GREENING IT

How Greener IT Can Form a Solid Foundation For a Low-Carbon Society

Editors:
Adrian T. Sobotta
Irene N. Sobotta
Dr. John Gøtze

Foreword by European Climate Action Commissioner Connie Hedegaard

Greening IT

How Greener IT Can Form a Solid Base For a Low-Carbon Society

Editors:
Adrian T. Sobotta
Irene N. Sobotta
John Gøtze

ISBN 13: 978-87-91936-02-9
ISBN 10: 87-91936-02-0

Printed in the World

Draft First edition (Published online):	2 December 2009
Draft Second edition (Published online):	31 January 2010
First edition:	31 May 2010

Contents

Acknowledgements

The editors sincerely thank the international group of hard working contributors who took part in this book. All of them are committed to Green IT in their professional lives - setting an example for all of us. Thank you for your support and great efforts in contributing to the book; it would not have been possible without your dedication.

Thanks go out to the The League of Movable Type (`http://www.theleagueofmoveabletype.com`) for their efforts to start a true open typographic community and for making the fonts available which are used on the front cover of this book. We also extend thanks to Roberto Cecchi's for creating and subsequently releasing his Aierbazzi font which is also used on the front cover. All fonts used on the front cover are released under the SIL Open Font License (`http://scripts.sil.org/OFL`).

We also extend thanks and gratitude to Leonard Fintelman who assisted in the task of proof reading, Tripta Prashar (Director of UK based independent Green IT consultancy firm Giving Time and Solutions Ltd), Laurent Liscia, Sean Whetstone, Ariane Rüdiger and everyone else who have been instrumental in promoting the book.

Finally we would like to thank all those who contacted us during the books evolution to voice their support and offer their feedback.

Disclosure

This book represents a collection of works from contributors spanning the globe. Where necessary, permission was sought and granted to contributors from their respective employers to take part. All contributors were motivated by a personal desire to examine how IT can help build a low-carbon society. The views, concepts and conclusions put forth by the contributors do not necessarily reflect those of their employers and may not be endorsed by them.

Foreword

By Connie Hedegaard, European Commissioner for Climate Action

Bringing climate change under control is one of the great historic challenges facing humanity in the 21st century. To succeed, the international community must reach an ambitious and comprehensive global agreement that provides the framework for worldwide action to keep global warming below dangerous levels.

The most convincing leadership the European Union can provide is to become the most climate friendly region in the world. My goal is to make this happen over the next five years. It is emphatically in Europe's interest: it will stimulate greener economic growth, create new jobs and reduce our dependence on imported energy.

The EU has already committed unilaterally to cutting our greenhouse gas emissions to at least 20% below 1990 levels by 2020, and we are now analysing the practical options for moving beyond that over the same period. The European Commission will then develop its vision for completing Europe's transition to a low carbon economy by 2050 including the necessary scenarios for 2030. This will require emission reductions of 80-95% by mid-century.

All sectors of the economy will need to contribute as fully as possible, and it is clear that information and communication technologies (ICTs) have a key role to play. ICTs are increasingly recognised as important enablers of the low-carbon transition. They offer significant potential - much of it presently untapped - to mitigate our emissions. This book focuses on this fundamental role which ICTs play in the transition to a low-carbon society. They can empower energy users and create completely new business opportunities.

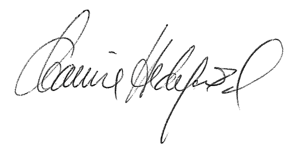
ICTs are already transforming the way we live and work, for instance by opening up possibilities for teleworking and videoconferencing. They make it possible to use energy more efficiently, for example in smart buildings where heating, ventilation, air conditioning, lighting and use of electrical and electronic devices are optimised. They are essential for creating the smart grids that will form the backbone of the low-carbon electricity system of the future.

But ICTs have a carbon footprint too. Around 8% of the EU's electricity use and some 2% of its carbon emissions come from the ICT equipment and services and household electronics sector. So ICTs need to be 'greened' if they are to be part of the solution and not exacerbate the problem.

The EU has legislation in place to improve the overall environmental performance of energy using products such as TVs, personal computers and other consumer electronics. We are setting minimum standards under the EU's "Ecodesign Directive" that will make a wide range of products marketed in Europe more energy efficient.

But top-down legislation for specific products can be only part of the solution. The most promising way forward would be for the ICT sector to take the lead in greening itself. This is also likely to be the most economically efficient approach. Some companies are setting the example already and getting a head start.

Connie Hedegaard



CHAPTER 1

Prologue

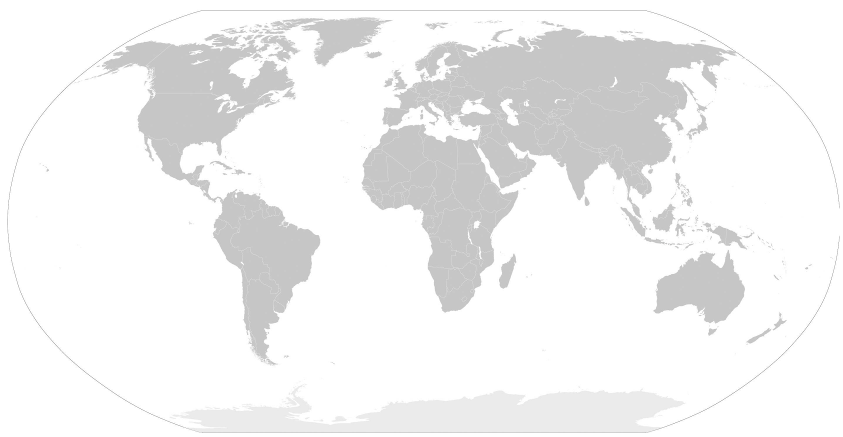
This book started out as two people's commitment to save the planet, and one guy crazy enough to suggest that a book was the way to do it. All three of us can now call ourselves the editors of this exciting, internationally collaborative, and non-profit (Creative Commons licensed) project. Allow us to introduce ourselves: Irene & Adrian Sobotta and John Gøtze.

Personally committed to contribute to solving human's impact on global warming, Irene and Adrian wanted to apply their professional fields of Environmental Politics and Information Technology to increase awareness of Green IT solutions. Using John's knowledge and experience in collaborative bookwriting, the Greening IT project was born.

Our common underlying assumption is that there is something wrong with the world today! We perceive Climate Change and Global Warming as the effects of unsustainable consumption patterns in an industrialised world. In an effort to contribute to solving the problem, we look into the great potential of Information Technology (IT). The overall goal is to communicate to a large audience how IT can be leveraged to transform today's society into one characterised by low emissions of greenhouse gases.

Although we strongly believe that IT is part of the solution, we must emphasise that we also do not believe in silver bullets and technical fixes. As such, the problem and indeed the solution, is at the end of the day a question of human, social, cultural and political commitment.

From the outset, the project was dependent on contributions from other committed souls around the globe. Thus, the book has been written as an internationally collaborative effort resulting in a compendium of works with a loose common thread, being Green IT. This approach allowed us to bring in expertise in various fields of Green IT and the environment, thus allowing for different approaches and perspectives on the potential of Green IT.



The contributors are situated in Denmark, United Kingdom, Germany, Netherlands, Switzerland, USA, Japan and Australia - a truly diverse team, which despite their geographical dispersion and cultural diversity, has communicated a unified message. That message being that IT is a strong and signficant enabler to transform our societies into those characterised by low-carbon footprints.

The aim of the book is to look into how Information Technology can support society in reducing CO_2 emissions, saving energy and optimising resource utilisation - thus becoming greener and developing towards a low-carbon society. The book seeks to cover the general potential of Green IT, as well as the potential of a number of specific technologies, such as Smart Grid and Cloud Computing.

May the book fulfill its intentions and help lead us to the Low-Carbon Society.

Enjoy!

Adrian, Irene and John

CHAPTER 2

Our Tools Will Not Save Us This Time

One of the initiating questions for this internationally collaborative book was: how green has the IT industry been so far?

From where I stand, that's the easiest one to answer, because we happen to have historical data. The answer is: not at all. Let me illustrate by telling my own story as a Web entrepreneur.

As I write this, I am using a tool, which in some remote sense is descended from the rocks and sticks our ancestors once used in the savannah. It's an IT tool, it's connected to the ubiquitous network (which is helping me form the thoughts and acquire the data that will populate this piece), and it uses power brought to my home by Pacific Gas and Electric's transmission and distributions lines. The power is generated at a power plant not too far from my home, and there is some power loss on the line due to electrical resistance. The data published on the network tells me that on average this loss is something like 7.5% of the power pumped through the Grid.

When I started my Web business back in 1997, I was proud of the fact that it was virtual business: the cool factor was certainly appealing. We weren't wasting money and resources on an office. We used very little paper. We traded in grey matter only - or did we? Soon enough, as we grew, we needed an office. While a large portion of the business remained virtual, we needed a centralised team to code apps and deploy Web sites; a set of office servers and test beds on top of our co-located machines; and numerous trips back and forth on airplanes and in taxis or rental cars to sell our stuff or simply stay in touch. Humans don't do well if they can't read each other's facial expression and gestures, another legacy from the savannah. They can do business, but they can't really build the kind of trust that makes a team more cohesive and effective.

Not only did our carbon footprint (which was not called that at the time) increase, but the city where we operated from, Ottawa, didn't have a good recycling program for businesses. As it turned out we started using a lot of paper: brochures which nobody read, business cards, countless white papers and office memos, all kinds of administrative paper destined to a drawer, contracts and the like. The Gutenberg paradigm, which propelled our species into the industrial age as surely as the steam engine, was and is very much alive. And a lot of our paper was ending up in waste bins.

Of course, being in Ottawa, we had to heat our offices for most of the year, and there was never a way to heat them just right: we erred on the side of too warm. We kept our neon sign on at night to remind the good people of Ottawa that we existed, and of course our machines, and some of our office lights were on 24/7. I learned that the machines we all used: the desktops, the big CRTs and even the laptops were electron guzzlers. Our IT staff advised us that it was best to leave our computers on all the time to minimise component wear and tear (wisdom that today no longer holds true), another blow to conservation.

Meanwhile, global warming was taking centre stage as an issue. Kyoto was on everyone's mind. The most energy intensive nation in the world, the United States, would not be a signatory to the treaty. That's when I started thinking of IT's carbon footprint as an industry, and how thoroughly my illusions about IT and the Internet's environmental benefits (which turned out to be a complete fantasy from the get-go) were shattered. I did some research and discovered that a typical fab consumes tremendous amounts of energy[1]. It also goes through whole lakes of water, puts out vast amounts of byproduct gases, and even more troubling, is getting less power efficient over time because new equipment is more power-hungry[2]. As for the network, which some people have come to call the "Cloud", it relies on huge data centers that store thousands of power-hungry servers, using at least 1.5% of all US power[3], and possibly 3% in another 2 years. This is more than all colour TVs combined. Speaking of which, there's another area where IT has made its mark: flat panel TVs are now nearly indistinguishable from computers - and as it turns out they use more energy than a conventional CRT.

And if that weren't enough, what happens to our discarded IT equipment? There's lots of that, given the very short product cycles. Printer cartridges are piling up in Chinese landfills, heavy metals and chemicals from batteries and screens take up more and more space in our own waste management facilities, old cell phones, iPods, laptops, desktops, keyboards and the like end up underground with the rest of our garbage. But you know this, because like me, you've thrown out your share of gadgets, and you too have squirmed in your ergonomic chair and wondered where it all goes.

If I step back from this picture as a cultural observer, what would I be tempted to say? Not only has IT never been green, it's horrendously wasteful, it encourages people to discard and adopt the newest gadget in ever-shorter cycles of consumption and it pollutes as much as any other industry. It has also taken Schumpeter's creative destruction model of capitalism to a new and disturbing height, and changed our expectations around growth, seed capital and return on investment. And as new as it is, it has already caused its share of pain besides the gains: the 2001 dot.com bubble. Forgive me for stating the obvious, just beyond the rose-tinted glasses.

What about the positives? That's the easy part: we all know about IT's contributions to productivity, knowledge dissemination, scientific advances and therefore, our global lifestyle. I do mean global: while many populations are underserved from an IT standpoint, they still benefit from the technologies that IT has enabled. I would be hard-pressed, however, to identify a positive impact of the IT industry on the environment at this point in time, other than indirectly - again, as a tool that allows us to study changes in our environment with more accuracy.

In my capacity as Executive Director of the Organisation for the Advancement of Structured Information Standards (OASIS), a standards body, I was taught a superb lesson in just how dependent the IT industry is on the power grid. Jon Bosak, best known for his eminent contributions to XML and also the Universal Business Language standard (UBL), has taken an interest in Peak Oil theory and its impact on our industry. It's still unclear when oil production will peak, but this event is not in our distant future, and possibly no farther than a half-century away. Because markets anticipate what happens down the road, we will feel the impact of this event well before it occurs - we already have. There will be more Oil crises, and chances are they will grow more severe each time. Because the network, both local and global, needs power, it's not a stretch to imagine a time when our "free" communication devices of today become too expensive to use. So far, the network has absorbed the variations in utility prices via increased productivity and growth, but no one can beat the laws of thermodynamics, especially when they combine with economics. The only way out of this quandary would be to draw our energy from sources other than fossil fuels: renewable fuels, alternative energy, nuclear, and some forms that we have not been able to tap into yet, such as fusion. There are problems with each one of these options, and the underlying belief is that technology can save us as it has in the past.

Let me get back to that crucial point in a minute, but let's just say right now that I view that belief as a fallacy, and simply a modern iteration of magical thinking.

Another question at the core of this book is: are we witnessing a greening of the IT industry?

