ASSESSING THE POSITIVE AND NEGATIVE IMPACTS OF ICT ON PEOPLE, PLANET AND PROFIT

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Abstract: There are numerous methods to measure the impact of ICT on the environment, all of them different in scope, some of them incomplete and it is difficult to see the connection between them. This study draws an inventory of methods to assess the impact of ICT which all of them have their pros and cons. Furthermore, this study defines the building blocks a more complete method to evaluate both the positive and negative impacts of ICT on People, Planet and Profit.

1 INTRODUCTION

Since the Copenhagen summit (2009, the United Nations Climate Change Conference), there is the insight that "nations talk, cities act". Indeed, the number of 'smart cities' that seek to address sustainability goals is increasing. However, many pilots and initiatives in these cities seem to be inspired mainly by what is possible, and not based on a careful analysis of the net sustainability effects.

The ICT4EE conference in Brussels (February 2010) concluded that no generally adopted and available framework exists to assess and compare the sustainability effects of pilots or measures. Good starts have been made in various initiatives, though. Bristol has been working on ecological indicators using sustainability and quality of life as starting points (McMahon 2002). The Amsterdam Smart City initiative (www.amsterdamsmartcity.nl) uses the concept of 'value cases', where a joint financial and carbon analysis of the projects is executed. However, only net carbon savings are calculated, and no attempt has yet been made to incorporate embodied carbon and second order effects. So, the 'profit' side of sustainability is accounted for, and the 'planet' side partially. The 'people' aspect of sustainability remains untouched.

A good initiative to gather and compare energy and environmental related data is the Urban EcoMap (urbanecomap.org), which is developed by Cisco as part of the Connected Urban Development program.

In this article, we describe some of the sustainability frameworks that exist for areas in which ICT is the main driving force. These frameworks have a large variation in scope and sustainability goals and none of them gives a complete assessment of the impact of ICT. The end of the paper defines the requirements for a more complete method.

We regard sustainability in the light of the Triple Bottom Line: People, Planet, and Profit.

2 IMPACT OF ICT ON SUSTAINABILITY

Gartner caused quite some attraction with its statement in 2007 that the whole ICT sector is responsible for about 2% of the world's energy consumption, comparable to the energy use of the aviation sector. Building on this, the observation has been made that if we want the ICT sector to still use 2% of all the world's energy by 2020, ICT has to become much more efficient because of the prolific rise of ICT in virtually any aspect of our society. (According to (The Climate Group, 2008), the Business As Usual scenario would mean that ICT would account for 2,7% of all emissions, compared to 1,25% in 2002, which is a 216% increase.) At the same time, it is good to note that ICT itself is a promoter of energy efficiency: the ACEEE (2008) states that "For every kilowatt-hour of electricity that has been demanded by ICT, the U.S. economy increased its overall energy savings by a factor of about 10. (…) The extraordinary implication of this

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Table 1: Sustainability on different levels.

Scale	Challenges, examples, frameworks
ICT / CT	Challenge: Maximum of communication throughput for a minimum of energy Framework: ECT
ICT/ IT	Challenge: Maximum of computing power for a minimum of energy Example: Intel 'Westmere' energy-saving chip Framework: Energy Star
ICT / facilities	Challenge: How to maintain the IT and CT functions with a minimum of energy for supportive technology? Framework: Energy Star
Data centre	Challenge: Given the application landscape, what is the minimum of energy needed to support this? Example: virtualisation Framework: PUE
Software/ application	Challenge: Given the functional requirements, what is the most efficient way to accomplish these? Example: Green coding Framework: Microsoft Joulemeter
IT Functions/ processes	Challenge: What is the most energy efficient way to reach a business goal? Example: e-billing Framework: OpenDCME
Companies	Challenge: Sustainable operation Framework: GRI, ISO14064
Cities/ Regions	Challenge: How to balance sustainable working, living and travelling? Example: Smart Cities Framework: none
Economies	Challenge: Combine maximum welfare with maximum sustainability Example: Framework: ISO14064

finding is that ICT provide a net savings of energy across our economy".

