers to base their decisions not only on monetary values - through Total Cost of Ownership (TCO) - but also fully and quantitatively considering the overall, life cycle wide energetic and environmental impacts and benefits of alternatives. Both methods will be combined for the foundation of EURECA cost-benefit calculations and support in Business case development. This will be complemented in the EURECA tool by a self-assessment of current maturity and aimed at maturity of the current data centre / server rooms, using the DCMM (and supplementing standards and best-practices from the EU Code of Conduct).

The EURECA tool will aid public sector in understanding the need for better initial scoping of the requirement, via better business cases and template award criteria, r questionnaires and forms, as well as reference to the vendor-filled EURECA Directory on products, services and providers to get an up-to-date market overview. It will furthermore signpost additional technical and non-technical resources (various relevant standards, guidelines and innovative solutions) via the inclusion of best practices, particularly pertaining to TCO, LCA, DCMM and from the EU Code of Conduct for Data Centres (Energy Efficiency) 2016 - including subsequent editions or any replacement EN standard or technical report that may be issued - into the benchmarking and potential improvement tool area and for tender document templates that help take full advantage of innovative solutions. Furthermore, with a special focus on PPI and PCP, innovative solutions developed by the FP7 Cluster can also be highlighted via the use of the EURECA tool to push take up.

The EURECA tool will also indicate which procurement scenario is the best option taking into account the input provided by the organisation, for instance whether it is better for the organisation to adopt "cloud" or colocation services (where national legislation allows) for their digital services although this also depends on the risk appetite of the commissioning organisation. Finally, to facilitate a continued positive market-uptake and impact, the EURECA tool must undergo revision on at least an annual basis to keep up with standards development, the addition of new best practices and new innovative products and services.

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