At the current point in time, yes and no, or rather, no and yes. If the yardstick for "green" is reduction in carbon footprint, emissions and waste, then IT has not even begun to turn green - it will get "blacker" before it greens, just from sheer momentum. If the criteria, however, are adoption of sustainability practices, formulation of policies and pilot programs, then yes, the leaves are getting a green tinge at their edges. Some instances: data centers and hardware manufacturers have banded together to standardise the greening of their machines and facilities; device makers are talking about reducing packaging (although we have yet to see this happen); more and more low-power chips are coming to market; the Energy Star program in the US is being adopted at a rapid clip, and this is making some IT devices more efficient. Similar programs have been implemented in Europe and are under way in Asia.

In my own sector: IT standards (which make it possible for software and devices to talk to each other), I'm happy to say that OASIS has been devoting a considerable amount of effort to bringing about the Smart Grid (see chapter 7). This new power grid will be much more frugal than our current, dilapidated one, by allowing homes, buildings and factories to constantly communicate with the power generation and distribution system to only get what they need, and even sell back the power that they in turn generate from alternative energy systems, such as solar or wind power, and in future, fuel cells. This will revolutionise the power market, reduce the number of brown and blackouts, and create significant energy savings - possibly up to 25% of what we are using now. OASIS, my organisation, is involved in developing some of the key standards for the Smart Grid.

Most of the “greening” we have been seeing, however, has nothing to do with the IT industry, or the goodwill of its executives. I would even argue that IT, when it comes to sustainability, is not anywhere near the forefront. The thought leadership is coming instead from a handful of visionary entrepreneurs such as Paul Hawken, academics like Jared Diamond, forward thinkers like Thomas Friedman and regulators - yes, regulators! Europe is well ahead of Asia and the US in this regard. If you walk the streets of Paris and you see a car advertised on a billboard, you will immediately notice its carbon credit or debit in very visible letters. Not what Chrysler or GM need right now, I realise. Then again, I would challenge Dell, HP, Apple and others to tell us exactly what the carbon footprint of their gizmos is. Here’s a harmless prediction: Armageddon will come and go before we see that happen.

Some optimistic souls feel that the embryonic greening of the IT industry can serve as a model for other industries. If the previous paragraph holds true, then the answer is: not at this point. Let’s face it: as an industry, we are like the glamorous but skinny models on the cover of fashion magazines. We’re so used to being sexy that we forgot we had an eating disorder. In our case, it’s energy bulimia.

That said, the perceived greening of IT is generating much punditry and anticipation, from CIO magazine[4] to Futurity Media[5]. Why is that? The answer to that deceptively simple question is, I believe, what really lies at the heart of our debate (well at least I hope it’s a debate), and at the root of this book.

Let’s go back 200,000 years - 100 times longer than what we refer to rather chauvinistically as the Christian Era, and a mere blink in geological terms. According to anthropological data[6] all modern humans emerged in Sub-Saharan Africa around that time, as a diverse group with one remarkable characteristic: the ability to speak. Information technology was born. Using the brain as a repository, sounds became repeatable patterns, carrying predictable meanings. All other technical developments are rooted in our ability to associate symbols with sounds: the perfection of tools for hunting, the rise of agriculture, the alphabet, philosophy, science, the printing press, take your pick. A further argument can be made that all dramatic modern human expansions and population growth spurts were supported by a technical innovation. Conversely, early declines in human colonies, as far back as 80,000 years ago, seem to have arisen from an inability to deal with local conditions, perhaps via the lack of appropriate tools.

In very broad terms, first we conquered the variability of the food supply through agriculture. The rise of agriculture, mostly in the Fertile Crescent, had side effects of its own: populations grew, creating an addiction to successful crops; because of labour division, city states emerged, whose first order of the day was to enslave, draft or otherwise oppress its farmers, with the inevitable consequences of organised war, organised religion, epidemics and taxes. We recognise all the traits of our modern nations. For the most part, despite the cycles of famine and pandemics, there were never enough diebacks to halt the increase in our numbers. Even after the Black Plague, European population bounced back in very short order. And World War II, the bloodiest conflict in recorded history, was a mere blip. While we perceive the 20^{th} century as the most violent ever, in fact it was the safest, with a smaller percentage of humans dying a violent death than ever. Most deaths occurred locally from domestic conflict, starvation, accidents, illness and just plain criminality which was unimaginably rampant until the Industrial Revolution. In "Guns Germs and Steel", Jared Diamond talks eloquently about the elaborate conflict avoidance rituals that still take place in Papua New Guinea because murder there is so commonplace.

And that was the second thing we did as a species: through industry, hygiene and medicine, we suddenly made our population growth exponential and nearly unstoppable. Notions that a super-virus or global conflict will wipe us out are misinformed. What's amusing is that 19th century thinkers did not believe that we had in fact broken the bounds of nature. Because the Irish Potato Famine was so spectacular, they thought that Nature would restore population balance through the economics of starvation. This had the following British theoretical manifestation: in one natural philosopher's thinking, too many children and wages would dip so low that entire neighbourhoods would die off until there were not enough workers left to fuel the plunge, and wages would go up again, until the next cycle. That was Malthus of course, and it was as callous as it was asinine. While wages were controlled by industrialists, thereby guaranteeing the rise of Communism as a nearly physical reaction to Industry, population kept growing through the relative prosperity created by new jobs.

This has not stopped for the past two centuries. Until now. *In cauda venenum*[7].

The one clear lesson from the Neolithic is that human expansion has its cost in misery but also impacts in unpredictable ways the quality of our survival as a species. If we look around, both geographically and historically, we find plenty of cautionary tales, and we must turn to Jared Diamond again to unlock their meaning. In Collapse, he chronicles the slow death of the Polynesian society that colonised Easter Island. They started out as a vibrant culture, one that had enough resources and know-how to carve those astonishing statues, that had abundant wood and farmlands, fresh water and space - until they grew too numerous. There came a day when they chopped down their last tree. Their crops were already failing, and their numbers had dwindled dramatically. It must have been a very ominous day. A few survivors clung to the island until they too passed on. How could they not see this coming? How were they not able to evolve norms that would save them from the brink? Of course these are the superior thoughts of hindsight. I think you know where I am going with this: we're doing the same, and yet, we have tons more information at our fingertips. We have our entire IT arsenal. More on this in a little bit.

The desertification of the Fertile Crescent and the Sahara is an older but ongoing tale; and I suspect the growth of the inner Australian desert must have something to do with 40,000 years of human presence. Worse, our billions upon billions have turned the entire world into an island, albeit one floating in space.

What I'm getting at is that global warming, environmental degradation, water shortages are all symptoms of that one underlying cause: our numbers have already spun out of control.

In our defence, no one has figured out a solution. Having travelled far and wide, I find claims that certain "wise" cultures have found ways to live in harmony with their environment somewhat hollow. As for animals, they are subject to the very boom and bust laws that Malthus described, compounded by our constant encroachment and pollution.

We humans only now understand how to address the problem. The Chinese, in a rather fascistic way, have imposed the one child ruled - but this would never fly in India, for instance, which needs it far worse. The West is seeing "natural" demographic declines; and if truth be told, this is happening everywhere prosperity is taking root and women are empowered to control reproduction. The latter factor is the more important one: if women have jobs and are allowed to choose whether to get pregnant or not, they are much more likely to have fewer children. In that scenario, children are no longer a labour pool, and the relationship between children and parents turns into what we are used to in more prosperous societies.

Therefore, in one view, we could just wait for these values to spread worldwide and solve our problems - but do we have that kind of time? And can we sustain Asia's demand for the same level of luxury that we have been used to? Then again, who are we to say "no" to the newly affluent populations?

We have reached an unprecedented point in our history: a planetary maturation event. If there were some galactic classification of civilisations, we would probably count as a child species entering the end of its childhood, and the throes of adulthood. It seems the aliens are not around to tell us how to play our cards. We are left to our own devices, and we are struggling to find ways to not soil our chrysalis any further.

How does any of this relate to the greening of IT? Some argue that our salvation is in technology and therefore in our IT tools. Perhaps - in this writer's opinion, our tools have been working against us, and we need to re-appropriate them for our benefit. IT is a tool of tools, the reflection of the shift that has transformed all information into bytes. IT can assist in our green quest indirectly: by underlying biological and demographic models, for instance, and helping us make more informed decisions as a species; by creating the medium for global consciousness; by reducing the need for travel (although my perception is that it has increased said need); by helping us devise the technologies that will contribute to our survival.

Its own greening will matter less in the bigger societal picture: while it may yet prove to be exemplary, if the other contributions to this collective opus hold true, it may not turn out to be impactful in and of itself. But it will certainly provide moral solace to technologists, a great marketing story for tech companies, and it may save a few kilowatts in the process. What we need to watch for are the megawatts and raw materials it will help save indirectly.

Laurent Liscia
San Francisco, United States of America - November 2009

Laurent Liscia is the Executive Director at OASIS, provides leadership, operational oversight, and strategic vision for the consortium. He represents OASIS in the international arena, serving as an advocate for open standards in matters of policy and adoption. Laurent also develops new opportunities to extend the breadth and depth of future OASIS *work. Prior to joining OASIS, he co-founded several Web-related companies, including Traackr and Webmotion. Laurent served as a Media Attaché for French Foreign Affairs and has worked in France, Canada, Italy, Ecuador, Morocco and the United States. He holds a doctorate from the Sorbonne University and speaks English, French, Italian, and Spanish. Laurent is based in San Francisco.*

Notes

[1]sciencedirect.com - http://bit.ly/daCUIC
[2]eetimes.com - http://bit.ly/armm0q
[3]arstechnica.com - http://bit.ly/9Qojtd
[4]cio.com - http://bit.ly/cV9Bcp
[5]silicon.com - http://bit.ly/cmDykf
[6]nature.com - http://bit.ly/dmdX72
[7]In cauda venenum means 'To save the worst for last'.

CHAPTER 3

Climate Change and the Low Carbon Society

The majority of scientists today believe that climate change is caused by human-induced emission of greenhouse gases to the atmosphere. The most common greenhouse gas is carbon dioxide or CO_2, which is emitted as a result of consumption (incineration) of fossil fuels in the energy sector. All sectors of society require energy to perform their function - thus contributing to climate change.

The effects of climate change is global warming that causes melting glaciers, rising sea-levels, floods and droughts, more extreme weather events and so on. All in all the effects of climate change will make life on Earth more difficult, and it will hit the hardest in low-lying and poor areas, thus enforcing social inequity.

Climate Change and Global Warming are the effects of unsustainable consumption patterns in an industrialised world. And most people are by now convinced that we need to solve the problem, to avoid severe consequences on the environment and on our livelihoods.

3.1 Greenhouse Gases in the Atmosphere

Today, scientists are able to measure the level of CO_2 in the atmosphere 800,000 years back in time. Detailed studies show that the concentration of CO_2 in the atmosphere coincides with the appearance of ice ages. During the ice ages the concentration of CO_2 fell to around 200 ppm (parts per million), whereas in 'normal' times, the concentration of CO_2 rose to approximately 280 ppm. Therefore, scientists find it reasonable to conclude that there is a strong correlation between the temperature on Earth, and the level of greenhouse gases in the atmosphere.

Once in the atmosphere, greenhouse gases act like the walls in a greenhouse, trapping the heat from the sun inside the atmosphere, thus causing global warming. Since 1750 the content of CO_2 and other greenhouse gases in the atmosphere, has increased with the industrialisation, due to the vast consumption of fossil fuels, and today the concentration of greenhouse gases in the atmosphere now far exceeds pre-industrial levels determined from ice cores spanning many thousands of years. In fact, today the concentration of CO_2 is 37% higher than before the industrialisation. The content of CO_2 is still increasing 2 ppm per year, and in 2007 it reached 383 ppm. During the last century the concentration of CO_2 has grown 80 ppm, and at the same time global mean temperature has risen 0.74 degrees Celsius.

According to the Intergovernmental Panel on Climate Change (IPCC), most of the observed increase in global average temperatures since the mid-20th century is very likely due to the observed increase in the concentration of greenhouse gases, which can be ascribed to human induced activities.

Carbon dioxide or CO_2 is not the only greenhouse gas causing global warming. Other large sources are methane (CH_4) and nitrous oxides (NO_2) - which comes primarily from livestock and agriculture. Others yet are CFCs and HCFCs from industry. Both methane, nitrous oxides and CFCs has a much larger greenhouse effect than CO_2 - so in order to have a common understanding of the effect of different greenhouse gases we convert them all into CO_2 equivalents.

3.2 Observed Climate Changes

According to the IPCC, global warming is unequivocal. This is evident from recent observations of increases in global average air and ocean temperatures, widespread melting of snow and ice and rising global average sea level. During the last few decades a growing number of events have shown us what we have in store. The observed changes encompass everything from sea level rises during the latter half of the 20^{th} century, changes in wind patterns, affecting extra-tropical storm tracks and temperature patterns, increased temperatures of extreme hot nights, cold nights and cold days and increased risk of heat waves, the area affected by drought since the 1970s and the frequency of heavy precipitation events.

The changes that pose the most imminent danger to natural and human systems are expected to be the altered frequencies and intensities of extreme weather, together with sea level rise. Global, anthropogenic warming could in fact easily lead to some impacts that are abrupt or irreversible, depending upon the rate and magnitude of the climate change. It all depends on our ability to respond timely to the events.

3.3 Responses to Climate Change

The observed climate changes across the world forces us to initiate responses in order to avoid disaster. We react at two levels - to mitigate the problem by reducing emissions of greenhouse gases, and by adapting to the problem, by making communities more resilient to the changes occurring. Mitigation and adaptation are both vital, and the efforts should go hand in hand, thus creating co-benefits. Neither adaptation nor mitigation alone can avoid all climate change impacts; however, they can complement each other and together can significantly reduce the risks of climate change.