The Climate Group (2008) expects that usage of ICT will increase substantially in the coming years, therefore paying attention to the direct energy consumption of ICT itself is certainly very important. However, besides the "greening of ICT" activities, it is recognized that the smart application of ICT can have a substantial impact on reducing our energy consumption in other fields. This is called 'greening by ICT' and includes for instance a shift from delivering physical products to delivering services: the 'dematerialisation' effect of ICT (Romm 1999). An example is less need for printing because more information will be available electronically (Boston 1999), although predictions concerning paperless offices do not easily come true (Kohl 2004). With the advent of e-paper solutions, however, the environmental aspects of dematerialisation in offices (Schmidt 2009) are receiving more attention.

Additionally, the effects of ICT that seem to have good advantages in the short term could be undone in the long run. That can happen due to so called rebound effects. If, for example, ICT enables cheaper production, the demand for products will raise thus increasing pollution. These rebound effects make it difficult to evaluate the effects of ICT on sustainability. What is needed is a method to look at direct, second order and third order effects in a uniform and structured way. An attempt is made by introducing the RAP method (Bomhof, 2009), that tries to assess the net effects of interlinked positive and negative side effects of ICT. The method is qualitative by nature, however, so it is not easy to compare measures and pick out the best.

A more elaborate way to assess the net impact of ICT-driven sustainability innovations is presented in (Hilty, 2006). This analysis is quite rigorous and has a good eye on so-called revenge (or rebound) effects, but is only carried out on a macro level (country or continent) and should be adapted to assess the net effect of a set of ICT innovations.

Knowing all this raises new questions: how can we estimate, or even calculate the effects of ICT? How can we be sure that ICT indeed has this greening effect? And if we knew that, how could we design ICT applications that enhance sustainability? The ACEEE analysis was made on a macro scale: the economy of a whole country is compared to ICT developments and investments. It enables to draw conclusions on a statistical basis. The ACEEE has formulated regression equations between factors as Total Electricity Use and ICT Capital Stock, or Total Energy Use and Economic Growth, and ICT Investments. The impact of ICT on a small scale (micro level: one worker, or one department in a company) could be determined by careful analysis of how processes and procedures change as a result of ICT. The energy impact could also be measured or estimated.

2.1 Sustainability on Different Levels

Looking at the various frameworks and methods, one can put them into a hierarchical order.

Within each level, initiatives and frameworks exist to achieve maximum energy efficiency for that level. The challenges at each level can be formulated as: "given the requirements of the next level, how can we achieve these with a maximum of sustainability?". Sometimes the challenge for a level is treated on that level alone. A pitfall that is commonly seen is that levels are skipped without even noticing them: a company that wants to 'greenwash' its image, will invest in energy efficient office lighting without paying attention to inefficient business processes.

Our starting point has been with energy efficiency, so not surprisingly the 'planet' aspect of each level is covered. An observation can then be made that the two other sustainability aspects, 'people' and 'profit' are usually not incorporated in the frameworks that are used on the lower levels.

In the next sections, some of these frameworks will be presented in a little more detail.

3 FRAMEWORKS TO ASSESS THE "GREEN-NESS" OF ICT

3.1 Energy Efficiency of Network Equipment: ECR

Today, the energy efficiency of network equipment is seldom taken into account in the purchase process of network equipment. One of the underlying reasons is that among vendors there is no generally accepted standard that defines the energy efficiency of network equipment. The Energy Consumption Rating (Cueppens, 2008) (ECR) Initiative is an attempt to provide an efficiency metric that provides this insight. The ECR initiative defines a framework for measuring the energy efficiency of packet based network equipment. The goal of ECR is to define a standard rating that can be used for comparing the energy efficiency of network equipment.

The ECR Initiative defines public available test procedures and methodology to asses the energy efficiency of various types of network equipment. The outcome of the testing procedure is two energy efficiency ratings, expressed in terms of Watts per Gbps. The basic ECR rating is defined as the energy efficiency at the maximum achievable network load without packet loss. Also defined is a variable load metric ECR-VL, which is a weighted average of the energy efficiency at network loads between idle and 100%.

The success of the ECR standard is dependent on the adoption by the vendors of network equipment. At this moment the ECR is only supported by Ixia and Juniper Networks.