3.3.1 Adaptation

Adapting to climate change is necessary for all sectors of society to respond to changes already happening and to prepare for the changes that will occur in the future. As already stated, there will be a great variety in how hard different geographical areas are hit by climate changes - developing countries generally being at the centre of the worst changes. A number of actions need to be taken, to prepare societies and sectors for what is coming. New structures need to be put in place, such as new infrastructure and early-warning systems - supported by new technologies and knowhow. This again requires both technology transfer and knowledge dispersal, including education and capacity building, to empower indigenous people to help themselves and their livelihoods.

Adaptation options are many, including:

- behavioural change at the individual level, such as conserving the use of water in times of drought
- technological and engineering options, such as increased sea defences or flood-proof houses
- risk management and reduction strategies, such as early warning systems for extreme events
- promotion of adaptive management strategies
- development of financial instruments, such as insurance schemes
- promotion of ecosystem management practices, such as biodiversity conservation to reduce the impacts of climate change on people, e.g. by conserving and restoring mangroves to protect people from storms.

A country's capacity to adapt is intimately connected to social and economic development but is unevenly distributed across and within societies. The capacity to adapt is dynamic and is influenced by a society's productive base, including natural and man-made capital assets, social networks and entitlements, human capital and institutions, governance, national income, health and technology. Those may act as barriers or as drivers of adaptation measures. Even societies with high adaptive capacity remain vulnerable to climate change, variability and extremes.

Adaptation measures should be initiated alongside mitigation efforts. A wide array of adaptation options are available, but more extensive adaptation than is currently occurring is required to reduce vulnerability to climate change - especially in developing countries. This will require substantial amounts of investments - of which most will have to come from developed countries. The UNFCCC has estimated annual global costs of adapting to climate change to be US$40-170 billion per year. But a new review study from August 2009 published by the International Institute for Environment and Development (IIED) and the Grantham Institute for Climate Change at Imperial College London, says that costs may be underestimated and may be 2-3 times higher.

3.3.2 Mitigation

There is much evidence that with the current climate change mitigation policies and the related sustainable development practices, global greenhouse gas emissions will continue to grow over the next few decades. Continued greenhouse gas emissions at or above current levels will cause further warming and induce many more changes in the global climate during the 21^{st} century that will very likely be a lot worse than the ones observed during the 20^{th} century.

The urgent need to mitigate emissions of greenhouse gases is intensified by the fact that greenhouse gases stay in the atmosphere for hundreds of years. Therefore, global warming will continue for centuries due to the time scales associated with the climate processes and feedbacks, even if greenhouse gas concentrations were to be stabilised. In order to stabilise the concentration of greenhouse gases in the atmosphere, emissions would need to peak and thereafter decline. The lower the stabilisation level, the quicker this peak and decline would need to occur.

Many impacts can be reduced, delayed or avoided by mitigation - and mitigation efforts and investments initiated over the next two to three decades will determine the speed of global warming.

And it will have a large impact on opportunities to achieve lower stabilisation levels. Delayed emission reductions significantly increase the risk of more severe climate change impacts.

Technology will take us far in mitigation efforts, and will surely support stabilisation of emissions towards 2020. Stabilisation can be achieved by deployment of a portfolio of technologies that are either currently available or expected to be commercialised in coming decades, assuming appropriate and effective incentives are in place for their development, acquisition, deployment and diffusion and addressing related barriers.

Yet, no single technology can provide all of the mitigation potential in any sector. The economic mitigation potential can only be achieved when adequate policies are in place and barriers removed. A wide variety of policies and instruments are available to governments to create the incentives for mitigation action. But their applicability depends entirely on national circumstances and sectoral context.

3.4 Reduction Paths

Stabilisation of greenhouse gas emissions needs to happen as soon as possible, and the UN has set 2020 as the deadline. Developed countries have the greatest role to play in mitigation of greenhouse gases, as they have allowed vast amounts of greenhouse gases into the atmosphere during the past centuries. Meanwhile developing countries will continue their growth, and will need to increase emissions of greenhouse gases. Thus, in order to reach global stabilisation of emissions by 2020, developed countries need to reduce emissions substantially. Industrialised countries should reduce emissions by 25-40% before 2020, and developing countries should reduce emissions by 10-30% in relation to a business as usual scenario. At least that is what science tells us is necessary at a minimum.

The IPCC has also suggested that we should work hard to keep temperature rises below 2 degrees Celsius, in order to avoid severe and dangerous damages to ecosystems and livelihoods. Keeping the 2 degrees target, means stabilising the level of greenhouse gases in the atmosphere at maximum 450 ppm (parts per million) - however, that gives us just 50% chance to steer away from devastating changes.

These reduction scenarios are going to demand huge amounts of investments. Therefore, we are going to need as much flexibility and cost-effectiveness as we can get, when reducing emissions. All sectors have to contribute, and we need to find the cheapest and best solutions for emission reductions. A low stabilisation level will require early investments and substantially faster diffusion and commercialisation of advanced low-emissions technologies. Without substantial investment flows and effective technology transfer, it may be difficult to achieve emission reduction at a significant scale. Thus, mobilising financing of incremental costs of low-carbon technologies is essential.

McKinsey estimated earlier in January 2009 that the world can keep global warming in check if nations spend at least US$263 billion a year by 2030. A study from Economics for Equity and the Environment from October 2009 states that immediate effort to rebuild the world economy around carbon-free technologies are in the range of one to three percent of global GDP per year.

3.5 The Low Carbon Society and Information Technologies

Stabilising greenhouse gas emissions requires the transformation of patterns and practices of society into a low-carbon society. Hence, the low-carbon society is a solution to climate change. It is the solution that allows societies to develop and thrive based on sustainable and resource efficient principles, without negatively impacting the environment or causing further climate changes.

In the low-carbon society, industrial processes have been optimised, energy production has been turned green (based on renewable energy) and consumption in general has been transformed to a more sustainable path. The low-carbon society is characterised by low consumption of fossil fuels - thus keeping greenhouse gas emissions from sectors at a low level. The low-carbon society is the first step to the zero-carbon society - where production and consumption is purely based on renewable energy sources. Reaching the low-carbon society is a matter of changing production and consumption of energy to a more sustainable path. It is about changing the energy system away from fossil fuels to renewable energy sources as well as a matter of making energy use more efficient and saving energy in general. Changing the energy sector is vital to support green growth, cleaner development and creating new consumption patterns, as changing the energy production system will enable feed-back to all other sectors of the economy that consumes energy - by feeding them with sustainable energy.

The low-carbon society is about integrating all aspects of the economy, from its manufacturing, agriculture, transportation and power-generation etc. around technologies that produce energy and materials with little greenhouse gas emission - thereby forcing change in populations, buildings, machines and devices, which use those energies and materials.

Low-carbon societies are not emission free, as there will still be a minimum of emissions for instance from livestock and food production that is based on nature and living animals - and therefore can never be completely free of emissions.

The change to a low-carbon and resource efficient economy is not going to be easy. There are no readily available one-step solutions or obvious choices that will take us there. Yet, IT plays an important role in the transformation stages due to its potential to further optimise processes and routines. Also, the IT sector will play a major role both in wider dispersal and use of renewable sources and in energy efficiency

- and for this reason greening IT will be a solid base for the low-carbon society.

3.6 Climate change and the IT sector

Today, Western economies are largely characterised by being service-based economies, sustained by Information Technologies (IT). Our economies evolve around IT. Our public sector is based on it, the financial sector is based on it, the energy sector, the transport system, the education system, the health system etc. - all are largely dependent on Information Technology. Our societies developed this way, because IT was able to make daily routines easier, quicker and more efficient. IT has optimised a number of processes and has helped societies progress.

In terms of climate change IT is part of the problem, but more importantly it is part of the solution. The IT sector is part of the problem due to its massive consumption of energy in the form of electric power. The sector creates a huge demand for stable and cheap energy, which feeds the unsustainable worldwide dependence on fossil fuels. On a global level IT is responsible for 2% of emission of greenhouse gases. However, the remaining 98% is seen as opportunity for IT to help solve the problem. Let us make this clear: The IT sector itself, responsible for 2% of global greenhouse gas emissions, can get greener, by focusing on energy efficiency and better technologies (we call this Green IT, see below). Yet, IT also has the potential to reduce emissions from other sectors of our economy - by optimising resource use and saving energy etc. (we call this the process of Greening IT, see below). IT can provide the technological fixes we need to reduce a large amount of greenhouse gas emissions from other sectors of society and obtain a rapid stabilisation of global greenhouse gas emissions. There is probably no other sector where the opportunities through the services provided holds such a reduction potential as for the IT industry.

3.7 Defining Green IT

The concept of Green IT consists of two main building blocks - 'green' and 'information technology'.

Information Technology refers to computer-based information systems, particularly software applications and computer hardware. Information Technology is seen as the application of computer, communications and software technology to the management, processing and dissemination of information.

The 'green' in Green IT refers to the environmentally sustainable application of Information Technologies. In our context 'green' is to be understood in relation to the environmental problem of climate change and emission of greenhouse gases. Green IT describes a situation where Information Technologies support reductions of greenhouse gas emissions - directly, indirectly or in a systemic way (see below).

Traditionally, discussions on Green IT have been focusing on how to make the technology itself greener, e.g. reducing energy consumption. However, this book mainly deals with the process of Greening IT, which is about using technology to green society. Greening IT is of course based on the application of Green IT, but Greening IT does not stop with the application of the technology - it is a wider process that disperses and transform our entire society.

The definition of Green IT is thus rather broad - as it can be applied to situations where IT enables greenhouse gas emission reductions (Green IT) and to situations where IT enables structural changes that lead to changes in broader societal patterns, which takes us closer to the low-carbon society and leads to further emission reductions (Greening IT).

In this sense we use Greening IT to explain the process of 'Greening it with IT', it being society.

3.8 Direct, Indirect and Systemic Effects

In their 'Outline for the First Global IT Strategy for CO_2 reductions' (Pamlin and Pahlman, 2008), the WWF divides the impacts of IT solutions into 'direct', 'indirect' and 'systemic' or 'societal' effects to allow for a better understanding of the impacts, ranging from:

1. Direct impacts from the IT product itself
2. The immediate impact on the surroundings (indirect effects) due to an IT product's use, and the
3. Socio-economic/structural (systemic) changes that potential use could result in.

The direct effects relate to the IT infrastructure and equipment itself and the resource consumption in terms of materials and energy related to the production, use and waste disposal of the products. The direct effects thus include emissions deriving from the entire value chain of the products, from cradle to grave. Greenhouse gas emissions from direct effects are easy to measure, and are the least important.

Indirect effects relate to the service provided by the IT product. This includes anything from the substitution effects to the supporting infrastructure. A good example is the use of video-conferencing instead of flying - where the infrastructure supporting the video conference is less than the infrastructure to support the flight, such as an airport etc. The emissions derive from the use and habits through communication-based applications, which can be both positive and negative - and are more complicated to measure.

Systemic effects relate to technological and institutional structures. These effects stem from new habits, social structures and consumption patterns that arise from IT products, applications and services when they are used in society. Changes in institutional structures provide feedback that is dynamic, which means that the system can provide low-carbon or high-carbon feedback. Low-carbon feedback means that it enables further reductions of CO_2 emissions, whereas high-carbon feedback supports increases in CO_2 emissions. It is important to explore whether these effects are positive or negative, even though it is not possible to know the effects precisely. Systemic effects are the most significant, but are also most difficult to measure.

If systemic effects over time are ignored - solutions that might seem as important could turn out to be counterproductive. For example, a good product which is delivering direct CO_2 reductions may contribute to a system that result in high-carbon feedback and lead to unsustainable development in society. Also, a service that might not provide much direct or indirect effect in terms of CO_2 reductions right now may still result in a significant low-carbon feedback when looking at the systemic effects on the same product.

The point here is that a product or service affects its surroundings when applied or used, and in some cases the impacts are significant over a longer term perspective, or can encourage further reductions. Some changes will trigger further use of low-carbon solutions, which will lead to further CO_2 reductions and thus create a low-carbon feedback. Other changes will result in a situation where emissions will increase or lock us into an infrastructure dependent on fossil fuels, thus creating a high-carbon feedback.

What we need are IT solutions that provide low carbon feedback and avoid solutions that only contribute to short-term reductions and to unsustainable investments that make larger and necessary reductions more difficult. We are interested in IT solutions that have a positive effect on CO_2-emissions. Yet, the solutions should not only contribute to solve the problem, but should also help 'fix' the cause of the problem of climate change. We need solutions that solve the problem in a longer time perspective, thus tackling the general flaws in consumption patterns that will continue to cause problems, if not attended to; thereby supporting our purpose to progress on the way to a Low-Carbon Society.

Irene Sobotta
Copenhagen, Denmark - November 2009

Irene is one of the founding editors of the book. She has a masters degree in Environmental and Social-Economic Planning and has been working as a Climate Change Adviser since 2007, during which she has followed the UN climate change negotiations. Irene has vast experience in strategic environmental planning, impact assessment and environmental technologies, such as renewable energy tecnologies. Irene is both professionally and personally committed to raising awareness and finding solutions to Climate Change. Irene is the treasurer of The Greening IT Initiative (A non-profit organisation dedicated to increasing awareness of the power of IT to reduce greenhouse gas emissions), and her core contribution to the book is within the field of environment and politics, looking into what is needed to facilitate societal change.

CHAPTER 4

Why Green IT Is Hard - An Economic Perspective

According to the common view, Green IT comes down to implementing technical measures. The idea is that, given better power management of equipment in the workspace (such as laptops and PC's), more efficient power usage of servers, storage and network components, virtualization of servers, better power and cooling management in data centers, the problems can be solved. But is this really true? The reason IT is not green at this moment is at least as much due to perverse incentives. Green IT is about power and money, about raising barriers to trade, segmenting markets and differentiating products. Many of the problems can be explained more clearly and convincingly using the language of economics: asymmetric information, moral hazard, switching and transaction costs and innovation. Green IT is not a technical problem, but an economical problem to be solved.

4.1 Setting the Stage

Business demands drive the growth of data centers and server energy usage. As organisations increase their offerings of digital services, the demand for computing and storage capability increases. Some examples of growing digital services are online banking, e-commerce, e-ticketing, music and video downloads. The need for faster, more complex data processing is becoming widespread; for instance financial services, film industry, and retailers to real-time inventory and supply chain management (see chapter 14). Additional demand for computing capability can only be met by increasing the processing capacity of servers within data centers. Along with greater computing capability, businesses have increased demand for storing digital data, both in terms of amount and duration due to new and existing applications and to regulations. New applications, like healthcare's use of electronic medical records require electronic storage, and existing applications like the growing needs of telecom databases, require more capacity.

To give an example where this growing computing capacity leads to - An estimate of the growth of servers in the world, by Stanford University, over the period 2000 to 2005, gives a rise in server numbers from about 14 million to approximately 27 million. In order to be able to retrieve and transport the corresponding exponentially rising amount of data, the data transfers both in the (wired) Internet and wireless networks (including cellular, WLAN and WPAN) have been rising at the same speed. The driving technology force that makes these two developments possible was, and continues to be, Moore's Law, according to which both the processing power of CPUs and the capacity of mass storage devices doubles approximately every 18 months.

The amount of electricity used to power servers in the world's data centers doubled in a five-year span (2000 to 2005) mainly due to an increase in demand for Internet services, such as music and video downloads, and telephony. Representing an aggregate annual growth rate of 14% per year for the U.S. and 16% per year for the world (Koomey, 2007). Almost all of this growth is attributable to growth in the number of servers.

As of 2006, the electricity usage attributable to servers and data centers in the United States was estimated at about 61 billion kilowatt hours (kWh) according to a 'Report to Congress on Server and Data Center Energy Efficiency'. It is similar to the amount of electricity used by the entire U.S. transportation manufacturing industry (which includes the manufacture of automobiles, aircraft, trucks, and ships). The total energy draw of data centers has grown. Using this amount of energy leaves a huge carbon footprint. According to KPMG, the total global ICT industry is responsible for approximately two percent of worldwide carbon emissions, equivalent to the emissions from the airline industry.

4.1.1 Drive Towards Energy Efficient Data Centers?

Is there a need to do something about these rising energy needs of data centers?

- *Increased energy costs for organisations;* The current volatility in the cost of energy and resultant exposure to rising energy costs may lead many organisations to reconsider the energy efficiency around the use of technology.
- *Increased strain on the existing power grid;* In some parts of the world the current power grid cannot support the anticipated growth in IT related power consumption. The term *Critical Areas for Transmission Congestion* is used to describe areas of the power grid that have insufficient capacity. The greatest concern about the power grid today is with the transmission system (see chapter 7).
- *Increased capital costs for expansion and construction of data centers;* Data centers typically account for 25 percent of total corporate IT budgets when the costs of facilities, storage devices, server, and staffing are included. High volumes, stringent service-level demands, ever-higher application availability requirements and expected environmental requirements must be accommodated. Keeping control of costs when constructing a new data center or retrofitting an existing facility can be an endeavour.

- *Regulations, standards and compliance;* Presently there is limited legislation and regulation around power consumption and carbon-emissions. But regulations about consumption and emissions move closer toward becoming a reality. As time passes and energy and carbon emission monitoring is determined, formalised and enforced, regular reporting may be expected.
- *Corporate reputation;* Because of the discussion about climate change, organisations are increasingly judged on their sustainability behaviour. Organisations are becoming more conscious of the perception of their reputation by internal and external stakeholders.

You could say there are technical, financial, legislative, compliance, and moral triggers to act and cut down energy usage. But are data center operators taking action to measure coming energy and carbon-emission regulations? In several reports and presentations contrary observations are made. For example, according to Christian Belady at the DatacenterDynamics conference in Seattle 2009, 17 percent of data centers in the U.S. track carbon emission. On the energy-efficiency side, Power Usage Effectiveness (PUE) is one of the most commonly used metrics, and formulae for its calculation and other metrics are also widely available, but also according to Belady only 15 percent of data centers do such measurements.

If we maintain the current modus operandi, "energy consumption by servers and data centers could nearly double again in another five years" in comparison with the year 2006 (Program, 2007). There are many drivers to act on this enormous energy consumption growth and those drivers are not new. Also there are many technical solutions to improve energy efficiency. So what's missing here, why is IT not so much greener than it is today? And isn't Green IT a requirement for using information technology as a green technology, Greening IT, that can transform our societies into low-carbon equivalents?

According to the common view, implementing Green IT, and thereby lowering energy costs, comes down to just implementing technical measures. The idea is that, given better power management of equipment in the workspace (such as laptops and PC's), more efficient power usage of servers, storage and network components, virtualization of servers, better power and cooling management in data centers, energy issues can be handled. But is this really true? It looks as if various factors prevent energy consumers from taking actions that would be in their private self-interest to do so, that is, would result in the provision of services at lower cost because of diminished energy costs. Is one of the main reasons that IT is not green at this moment at least as much due to perverse incentives? Shouldn't we incorporate economic-behavioural analysis to Green IT to explain this current failure better?

4.2 IT at Work, The Risk of Incoherency

Data centers take several years to be designed and build, and are expected to last at least 10 years. Therefore capacity and technical criteria must be estimated well before the actual needs of business are known and the technology used.

The quickly changing IT infrastructure is a big issue for improving energy efficiency in data centers. Business demands have led to constant replacement of IT infrastructure because of increasing processing power needs. This pace of replacement of IT infrastructure is not in sync with the changes of the site infrastructure. The components of power, cooling, air handling last a longer time (10 years) than IT infrastructure (two to five years). The site infrastructure often ends up being mismatched with the cooling requirements of the IT infrastructure. Applying site infrastructure solutions depends on whether installation occurs as part of a new facility or as part of a retrofit of an existing operational and running data center. In new data centers energy cost savings create the incentive to use more expensive solutions that are highly energy efficient. While technically feasible, using these kind of solutions in current operational data centers may not always make sense. For some data centers, the cost savings from energy consumption may not justify the cost for renewing the site infrastructure. For other data centers, the criticality of their function to the business just prohibits downtime and inhibits facility managers from making major overhauls to realise energy-efficiency improvements. This makes it difficult to continually optimise data centers in such a rapidly changing environment.

The software and the equipment for the IT and site infrastructure is delivered by a complex distribution system of Original Equipment Manufactures (OEM), Resellers, Value Added Resellers (VAR), System Integrators, etc. All these parties, with conflicting commercial interests, are in some way involved in the decisions about energy efficient solutions. This conflict of interest can bring a coherent overall energy efficient solution in jeopardy if not properly managed.

In the short-term there is also the difficulty of determining whether a certain percentage increase in customer demands relates to an increase of IT infrastructure capacity. Therefore as an assurance, frequently an excess of devices are purchased to guarantee capacity in extreme IT load scenarios. Energy is not a concern in these decisions. Typically the IT department is unaware of the energy use since someone else pays the energy bill. Also their primary concern and focus is to ensure that the IT infrastructure runs, not that the IT infrastructure is energy efficient. The consequence is increased energy usage from the IT infrastructure. The data center is a large drawer of power. Nowadays the server hardware is no longer the primary cost component of a data center. The purchase price of a new (1U) server has been exceeded by the capital cost of power and cooling infrastructure to support that server and will soon be exceeded by the lifetime energy costs alone for that server (Program, 2007).

At the current time there is mostly a qualitative knowledge and appreciation of energy usage of data centers, although there are some rough quantitative estimates. There is a problem with collecting data on energy consumption of the individual IT and site infrastructure components. Energy Monitoring systems that measure and report about energy consumption are, in most data centers, not in place. This is also one of the reasons that energy metrics like PUE are so poorly used. Quantitative facts and figures are necessary for a business process improvement, such as the well known Deming cycle, plan-do-check-act (PDCA).

Business and managerial responsibility for information needs fall to general business management who have little insight into the cost and implications of their demands on IT infrastructure capacity. Technical and managerial responsibility for IT infrastructure fall to the IT department who have little insight into the cost and implications of their demands on real estate and the energy consumption of the installed IT infrastructure. Financial and managerial responsibility for facilities often fall to the real-estate managers or department who have little insight into how IT infrastructure demands are related to them and how IT relates to core business issues. Attention to data center energy use is often motivated by electricity supply, cooling, and building space constraints than by electricity costs.

Responsibility of using a data center effectively and efficiently falls across projects, IT departments, business departments, corporate real-estate and last but not least (depending on the sourcing model being used) other IT organisations. Performance measurement will effect the various competitive and conflicting interests of the stakeholders who are involved with a data center; any definition of energy efficiency will benefit some and disadvantage others.

With siloed decision making, the measurement and accountability issues and the absence of true energy usage and cost analysis, energy inefficiency becomes the rule.

4.2.1 The IT Development Perspective

Many organisations are accustomed to an informal method of making project investment decisions, which looks more like a political process. Many times the (virtual) project portfolio of the organisation is a loosely coupled bundle of projects without high cohesion. Relationship or interdependencies with other projects in the portfolio are weakly managed. This approach of making project investment decisions has led many organisations to unsatisfactory results. Each project goes for its own merits and success. On top of this, within these projects more or less the same process, an informal method of decision making, is repeating again. Individuals and groups within the project go for their own merits and success. There are documents and designs but many design decisions are made in 'splendid isolation'. Is the design rationale behind these documents and designs coherent? Application developers often don't think beforehand of fine tuning their work to use the smallest amount of IT infrastructure, or of creating design applications that can be shared across IT infrastructure. This results in unnecessarily storing multiple copies of data at several locations. Network, Server, Storage and DC facility teams often don't make an integrated architecture and design at the beginning of a project but more or less integrate their own designs later on in the project. Purchasers buying IT infrastructure may select those with the lowest prices or those with which they are familiar with, or where there are contractual obligations. Project managers often make their technical decisions based on the devil's triangle (cost, time, quality) of project management to meet the project deadline. With the risk that this basic set of orthogonal relationships pushes the projects to a suboptimal solution.

This way of working leads to a suboptimal mix and sequencing of projects to best achieve the organisation's strategy and business goals and a proper use of assets. Multiplied across an organisation, these kind of decisions result in costly implementations increasing energy usage and carbon emissions. Because of this stovepipe approach of projects in many instances, only a single software application runs on a server, which can result in utilisation rates below the 10 percent level. The site infrastructure (power, cooling, etc.) and real estate are not very flexible. Data center site design and location choices set the stage and the constraints of the energy usage, and for the IT load to be handled in the data center. A proper integrated architecture and design is needed to correct unnecessary redundancy and inappropriate use of infrastructure. This approach reduces not only the capital expenditure on server, network and storage systems but also the energy needed to run them.

The Engineering issue is how to get to fact-based discussions:

1. Implicit in data center *Availability* means increase the chance of over-engineering ...
   This leads to Excessive Capital & Operational Waste.
2. Implicit in data center *Usage* means increased chance of improper utilisation of assets ...
   This leads to Excessive Capital & Operational Waste.
3. Implicit in data center *Capacity Management* means increased chance of over-engineering ...
   This leads to Excessive Capital & Operational Waste.
4. Implicit in data center *Energy efficiency* means increased chance of energy waste ...
   This leads to Operational energy waste and energy issues for the long term.
5. Implicit in data center *Energy usage* means increased chance of interoperability, portability problems between IT infrastructure and Site infrastructure components ...
   This leads to lock-ins and Capital & Operational Waste in projects and IT delivery.

4.3 Energy at Work, The Risk of Inflexibility

The electrical power infrastructure that delivers energy to the data centers is composed of several service blocks: power generation, power transmission and power distribution (Figure 4.1). After the electrical energy is generated by means of coal, oil, gas, etc., it has to be transported to the consumer by means of a power grid (transmission network). Here a high voltage is used to reduce energy loss when transporting over large distances. In the vicinity of the consumer the electrical power is reduced from a high range to a mid range (for large energy consumers) and eventually to a low range (for small energy consumers) voltage by means of transformers and brought to the customer with a distribution network. A very specific element of an electrical power infrastructure is that there is no storage. Therefore demand and supply must be the same, in equilibrium, else there is the risk that this infrastructure shuts down. A controlling agency must coordinate the dispatch of generating units of electricity to meet the expected demand of the system across the power grid. If there is a mismatch between supply and demand the generators speed up or slow down or the controlling agency will demand to add or remove either generation or load. The laws of physics determine how electricity flows through a power grid. Loss in transmission and the level of congestion on any particular part of the grid will influence the economic dispatch of the generated units of electricity.

In this supply chain there are several actors. Organisations that generate power at a large scale and at a low scale, transmission network organisations, organisations for distributing power (physical distribution) and companies that sell electricity to customers (functional distribution). Because of the specific properties of electrical power infrastructure, mid and short term capacity management must be coordinated between all these organisations. Another element to be aware of is that upfront investments in this long term power infrastructure are huge and customer needs in the future are at best unclear and uncertain. The energy market, for large energy consumers, with the specific technical constraints and the number of stakeholders with different interests is not very flexible.