3.2 Energy Efficiency of Computer Systems

A well known standard to rate the efficiency of consumer products is the EnergyStar standard (EnergyStar, 2009). Energy Star includes a specification to rate the efficiency for desktop and notebook computers. This includes an efficiency rating based on separate categories for computer systems (desktops, notebooks, thin-clients and small servers) as well as a minimal required PSU efficiency.

3.3 Energy Efficiency of Data Centres: PUE

The green grid (GreenGrid, 2007) is a global consortium of IT companies and professionals with the goal to improve energy efficiency in data centres. The green grid works on the development of standardized and accepted set of metrics, methodologies and processes to achieve this goal. The Green Grid has defined the efficiency metric PUE, and its inverse DCiE, as a standard to express the energy efficiency of data centres. Today, the Green Grid, and the PUE metric are widely adopted by the ICT industry. The Power Usage Effectiveness metric PUE is defined as:

$$\text{PUE} = \text{Total Facility Power} / \text{IT Equipment power} \quad (1)$$

The Total Facility Power is the measured power dedicated to the data centre and the IT Equipment power is the power measured of all ICT equipment, mainly computers, network components and storage. The calculation of PUE is relatively straightforward and most complexity finds its origin in accurate bookkeeping: the allocation of energy measurements to IT equipment and facility power. The major advantage of PUE is its wide acceptance, and straightforward implementation.

At the same time, PUE methodology has some limitations. The most important limitation is that energy efficiency of hosted ICT infrastructure in data centres is beyond the scope, and therefore not known. PUE does not provide insight in the effectiveness of individual ICT systems. As an example: Computer systems which are in a continuous idle state could possibly be switched off so that energy is saved. From a mere PUE perspective switch of a system could have a negative impact on efficiency because the total IT equipment power consumption is reduced, but probably the total cooling capacity of the data center is not: this means that the ratio "Total Facility Power" versus "IT Equipment Power" becomes less favourable.

One criticism of measures like PUE is that it only focuses on the hardware, and not the logic behind it. An example is easily demonstrated: in an overdimensioned data center, where lots of cooling equipment is running but where only part of the floor is occupied by working IT equipment, it is easy to increase the power efficiency by just adding a bunch of old, unused computers. In that case, hardly extra cooling is needed, but these old computers do use power. This means that the ratio of 'total energy used' versus 'energy used for IT only' becomes more favourable. The main problem is that PUE is a ratio, that can be made 'better' by decreasing the numinator, but also by increasing the denominator. Another problem is the scope of the PUE itself: it does not give an idea of the usefulness of the IT equipment.

Another limitation is that some sustainability measures, like reusing generated heat though heat pumps, do not have an impact on the efficiency of the data centre itself and therefore have no impact on PUE.

3.4 OpenDCME

The Data Centre Measure of Efficiency (openDCME.org) is positioned as an extension to more 'technical' measures like PUE, EUE and DCiE. These technical measures give an indication of the efficiency of the datacenter hardware, including infrastructure needed for cooling and other operating conditions.

OpenDCME strives to overcome the drawbacks of for example the PUE, by focusing on efficiency-inducing policies rather than mere hardware measurements. The model identifies 16 Key Performance Indicators that are grouped into 4 quadrants.

Table 2: OpenDCME model.

The data center: • DCiE • Floor usage • Bypass • Recirculation	The IT Assets: • Network architecture efficiency • Storage architecture efficiency • X86 architecture efficiency • RISC architecture efficiency
The tooling: • Network management • Storage management • Compute management • Electrical and mechanical management	The processes: • Change and configuration management • Product lifecycle management • Capacity management • Service Level management

This approach enables datacenter management to assess more areas that have impact on energy use, to incorporate supporting processes, like product lifecycle management, as well. The scope is limited to datacenters, so this approach is only suitable for 'green it' initiatives. Besides, it cannot be easily used to compare different scenarios.

3.5 Global Reporting Initiative

The Global Reporting Initiative (gri.org) has introduced the Sustainability Reporting Guidelines that should be applicable to any organisation regardless of size or business. The guidelines are meant to provide transparent information on the sustainability performance of the organisation.