We may take electrical power supply to the data center for granted, but these data centers are part of the complex electrical power value chain where the power transmission networks can be a bottle neck. The power grid can be thought of as a highway system: in most places and at most times, traffic flows smoothly, but at certain critical locations, also known as Critical Areas for Transmission Congestion, there is insufficient capacity to meet the demand at peak periods (DOE, 2006). This rises concerns about data centers at these locations in the short term. Also for the long term, certainly for the mid and large scale data centers, there are concerns. Given the steep rise in energy consumption of data centers and the inelasticity of the electrical power infrastructure in terms of technical-infrastructural and capacity management, location strategy is of utmost importance.

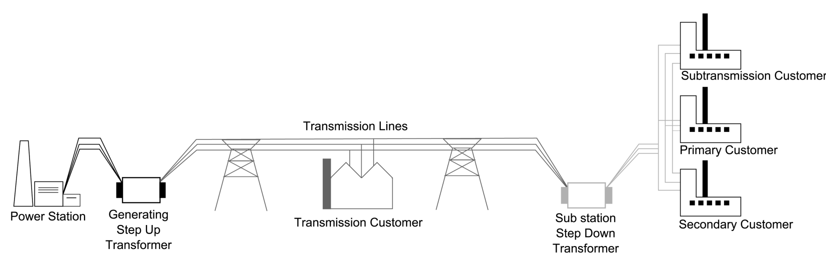


Figure 4.1: The Electrical Power Infrastructure

4.4 The Service Stack, the Risk of Incoherency and Interdependency

It is not only the way people are working, but also how things are working, at the current moment, that influence the usage of energy.

4.4.1 The IT Perspective

IT infrastructure is basically a *value stack*. A supply chain of stack elements who acts as a service component (People, Process and IT that adds up to an IT service). Although IT infrastructure delivers no direct business value, much of the business value is created in business processes that depend upon a solid and stable IT infrastructure. With an IT infrastructure in place, you can run applications, but they can't deliver any value without the physical IT infrastructure of server, storage and network components. These stack elements (business processes, workspace, applications and infrastructure) are all interdependent, and, of course, any one of them can be further decomposed.

As technology matures, the things in the lower levels tend to become compressed, standardised, and because of commoditisation become irrelevant to most of us. This development enables IT organisations to shift their focus and attention to the next higher element or layer of the IT service stack and to resource elements of the service stack. With XaaS (X as a Service, where X stands for Infrastructure, Platform or Software), we are seeing things from the stack move out of the closed proprietary world and into the open and external world. This also gives a shift in focus from supply management to demand management.

Zooming in and looking closer to this value stack or supply chain we see not only the expected functional interdependency, but also several hard, unwanted, dependencies between the stack elements from a technical, procedural and organisational perspective. Examples from a technical perspective are dependencies between hardware and operating system, operating system and application software, client software and server software. Choices in aggregation of IT services in this stack, sourcing choices, creates and sometimes dissolves all kinds of procedural, organisational and commercial dependencies between involved parties. Examples are (in)consistencies between Service Level Agreements (SLA) and contracts for the different stack elements. This makes substitution or replacement of service stack elements with better alternatives difficult because of high transformation costs either in terms of money or effort.

For each element in the stack, the IT organisation has to ensure quality as agreed on. In essence these quality attributes are performance,

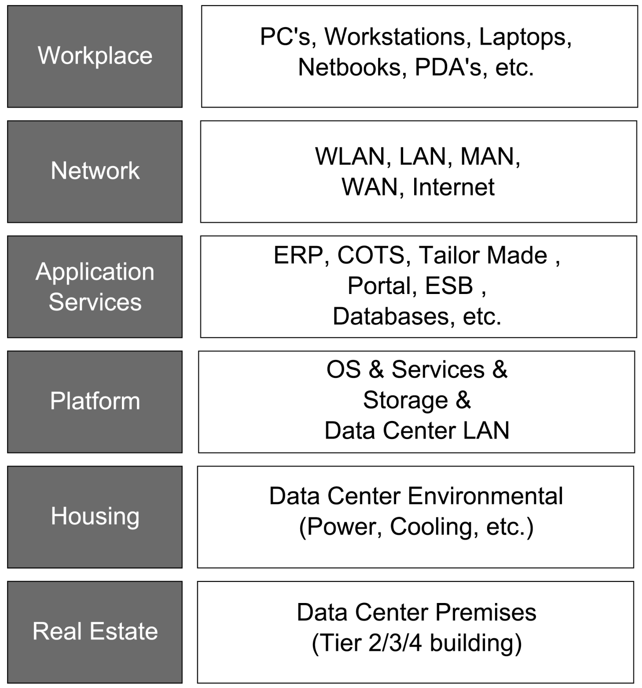


Figure 4.2: An example of an IT service stack

availability, confidentiality and integrity. One of the most significant challenges for the IT organisation was and is to coherently manage these quality attributes for the complete service stack or supply chain. Green as a quality attribute is a new kid on the block. This 'Housing' or site infrastructure attribute is composed of the power, cooling and floor space sub attributes. These attributes are not independent of each other. To paraphrase Greg Schulz, author of 'The Green and Virtual Data Center' (Schulz, 2009): *"For a given data center these site infrastructure resources are constrained therefore, together, these attributes form a certain threshold. If the demand for IT capacity reaches this threshold, further growth of the IT load is inhibited because of technical (over heating, not enough power) and or financial (excessive capital investment) reasons. In that case IT services are constrained and therefore business growth inhibited, which causes economic penalties and lost opportunities"*, see also Figure 4.3.

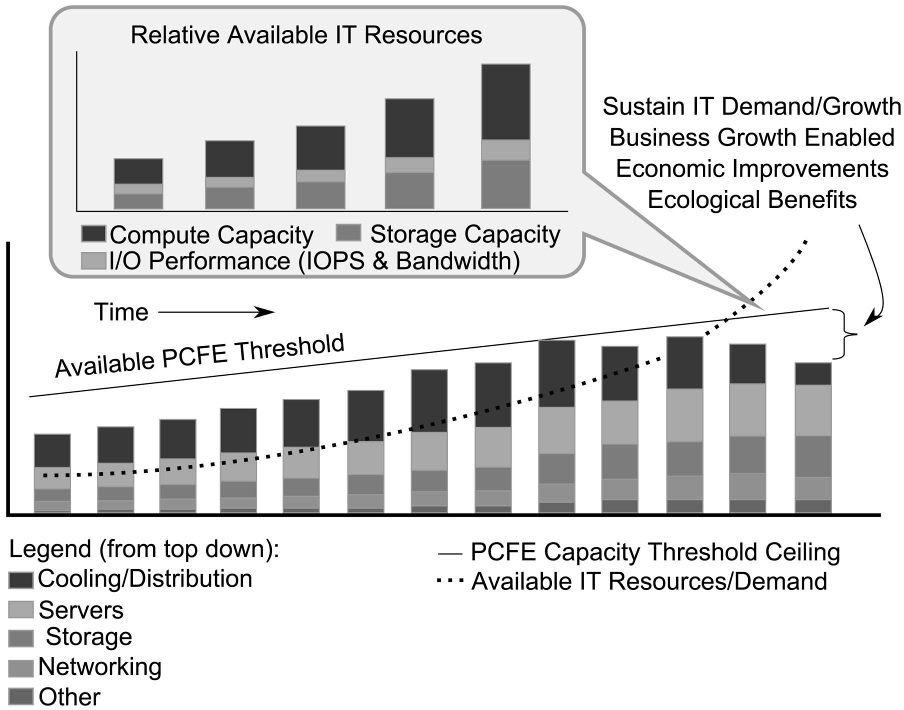


Figure 4.3: Site Infrastructure as Inhibitor - Greg Schulz (2009) The Green and Virtual Data Center. CRC/Taylor and Francis. Used with permission.

High density computing is being driven by the need to maximise the use of valuable data center floor space. This concentrated computing power causes concentrated heat generation, and data centers must ensure adequate localised cooling capacity to match non-uniformly distributed heat loads. The power and cooling capacity and resources of a data center are already largely set by the original MEP (Mechanical Electrical Plumbing) design and data center location choice. Limited rack power based on power consumption of high density computing results in lower rack utilisation. However, this is partly resolved with increasing computing power per server. Therefore it is sometimes also possible to prolong the life cycle of space-constrained data centers. Another effect of high density computing and high density storage is the intensifying level of network traffic within the data center and by this, the necessity for using high traffic volume network components. Avoiding energy usage by turning off devices when they are not needed, by proper and intelligent power management, should be mandatory in the workspace. On the other hand, turning off servers and associated storage systems (sometimes used as a shared service) in a data center that is committed to service-level agreements is a different story. This can put a burden on the IT organisation by making work processes difficult and complex.

The IT Service Stack is a highly complex system with many interdependencies between the stack elements on a technical, procedural, organisational and commercial level. It is difficult to define and realise energy efficiency for such a complex system.

4.4.2 The Energy Perspective

Once electricity is supplied to a data center, various devices consume the electrical power. A data center has, from a power perspective, a supply chain that consists of four large building blocks: the IT infrastructure (servers, storage and network), the primary power supply (UPS, PDU, etc.), the secondary support supply (cooling, generator, air handling) and the tertiary support supply (lighting, office space). Virtually all power consumed by the IT infrastructure is converted to heat. Typically about thirty to fifty percent of total power usage in a data center is derived from the IT infrastructure while the other percentage is for cooling, power distribution, lighting, etc.

In the past when data centers mainly housed large mainframe computers, power and cooling design criteria were based on the assumption that power and cooling requirements were uniform across the entire data center. In reality organisations have populated data centers with a heterogeneous mix of hardware as they try to extend the life of their existing space and/or because of changing contractual obligations (change of vendor) and/or specific hardware demands from applications. The introduction of high-density hardware (Moore's Law[1]) in the data center even put more pressure on the energy demand. It requires enormous amounts of electricity and produces previously unimaginable amounts of heat. The average data center power consumption has grown from 2.1 kilowatts per rack in 1992 to 14 kilowatts per rack in 2006, according to HP. Peak power usage for data centers can range to tens of megawatts for the largest data centers.

Data centers require special power handling to smooth out and transform the power input into something that the IT equipment can safely consume. Power drawn from the switch gear passes through an Uninterruptible Power Supply (UPS) that acts as a large battery. The smoothed power travels through a Power Distribution Unit (PDU) that transforms the power input to the right phase and voltage, and then delivers it to the IT equipment. Within the IT equipment, internal power supplies transform the power down to those used at the electronic component level. As power is treated and transformed, some of it is wasted due to inefficiencies. To ensure proper operations and prevent system failures, this heat must be removed by the same amount of cooling, which consumes even more energy.

To improve the energy efficiency of existing data centers, as well as making decisions on new data centers there are some metrics (Belady et al., 2008) being used : Power Usage Effectiveness (PUE), Data Center Infrastructure Efficiency (DCIE) and Data Center Productivity (DCP). Ideally, these metrics and processes will help determine whether the existing data center can be optimised before a new data center is needed.

The overall design of electrical power, cooling, air handling etc. is called the MEP (Mechanical Electrical Plumbing). MEP designs and forms the foundation and defines a large part of the constraints on the IT load a data center can handle. Also the location choice of the data center power influences consumption (losses) by the IT load because of Outdoor Temperature & Humidity conditions. Thus some data centers will do better if they are located in a cool-dry climate and use free-

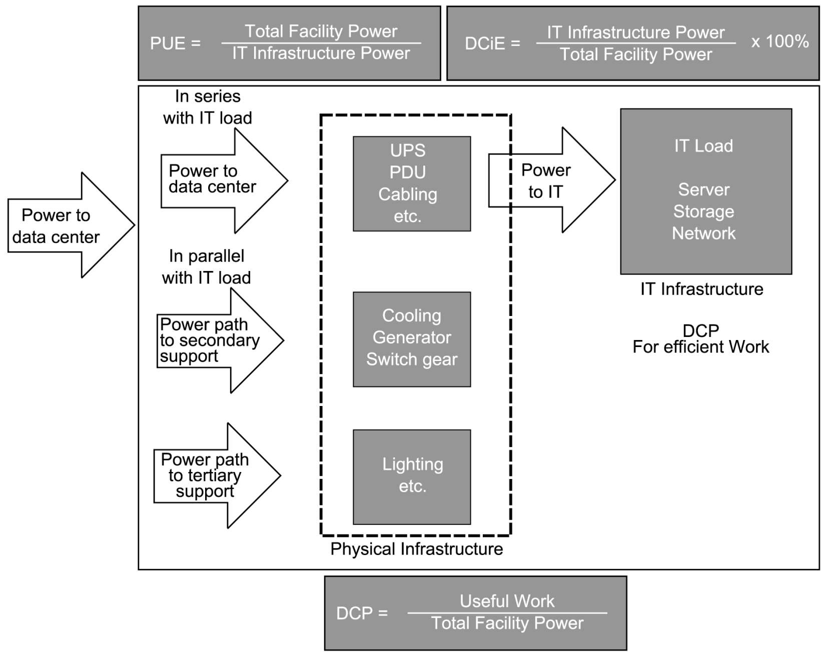


Figure 4.4: The electrical power infrastructure of a data center

cooling.

4.4.3 Anti-Patterns

The aforementioned reality shows that the old design and engineering wisdom of loose coupling and high cohesion, the attention for interoperability, portability, are not always very visible to put it mildly. Here, there are still several classical anti-patterns at work (Brown et al., 1998):

1. *Stovepipe Enterprise*: "Multiple systems within an enterprise are designed independently at every level. Lack of commonality inhibits interoperability between systems, prevents reuse, and drives up costs; in addition, reinvented system architecture and services lack quality structure supporting adaptability".
2. *Stovepipe Systems*: "The Stovepipe System anti-pattern is the single-system analogy of Stovepipe Enterprise, an assemblage of

interrelated elements that are so tightly bound together that the individual elements cannot be differentiated, upgraded or refactored".

3. *Vendor Lock In*: "A project adopts a product technology and becomes completely dependent upon the vendor's implementation. When upgrades are done, software changes and interoperability problems occur. Furthermore continuous maintenance is required to keep the system running."
4. *Design By Committee*: "A complex design is the product of a committee process. It has so many features and variations that it is infeasible for any group of developers to realise the specifications in a reasonable time frame. Even if the designs were possible, it would not be possible to test the full design due to excessive complexity, ambiguities, over constraint, and other specification defects. The design would lack conceptual clarity because so many people contributed to it and extended it during its creation."
5. *Wolf Ticket*: "A Wolf Ticket is a product that claims openness and conformance to standards that has no enforceable meaning. The products are delivered with proprietary interfaces that may vary significantly from the published standard. A key problem is that technology consumers often assume that openness comes with some benefits. In reality, standards are more important to technology suppliers for brand recognition than for any benefits that the standards may offer users"
6. *Dependency Hell*: "unwanted dependencies between components and or specific versions of components."

Maybe a subtle statement could be made that the quality attributes have an orthogonal relationship, so to make an 'optimal' solution, priorities should be clear and shared between all stakeholders to make consistent and coherent decisions. A difficult and complex job to say the least.

4.5 The Gap, Barriers to Energy Efficiency

The facts, figures and observations about the growing data footprint and data exchange, the rising power usage of hardware per square meter, the growing demand for electricity by data centers, and the increasing energy costs show that there is a gap between the economic demands and the environmental awareness about the strained energy (electric power) infrastructure, energy usage, carbon emissions and climate change and thereby the level of social and environmental welfare. There is a disconnection between the environmental sustainability and the economical sustainability. To put it another way, there is a disconnection between the site infrastructure footprint (power, cooling and floor space) and related costs, the supply constraints, and the need to sustain business growth, the demand drivers.

There is a lot of discussion about Green IT, but the facts show differently. This kind of behaviour even got a name 'green washing', painting a message green to appeal to environmental awareness. While businesses generally in essence want to earn money by delivering products and services and don't want to a priori deliberately harm the environment, the reality is that it is hard cold economics that dictate how business operate. This is the reason of the gap between demand and supply. The observed Energy Gap is certainly not a technical thing but it is (mostly) about how IT works. In addressing this gap the solution must be found in and emphasis should be placed on economics.

4.6 Which Energy Efficiency Are We Talking About?

When we are talking about Green IT, energy efficiency and optimal usage of energy, what do we mean exactly by 'efficiency' and 'optimal'? What is the perception and what are the goals that go behind this terminology? Some terms are being used as synonyms although they have a specific meaning and putting a different emphasise on energy usage (Office, 2001):

1. *Energy savings;* emphasise on (absolute) reducing energy consumption because of the need to reduce consumption of primary energy resources (oil and gas) caused by the Oil Crisis.
2. *Energy conservation;* emphasise on (absolute) reducing energy consumption because of the need to reduce consumption of primary energy resources (oil and gas) because they were regarded as in danger of exhaustion.
3. *Energy efficiency;* emphasise on becoming increasingly efficient in the usage of energy whilst economic growth can cause continuing use of more energy.
4. *Energy productivity;* emphasise on sustainable development because of the scarcity of energy resources and the interest and concern related to climate change and carbon dioxide emissions.

The effect that increases in energy efficiency raise energy consumption is known as the Khazzoom-Brookes Postulate. As stated by the economist Saunders (1992), this is explained by the micro level increases in energy efficiency leading to lower costs of energy, and on the macro level side increases in energy efficiency leads to increased economic growth. The Khazzoom-Brookes Postulate is a special case of what in economics is called the Jevons paradox, increases in the efficiency of using a resource tends to increase the usage of that resource.

It appears that Green IT is more about sustainability, then energy productivity, and finally energy efficiency. Yet, Green IT and energy efficiency are more commonly used and accepted as the goal, since it is about how to reduce energy use without loss of economic performance. Considering the Climate change issue, the goal of economic performance instead of economic sustainability looks rather short sighted.

The gap that exists between actual and optimal energy usage raises the question of how to define the optimal level of energy efficiency. To answer this question we can look at a micro, meso and macro level of this issue; or to put it another way, on the level of a firm or organisation, the market and society. Based on 'The energy gap' Jaffe and Stavins

(1994), here we define four potential levels of optimising energy usage:

- Micro level - *Firm/organisation optimum;* indicates the amount of energy efficiency that might be expected to occur under current market conditions and market behaviour.
- Meso level - *Market optimum;* indicates the amount of energy efficiency that can be achieved if all technologies that are cost-effective from a consuming organisation point of view were implemented.
- Macro level - *Social economic optimum;* describes the amount of energy efficiency that would be achieved if all technologies that are cost effective based on a social, rather than a private perspective (by taking externalities into account) were implemented.
- Macro level - *Hypothetical optimum;* represents the maximum amount of energy efficiency that would be achievable through technology diffusion if all technically feasible technologies were used without regard to their cost acceptability of certain stakeholders.

To reach one of these energy consumption optimisation levels, barriers must be dismantled and removed. Which kind of barriers must be eliminated depends on the optimal level one tries to achieve.

4.7 Rational Decision Making or Strategic behaviour?

A central idea in economics is that in a multi-actor environment, the free market, actors behave selfishly and try in *rational* ways to succeed and reach their goals. This market leads as if by an invisible hand (Adam Smith) to economic efficiency. In this perspective the behaviour of and action taken by each consumer and producer in the supply chain, and the efficiency and performance of the accompanying markets, lead to energy efficiency as a function of prevailing prices. Rational decision making requires that the decision maker has all the information he needs and that he is knowledgeable about the consequences of possible decisions. In real life not everything is known and the decision maker is limited by the amount of time and resources he has to make decisions, so rationality is bounded (Simon, 1997). The decision maker is therefore one that is seeking a solution that he is satisfied with, and not willing to take any action for better solutions.

For large enterprises many times the market structure of the IT service stack looks like what the economist William Fellner calls *"the competition of the few"*: a few decision making units shape their policies and market action in anticipating a whole sequence of moves, and countermoves of other involved parties, in determining how to achieve their objectives.

If all the parties that are involved in a transaction don't have access to the same relevant information, then we are talking about information asymmetry. This creates an imbalance of power in a transaction. Where one party is trying to motivate another party to act on ones behalf, this is also known as the *principal-agent problem* and can lead to *adverse selection* and *moral hazard*. Here, principals do not know enough about whether (or to what extent) the agent acts in the way principals wish and that the self-interested rational choices of the agent coincide with what the principal desires. *Adverse selection* is taking place when 'wrong' choices are being made, because of asymmetric information, inefficient transfer of information between producers (agents) and consumer (principal). For example reliance on old information may prolong the use of outdated or suboptimal technologies, even though this is economically inefficient. This can limit the usage of energy efficient products. *Moral hazard* is the fact that the principal lacks information about the performance of the agreed-upon transaction or lacks the ability to retaliate for a breach of the agreement. Therefore the agent may behave differently from the way it would behave if all the information about the transaction performance was available.

Bounded rationality, information asymmetry and opportunism, accordingly to the economist Oliver Williamson, add up to information impactedness. "It exists when true underlying circumstances relevant to the transaction, or related set of transactions, are known to one or more parties, but cannot be costlessly discerned by or displayed for others.". This leads to *strategic* behaviour which has, according to Heuvelhof et al. (2003), the following characteristics:

- *Strategic behaviour with rules/policies;* parties interpret policies, legislation or contracts in their one gain and act accordingly boundaries.
- *Strategic behaviour with information;* parties are selective with sharing information with other parties because they think there is a gain in doing so.
- *Strategic behaviour with prices and quantities;* parties setting their services and product prices accordingly to the market power of the other parties.
- *Strategic behaviour with bottleneck facilities;* parties abuse their ownership or control of an essential component of a system, through which all service products (like electricity) must pass to reach the ultimate buyers. By refusing or reluctantly giving access to these facilities by means of high prices and or poor quality so that these facilities become nearly worthless for other parties.

4.7.1 Market Failure

In some way there is a lack of sufficient incentives to create an effective and potential market in energy for IT, and the nearly nonexistence of this market results in the loss of efficiency in energy usage. In other words this looks like a market failure. As stated by Hanley et al. (2007) in their book Environmental Economics: *"A market failure occurs when the market does not allocate scarce resources to generate the greatest social welfare. A wedge exists between what a private person does given market prices and what society might want him or her to do to protect the environment. Such a wedge implies wastefulness or economic inefficiency; resources can be reallocated to make at least one person better off without making anyone else worse off."*

This market failure has three aspects. In economic terminology there is an *externality*: a party makes a choice or transaction that has an effect on other parties that are not accounted for in the market price. In such a case, prices do not reflect the full costs of production or consumption of a product or service. For instance, a firm using excessive energy and thereby emitting carbon will typically not take into account the costs that its carbon emissions imposes on others. As a result, carbon emissions in excess of the social optimum level may occur. The second one is that the use of energy by data centers is an example of the concept of *tragedy of the commons* as stated by Garrett Hardin in 1968. This concept refers to the situation that if people ignore the scarcity value of the commons, they can end up over harvesting a resource and leading to environmental degradation. Where in this case energy is seen as the common property, which usage is non exclusive. Multiple individual data center organisations and/or the organisations that makes use of them, acting independently, rationally consulting their own self-interest in consuming energy, will ultimately deplete the shared limited resource of energy supply even when it is clearly not in anyone's long-term interest for this to happen. A third aspect of market failure is *property rights*. As Gravelle and Rees (2004) put it *"a market is an institution in which individuals or firms exchange not just commodities, but the rights to use them in particular ways for particular amounts of time. [...] Markets are institutions which organise the exchange of control of commodities, where the nature of the control is defined by the property rights attached to the commodities"*. If a party doesn't have the right controls over the use of their commodities, exclusive use and/or the delegation of use and the related costs of doing so, this will result in inefficiency. An effect that is often visible in all kinds of sourcing arrangements of IT services.

4.7.2 Split Incentives or Who Pays the Ferryman?

Who pays the energy bill of the data center? Many stakeholders do not know much of the energy costs of data centers and thus do not act on energy usage. This brings us to the concept of split incentives. Split incentives occur when the party that is responsible for paying the energy bills, is different from the party that is responsible for capital investment decisions. A very obvious form of a data center split incentives case is that many data centers are housed in buildings that are not owned by the IT infrastructure user. If the user is not the sole tenant of a data center it is a shared service. The energy use per square metre of data center is allocated among all tenants rather than by actual energy consumption of each tenant. Tenants of leased data centers are generally unaware of or indifferent to the energy use of the IT infrastructure and have little incentive to make long-term investments in site infrastructure.

The sourcing structure of IT service stack often leads to the issue of split incentives. There are four basic IT services propositions. With *Software as a Service* (SaaS) the complete IT service stack is delivered to a customer who can only do some functional application administration. In the case of *Platform as a Service* (PaaS) an application of a customer is hosted on a platform (hardware and basic system software such as an operating system) and the customer himself can install and administrate applications. *Infrastructure as a Service* (IaaS) delivers just plain hardware where the customer himself can install and administrate applications and system software. With *Housing as a Service* (HaaS) the customer is offered a serviced site infrastructure were he himself can install and administrate applications, system software and hardware. These IT propositions can be offered by an internal (insourced) or external IT organisation (outsource) or with a mixture. This rises the question if the organisation that controls the site infrastructure also delivers the IT infrastructure (IaaS) and manage the IT infrastructure (PaaS) or whether the IT infrastructure is delivered and managed by separate organisations. In either of these cases, while the IT infrastructure side is responsible for purchasing and managing the IT infrastructure, the site infrastructure side is responsible for providing the power and cooling infrastructure and paying the energy bills. Under this arrangement, most tenants never see the energy bill for their IT infrastructure. And then there is little to no incentive for the tenant to make a capital energy efficiency investment with a usual payback time of several years, and which in the end will revert to the site owner as property.

The issue of the split incentives problem can be seen as a principal - agent problem. In their article, 'The Energy-Efficiency Gap', Jaffe and Stavins already in 1994[2] discussed the case of the landlord-tenant problem with energy issues as a principal - agent problem: *"If the potential adopter is not the party that pays the energy bill, then good information in the hands of the potential adopter may not be sufficient for optimal diffusion; adoption will only occur if the adopter can recover the investment from the party that enjoys the energy savings. Thus, if it is difficult for the possessor of information to convey it credibly to the party that benefits from reduced energy use, a principal/agent problem arises."*

4.7.3 First Cost or More Costs?

Energy efficiency improvements are burdened with discussions about costs, as for example addressed in 'Transaction Costs of Raising Energy Efficiency' by Ostertag (1999) or in 'Market failures, consumer preferences, and transaction costs in energy efficiency purchase decisions' by Sathaye and Murtishaw (2004). In particular, it is a discussion whether all the costs are taken into account for a proper costs evaluation. There is also a discussion about where to draw the line between transaction costs, switching costs, hidden costs or even production costs. This forms one of the barriers in the diffusion of energy efficient technologies. A proper overview of all the costs that are involved in diffusion of technologies could help to explain this barrier.