The 'people', 'planet' and 'profit' aspects of sustainability can be recognized from the indicators that are proposed for:

- Economic
- Environmental
- Social performance (labour practices & decent work; human rights; society; product responsibility)

Each indicator is supplied with a protocol that describes how the indicator should be measured. The focus of GRI is to encourage organisations to report on their sustainability indicators, and to make this kind of reporting just as normal as financial reports for the organisation's profit are today.

The indicators in the GRI form a very good basis for judging the net sustainability performance of an organisation, yet it does not make an attempt to bring the indicators on a level that enable to compare organisations.

3.6 ISO 14064

ISO 14064 is an international standard that specifies and guides the quantification and reporting of greenhouse gas (GHG) emissions. ISO 14064 is compatible with the GHG protocol (www.ghgprotocol.org). It provides governments, businesses, regions and other organisations with a set of tools for programs aimed at measuring, quantifying and reducing greenhouse gas emissions. These standards allow organisations take part in emissions trading schemes using a globally recognised standard. ISO 14064 provides a comparable method of reporting that is internationally considered as "good practice". The standard provides a methodology to quantify GHG emissions at the organisation level and the project level. Also includes are guidelines and requirements for validation, verification and certification.

Assessing GHG emission at the organization level is separated into three tiers:

- Direct GHG emissions occur from an organization's own resources, like furnaces, machines or owned vehicles;
- GHG emissions related to purchased electricity;
- Other GHG emissions i.e. related to purchased products and services like transportation.

The Carbon Disclosure project (www.cdproject.net, CDP) provides a platform, where organisations can disclose their measured GHG emissions like ISO14064. This includes climate change strategies and reduction targets. The CDP data is available to investors, policy makers, governments, researchers and the public.

4 REQUIREMENTS FOR A COMPLETE ASSESSMENT OF THE IMPACT OF ICT

We found a lot of initiatives of communities and cities on doing something sustainable and often, some form of ICT is used. However, not one of them seemed to be able to answer questions such as 'which are to most sustainable activities?', and 'which of these systems is able to reduce the most CO2? What about the effects on people and what about the business case? In short, in order to compare ICT and ICT applications and advise on which are the most sustainable choices to make, none of the frameworks described above did fit our purpose.

With one of the statements made in Copenhagen ("nations talk, cities act") at the background, it seems appropriate to aim our efforts to the scale of cities and/or regions. It is the scale at which concrete measures can be designed, implemented, and evaluated, often with the help of local companies. And, to reduce the carbon footprint of a city or region, it is not enough to focus on 'Green IT' alone: the 'Greening by IT' effects have to be accounted for as well.

What is needed is a method to make a complete assessment the sustainability of ICT (applications) that is able to tell whether solutions such as videoconferencing, e-invoicing and working at home really do make a difference. The method should include not only the direct effects of ICT but also the indirect and system effects. Direct effects are the effects of the production and use of ICT; indirect effects are the effects of the use of ICT on the use of energy; and system effects are the effect of behavioural changes or completely different industrial processes and usage patterns by ICT (Bomhof, 2009). Sustainable development is defined by the UN (Brundtland, 1987) as a process of change in which the exploitation of resources, the direction of investments, the orientation of technological development; and institutional change are all in harmony and enhance both current and future potential to meet human needs and aspirations. That implies that all aspects of sustainability, People, Planet and Profit should be part of the method since all three are equally important to create a true sustainable solution.

The method should focus on long term maximum added value; however that should be the maximum added value for all aspects of society and not for individuals and individual companies. That means that prices should reflect added value and lost added value to society and that all societal values and cost should be calculated to the investor. If the method is able to show the added value and lost added value of different solutions and options, it will enable cities, companies and other organisations to make the most sustainable choices. Research is currently done to achieve such a method. It can already be observed that this encourages to bring together knowledge from various fields (such as, technological knowledge, labour efficiency & quality, business modelling, life cycle analysis) and leads to a better mutual understanding of representatives from these fields.

5 CONCLUSIONS

A lot of excellent work has been done on assessing the sustainability effects of ICT-driven initiatives. However, it is not yet possible to make a sound comparison between these initiatives in terms of sustainability effects. We propose building a framework that takes into account all relevant aspects of sustainability, people, planet and profit, and quantify them as much as possible. This framework also makes a clear distinction between direct, indirect and system effects.

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