Production costs and upfront cost to obtain the energy efficient technology are not the only costs to take into account. Also, there is the barrier that the high upfront cost for energy-efficient technology is more tangible than the money not spent on uncertain energy costs in the future. There are also transaction costs. According to the economist Ronald Coase (Coase, 1992), transaction costs are resources that have to be used to carry out a market transaction, search, negotiation, verification, etc. Thus, this is the costs of arranging a contract ex ante where we have also the costs, ex post, to enforce the contract, as opposed to production costs. The transaction costs depend on the organisational set-up and the routines for making and implementing decisions. Traditionally there is the assumption that transaction costs to acquire and introduce new technology, to achieve energy and emission reductions, are costless. But in the different phases of a transaction, several sources of costs can be spotted:

- *Planning;* search for information, assessment of information, development of proposal, project identification and evaluation.
- *Implementation;* negotiation of contracts, procurement, project validation.
- *Monitoring and verification;* mechanisms to monitor, quantify and verify savings and related emission reductions.

There are also the switching costs. Switching costs are made when a customer makes a change of services and/or products. Types of switching costs include: exit fees, search costs, learning costs, cognitive effort, software and hardware costs, installation and start-up costs, costs for process and organisational changes, and financial risk. These costs are very much depending on the flexibility of the IT service stack: how the stack is technically build and the set-up of procedural routines and the organisation of the stack. Hard interdependencies between the stack elements can put a heavy burden on substitution or replacement of service stack elements with better alternatives, because of high switching costs in terms of money and effort. Factors that may form a barrier to switch include:

- High investment in non transferable infrastructure and/or software.
- Costs for changing proprietary interfaces.
- Costs for redefining configurations.
- Time to change, project duration.

These factors can even prevent or prohibit the supplier itself to change. System integrators with large investments in data centers with accompanying complementary business models with ROI and NPV assumptions, can be very reluctant to make large changes to their infrastructure.

The switching costs can even lead to a barrier in the form of a vendor lock-in, where the customer dependent on a supplier for services and products, is unable to use another supplier without high switching costs.

A consequence of the cost discussions is that cost comparisons between several energy efficient solutions can be messy due to unequal comparisons. There is also the risk of underreporting the costs of achieving 'energy over consumption' mitigation reductions. This blurry view can also seduce consultants and suppliers from recommending cost-effective improvements. For a supplier it is less risky to offer a cheaper, inefficient package of recommendations than to try to convince a customer that the high price of the efficient design will eventually be repaid through energy savings. We should be aware that *"despite the rising cost of energy and the relatively large share of data center costs attributable to energy expenses, data center energy costs remain a relatively small portion of overall facility costs for even the largest data center operations"* (Program, 2007).

4.7.4 Innovation and Risk Appetite, the Diffusion of Efficient Technologies

In 'Diffusion of Innovation', Everett Rogers puts forwards the idea that innovative solutions are adapted by successive groups of consumers. These groups are differentiated and categorised from each other on the basis of innovativeness: innovators, early adopters, early majority, late majority, and laggards. Concurrent to this adoption and diffusion of the solution, the growth of revenue or productivity of the solution itself also develops. In the start-up stage, growth is relatively slow as the solution establishes itself. Within the rate of adoption there is a point at which an innovation reaches critical mass. This is a point in time within the adoption curve where enough individuals have adopted an innovation in order that the continued adoption of the innovation is self-sustaining. That turning point is also referred to by the phrase 'crossing the chasm' (Moore, 1991). At this point customers begin to demand and the solution growth increases more rapidly. New incremental changes to the solution allow growth to continue. Towards the end of its life cycle growth slows and may even begin to decline. In the later stages, no amount of new investment in that solution will yield a normal rate of return. This staged product life, with stage names such as wild cats, stars, cash cows, or sleeping dogs is better known as the Boston matrix (Boston Consulting Group, 1968). The growth has the form of a so called s-curve. Figure 4.5 shows the adaption and growth curve, with successive groups of consumers adopting the new technology shown with the bell curve, and its market share that will eventually reach the saturation level shown with the s-curve.

The rates of adoption for innovations are closely related to the risk appetite at the individual and organisational level. Risk Appetite is the amount of risk exposure that the individual, group or organisation is willing to accept. This is influenced by the used business models and the derived incentives, the (perceived) flexibility of the IT service stack to make switches (interdependencies), the estimation of the (perceived) costs that are involved in making a transition, and the risk of outages when making transitions. For example if the data center is seen as a profit center rather than a cost center (a business enabler as opposed to energy cost center), it will certainly give other incentives. As insurance against the outage of IT services, most data centers have some

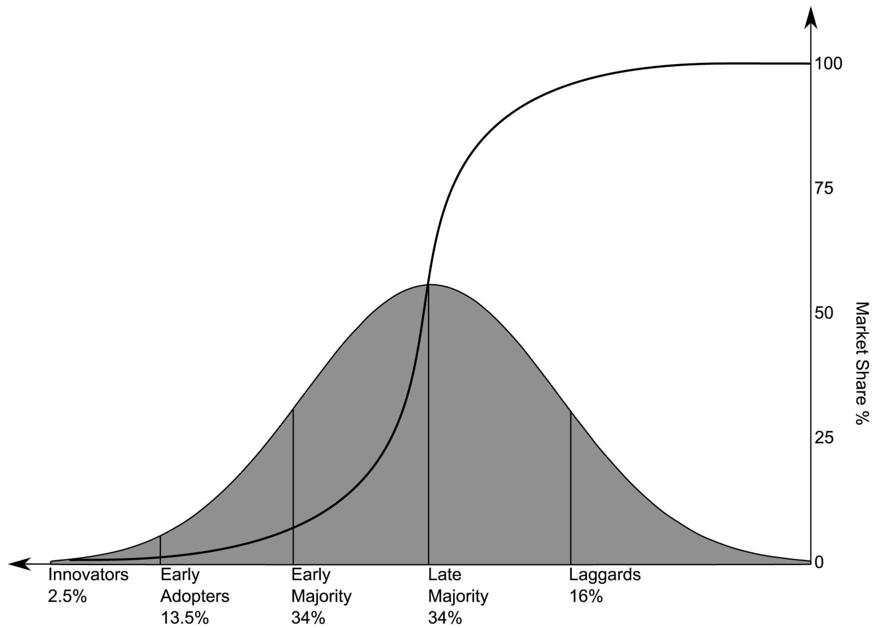


Figure 4.5: The Diffusion of New Technologies

level of redundancy of system components. The costs associated with additional extra energy usage as a result of redundancy will be taken for granted. The key question is how to ensure that the redundancy is achieved in the most energy efficient way possible. For a data center it is unlikely that people will be willing to pursue an innovation if there is any uncertainty about the system reliability and/or timely response by well trained staff or consultants. Suppliers may also contribute to excessive system redundancy or sub optimal solutions. They sometimes have a vested interest to postpone because energy efficiency measurements of the customer can force them to speed up their own product development. Some application software vendors advise operators not to run on virtual servers because the applications have not been tested and certified with virtualization software and thus have an unknown effect on reliability.

For a successful data center, '*Risk Management*' is a key success factor. Once the risk threshold has been passed, risk mitigation treatments and business controls should be well in place to bring the exposure level back within the accepted range. If there are uncertainties about this when using new solutions they will form a huge barrier in the diffusions of new energy efficient technologies.

4.8 Yes, We Can Change

In cutting down energy usage and energy costs, the focus is mostly on technical measurements, but figures show that this is not enough. There is a disconnection between the environmental sustainability and the economical sustainability. Applying economic-behavioural analysis to IT energy usage and dependability shows that it often explains failure better. Systems are often wasting energy because the people who manage them, or who could fix this, have insufficient incentives. Energy usage is for most involved parties an externality. Many measurements are ineffective because of asymmetric information, which causes adverse selection and moral hazard and even leads to strategic behaviour. The IT service stack is a complex system so it is the sum of efforts that counts. How much should be spend of efficient energy usage? That depends on which optimum you have in mind. The earlier defined potential levels of optimal energy usage can form a framework (Figure 4.6) form a first sketch of solutions on a conceptual level. Because asymmetric information leads to many behavioural aspects, the framework must explicitly take decision makers and stakeholders into account.

Optimisation Level	Issues	Decision Makers	Stakeholders	Goals	Criteria	Scenarios	Actions
Firm Organisation							
Market							
Social economic							

Figure 4.6: Solution framework

4.9 Firm-organisation Optimum

The issues to be solved are more or less technical and procedural coordination issues and motivational issues based on lack of information:

- Interdependency of the service stack
- Cost management
- Risk management

The goal to achieve is: eliminate barriers considered by economists as rational, achieve operational excellence. That is the amount of energy efficiency that might be expected to occur under current market conditions and market behaviour.

Contra arrangements:

- *Production coordination;* Organisations pursue a spectrum of goals and along with these goals individuals and departments within the organisation and between organisations will have specific 'subgoals'. Given that, not all of these goals are self consistent, is a fact of life. Unwanted interdependency in the IT service stack, caused by chasing different goals, should be countered by use of proper engineering and IT architecture methods to get coherent solutions. From an energy usage perspective, conflicting requirements of the various stakeholders of the total value chain, the used design rationale and the accountability must be made explicit so that things can be managed properly. By a better overall coordination it is also possible to get a grip on the costs that are involved (production, development, transactional and switching costs). Being well- informed about the design rationale, risk management becomes easier because risk taking decisions represent a well balanced act in which perceptions of risk are weighed against propensity to take risks and the potential rewards of risk taking.
- *Competition Engineering;* Conservation of competition is a very important quality attribute to prevent a (vendor) lock-in situation. To stay in control of the IT service stack, the organisation's sourc-

ing strategy is important to prevent barriers in technology diffusion. Competition can be designed. By taking appropriate actions in designing the IT service stack, procurement and contracting of technology, a level playing field, that is where all competitors play by the same set of rules, can be created.

- *Technology Procurement;* The different actors involved in a product's lifetime have a significant effect on its overall energy efficiency. The procurement of technology must be tightly integrated with development and production processes to counter inconsistencies and unnecessary energy costs.

4.9.1 Market Optimum

The issues to be solved, ask for active interventions and the success rate depends a lot on the actual power the organisation has in the market:

- Strategic behaviour and information asymmetry
- Split incentives

The goal to achieve is: eliminate market failures, which can pass a cost-benefit test. That is the amount of energy efficiency that can be achieved if all technologies that are cost-effective from a consuming organisation point of view, were implemented.

Contra arrangements:

- *Signaling and screening;* Signaling, in case of asymmetric information improve the market outcome by signaling some private piece of information to a poorly informed party, this party would then interpret the signal and adjust her purchasing behaviour accordingly. Screening, the screener (the party with less information) rectifies this asymmetry by inducing the other party to reveal their information. The screener offers a menu of choices to the other party with private information. The selection of the elements of that menu (which might be, for example, employment contracts containing pairs of pay rates and working hours) is a choice for the uninformed party to optimise based on the choices of the informed player.

- Contract design; in the presence of asymmetric information, proper contractual arrangements can help by creating the right incentives. Milgrom and Roberts (1992) identify four principles of contract design:
  1. *Informativeness Principle;* any performance measure reducing the error with which the producer's choice is estimated should be a part of the contract.
  2. *Incentive-Intensity Principle;* setting incentives as intense as possible.
  3. *Monitoring Intensity Principle;* setting performance monitoring as intense as possible.
  4. *Equal Compensation Principle;* states that activities equally valued by the principal should be equally valuable to the agent (shared-savings contracts, where both parties benefit from the efficiency savings to counter the split incentives problem).

4.9.2 Social Economic Optimum

Issues to be solved, because of the (environmental) externality, ask for active interventions of the government in terms of policies and regulations:

- Market failure
- Strategic behaviour and information asymmetry

The goal to achieve is: eliminate market failures, including environmental externalities, which can pass a cost-benefit test. That is the amount of energy efficiency that would be achieved if all technologies were implemented that are cost effective based on a social, rather than a consuming organisation perspective (by taking externalities into account).

Contra arrangements:

- *Taxes and tariffs on pollution;* creating disincentives by increasing the costs of polluting (because of energy usage) with taxes and tariffs, shall discourage polluting. The polluter must pay, even as pollution levels fall, the disincentive continues to operate, thereby creating incentives by subsidising energy saving and energy efficient technologies.

- *Environmental regulations;* a limit is set on the amount of a pollutant (because of energy usage) that can be emitted. Regulations are enforced by fines and forced accounting of energy usage and/or energy efficiency measurements. Fines should be paid if pollution rises above the thresholds or if appropriate actions are not taken. The total cost of the regulation can be a barrier.
- *Quotas on pollution;* pollution reductions achieved by way of tradable emissions permits. The total amount of allowances and credits cannot exceed the cap, limiting total emissions to that level. Companies that need to increase their emission allowance must buy credits from those who pollute less. For example the EU Emissions Trading Scheme.

The management of energy usage in IT is a much deeper and more economic-political problem than is usually realised. Most of the economical driven barriers are common to both private- and public sector. Solutions are likely to be subtle and partial, while many simplistic technical approaches are bound to fail.

Rien Dijkstra
Utrecht, Netherlands - December 2009

Rien is an innovative technology professional with over 20 years of combined experience delivering results in various IT positions in different governmental and non-governmental organisations. He has a broad and longstanding experience in IT (services) in different roles and functions such as: system administrator, software engineer, system designer, DBA, project manager, consultant and architect. During the first years of his *career he was mainly involved in software development. Later on his focus shifted to consultancy where he divided his attention to a number of differentiated IT subjects. After that he focused his attention to IT architecture as lead architect. The past years he has been focusing on developing and giving guidance to IT enterprise strategies. Currently, he is working as an Enterprise Architect. His main focus is on IT Vision and Strategy and the realisation of innovation.*

CHAPTER 5

Cloud Computing

The question of what does and does not constitute Cloud Computing is one which even today is the subject of much debate. The difficulty in defining what Cloud Computing is comes down to a number of factors such as the relative immaturity of the technology, the misuse of the term by the media and opinion leaders, as well as its shear size. Nevertheless, there is general consensus that Cloud Computing does represent a potent Green IT initiative through its direct, indirect and systemic effects which have the potential to significantly reduce CO_2 emissions.

This chapter uses a technique made popular by Nicholas Carr in his book The Big Switch to explain the concept of Cloud Computing by highlighting numerous parallels between the paradigm and the power generation industry. This comparison is even more interesting in the context of Green IT since the power generation industry also had, and continues to have, a huge impact on nations CO_2 footprints albeit in opposite directions. While the power generation industry is now using Smart Grid's to address efficiency and optimisations, the IT industry is capable of providing surprisingly similar benefits. Therefore to start the analysis of cloud computing as a Green IT initiative we start with a brief look at the evolution of the power generation industry from the late 1800s to the present and how people, institutions and society were/are influenced by it. Then the same is done with the information processing industry which culminates with Cloud Computing. By highlighting the many parallels between the two industries it will become clear that they also share many commonalities in their future evolution into 'green' technologies.

Once the concept of Cloud Computing has been canvassed, the focus will narrow on its impact as a Green IT initiative and answer the question of 'how green is the cloud?'

5.1 The Evolution of the Power Generation Industry

Crucial to the development of the modern industrialised world was the mass production and distribution of electricity. The distribution of affordable electricity to the population of many countries across the world in the late 1800s impacted society in a hugely disruptive manner. Some of those impacts were positive and some were negative, but the world had been changed forever due to it. The subject of this book itself is the product of both the positive and negative impacts of the production of electricity.

Before the invention of the technology to harness and control electricity, societies and enterprises alike where forced to position themselves in geographical locations where natural forms of energy were readily available. This meant that manufacturing for example needed to occur in geographical locations where there was wind to power the mill, wood to fuel a fire to produce steam, or fast moving water to power machinery. The societies and enterprises were reliant on this free form of energy and they could not function without it. These natural power sources were often seasonal in nature (abundant during some months and scares during other months) and could not be stored for use when its supply was limited. This absolute reliance on an energy source which was not guaranteed and the desire to increase efficiency drove inventors and engineers such as Nikola Tesla (Tesla, 2007) to experiment with using electricity.

For an enterprise, electricity brought with it the possibility of becoming independent of traditional energy sources, increases in efficiency, boosts in production scale, and broke the shackles forcing geographical proximity to 'traditional' sources of energy. For the wider society electricity proved to be even more liberating. However the power generation industry did not evolve from its humble beginnings converting wind powered flour mills (for instance) to mills powered by nuclear powered (for example) overnight. The conversion of factories into ones powered by electricity happened in a more pragmatic manner with technology used that was available at the time, sometimes despite its many shortcomings.

One major shortcoming of the technology in the late 19^{th} century was that it was unable to be transmitted very far. This shortcoming stems from the fact that at the time, Direct Current (DC) power was the dominant form of electricity available. DC electricity is a current that flows only in one direction, such as the current drawn from a battery[3]. This is in contrast to Alternating Current (AC) which flows periodically reversing direction. Furthermore, the generators were not very powerful, and their reliability was far lower than that expected by today's generators. Commercially speaking, this young commercial power generation industry was focused on the production of machinery to generate DC electricity rather than the electricity itself. The industry did not sell electricity, it sold the means for individuals to make their own electricity. Furthermore, there was a far shorter leap of faith for the managers of these companies to install hardware which they could control - they were at the time easily convinced that outsourcing such an important business function would be a strategic mistake. These technical and commercial features which characterised the industry at that time resulted in individual enterprises owning and operating their own power generation machinery.

With the help of engineers such as Nikola Tesla, Lucien Gaulard and John Dixon Gibbs, many of the shortcomings that did exist were rather quickly overcome. The famous “Current Wars” were fought over whether AC or DC power should be the standard for distribution and AC power was victorious. AC power could be transmitted vast distances cheaply, and transformers meant simpler generators and more elegant architecture. This resulted in small power stations being built which were designed to provide power for many customers rather than just one single one. Over time economies of scale made using these centrally located power stations more of an attractive option, and this eroded the traditional attitude that power generation was part of the core business and a strategic benefit over competitors. So while enterprises had always been responsible for harnessing or generating their own power, attitudes were now shifting and they were becoming more open to the idea.

Today, especially in the developed world, to contemplate building/installing your own means of power generation is very rare. It doesn’t make commercial sense any more - economies of scale have resulted in the prospect of using the large centralised power stations far more attractive. Generally speaking the average person cares not how the power is generated or distributed, and only that when an appliance is plugged in, it works. By outsourcing this function, enterprises can focus on their core business and leave power generation up to the ‘experts’.

5.2 The Evolution of the Information Processing Industry

The information processing industry has followed an uncannily similar evolutionary path as the power generation industry. To begin with, prior to the advent of the personal computer (PC), the dominant computing model/paradigm was the use of large mainframe computers serving multiple users via time-sharing its processing capacity - the Mainframe Model (Campbell-Kelly and Aspray, 2004). This paradigm is characterised by substantial computing power being located centrally and accessed via thin clients. These thin clients do little more than provide a user interface to the mainframe to write/read to/from the mainframe which is doing all the processing. This model is comparable to enterprises installing power generators on their own premises for their own private needs. Once again, this computing power was/is such an important part of the continuity of the business it was unthinkable to outsource it, and meant enterprises must be both an expert in their core business and manage their own technology.

The appearance and subsequent mass production of the microprocessor led to the proliferation of the personal computer and a significant reduction in popularity of the mainframe/time-share model (Freiberger and Swaine, 1984). This change in the hardware status quo changed the software paradigm as well. Rather than sharing software stored on a central mainframe computer, individual users enjoyed individual copies of software applications installed on each personal computer. Because each user ran software on his/her own dedicated PC this new model of computing avoided the difficulties of dividing CPU-time among multiple simultaneous users attempting to share one mainframe CPU. This evolutionary stage draws direct parallels with the stage in the power generation industry's evolution characterised by improvements in generator design and architecture. It also draws parallels with changes in mindsets seen in the power generation industry - conventional wisdom was being questioned and new technology was leveraged in an attempt to gain strategic and operational improvements.

This model did have its disadvantages though - some applications were too demanding to run on individual PC's, there was far more infrastructure to maintain, and most importantly there was a fragmentation of computing power over a disperse area (typically an office building). These disadvantages among others laid the seed for the creation of the client/server model. The client/server model divided work between two processes running on two different computers: a client process ran on the end-users PC, and a server process ran on some other computer connected to the same network. The client and server processes communicated by sending data back and forth across the network. This is an important evolutionary jump and it would for the first time allow the core information processing to happen at one place and lighter tasks were still off-loaded to clients. This draws parallels with the stage in the power generation industry's evolution where small centralised power stations were being built and utilised by numerous small customers.

The client/server architecture was later extended to include more than two processes. The original client/server model adopted the name 2-tier client/server or just 2-tiered architecture. More elaborate architectures were called 3-tiered, to indicate three processes, 4-tiered, to indicate four processes, etc. Eventually, as more processes became involved, the distinction between client and server blurred, and the industry just started using the term distributed processing to encompass all of these schemes. This is similar to the continued growth of small power stations and an expansion of the power grid. One fundamental disadvantage of this model was that management and maintenance was far more complex now.

In part to fight the shortcomings of the more complex client/server architectures and to design a more manageable architecture for heavy computing, Grid Computing was born. In the grid computing model processing occurs where capacity exists to do so. The task of processing shifts across the grid from node to node, splitting up tasks into small manageable tasks distributed in the potentially vastly geographically disperse network. These distributed networks are often shared by numerous organisations since the computing capacity is typically large.

As you can see the general evolution of the information processing industry has followed a similar path as the power generation industry - starting with an industry focused on providing the means of information processing to individual enterprises, underwent a number of fundamental shifts which saw resources shift between being centralised to distributed, isolated to connected and independent to co-operating to intelligently share the workload. This brings us to the current evolutionary shift that the IT industry is currently undergoing - the shift to Cloud Computing.

5.3 Cloud Computing

Within IT there is a small but growing class of terms which transcend the IT domain and become common vocabulary to a larger non-technical audience. This is especially true when once certain practices, architectures, paradigms or standards show tangible improvements to the non-IT related domains - Twittering[4] comes to mind, which was during it humble beginnings only used by tech savvy people but is now used by all walks of life. Once this happens their positive influence is quickly noticed outside the IT domain in which they started by non-technical observers. Such positive influences provide incentives for further use of the practice, architecture, paradigm or standard, and the usage of the terms outside of the IT domain increases further.

The problem with the adoption of terms by vastly different groups of people is that the interpretation of the term inevitably changes. Tech savvy individuals have their understanding, business focused individuals have different understandings, and so on. This effect is a function of the varying levels of exposure to the subject matter, their experience with similar subjects and their general perspective on it. *Cloud Computing* is one of these terms whose definition and interpretation varies between groups of people who have different perspectives and varying degrees of exposure. Today there seems to be a virtual cornucopia of differing definitions and opinions answering the question of 'what is cloud computing exactly?'.

To exacerbate the problem, the term Cloud Computing is all-encompassing (an umbrella term for many cloud based solutions) and even people from the same general domain can have different understandings. Just like the old Indian fable of six blind men who, due to their disability had never seen an elephant - each one that reached out and touched the elephant had a different understanding of what it was due to their limited perspective. One of the men touched a leg and concluded an elephant is like a tree trunk, another touched the trunk and concluded an elephant was like a snake, and so on. So just like the elephant, Cloud Computing is such a huge subject matter, that if you don't get your perspective high enough, then you risk being like one of the blind men.

For this reason (and the fact that the paradigm is relatively young) it is very difficult to provide a meaningful definition of cloud computing which is concise, meaningful, articulate and descriptive without being too specific as to define just one segment of cloud computing. All too often the definition of cloud computing provided defines just one aspect of the wider cloud computing universe. Therefore there is no alternative but to start with a high level definition and then dissect it into more specialised versions for each segment of cloud computing which is relevant for each unique perspective.

Based on this fact, the 30,000 feet definition of cloud computing developed for this book is:

> *The outsourcing of IT hardware and software to centralised external third parties capable of providing IT capabilities as a service, leveraging the Internet [the cloud] and accessed via (potentially thin) clients that know not, nor care not, how the services are implemented, maintained or what infrastructure is used to support it.*

You would be forgiven for thinking this really is not that revolutionary and that we have been doing this for decades. It is certainly true that the concept is old, however what has changed is its size, its adoption by enterprises and individuals and its technical foundation. You could say modern cloud computing is a re-implementation of an old

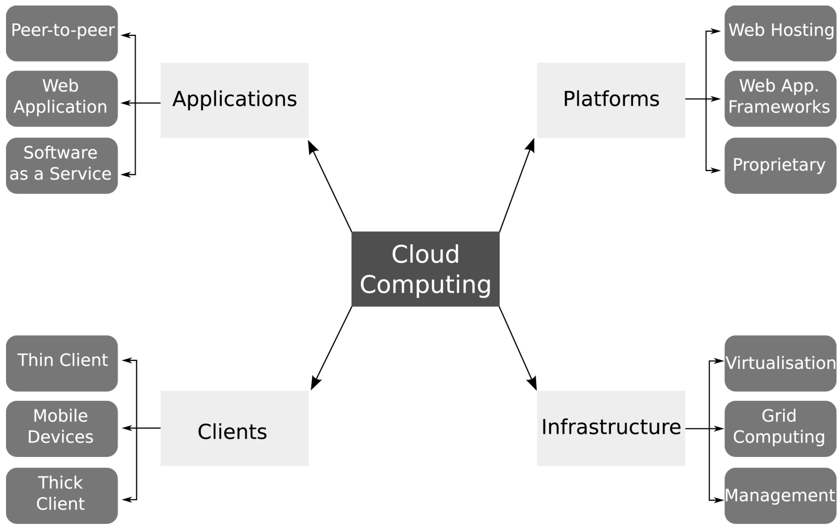


Figure 5.1: Cloud Computing Segments

idea which could finally gain enough momentum to stick around. This 'old idea' being yet another evolutionary jump for the IT industry to another paradigm in a similar fashion to the paradigm shifts between mainframe/dummy terminals, client/server and grid computing.

Given this high level definition of cloud computing we can now dissect it into smaller (less abstract) segments. Each segment adds a sub-domain to the cloud computing ecosystem and also adds to the potency of cloud computing as a significant Green IT initiative.

1. Applications - The applications segment of cloud computing represents the applications that are accessed via the cloud. Examples are Google Mail, or Salesforce.com[5].
2. Clients - A cloud client is computer hardware and/or computer software which relies on the cloud for application delivery, or which is specifically designed for delivery of cloud services. Most importantly however the cloud client is rendered essentially useless without having access to the cloud. An example of a software client is a web browser such as Firefox or Chrome, and examples of a hardware client are Nokia's Internet Tablet the N900, Apple

iPhone or many of today's Netbooks.

3. Platforms - A cloud platform is the delivery of a platform within which to run applications as a service. As such it is often referred to as platform-as-a-service (PaaS). Cloud platforms enable the user to deployment applications without the cost and complexity of buying and maintaining the underlying hardware and software layers. As you can see from Figure 5.1 cloud platforms can be further broken down into 3 sub-segments - Webhosting, Web App Frameworks, and Proprietary platforms. Webhosting and Web App Frameworks have evolved significantly, but it has been the proprietary platforms that have received most of the mainstream media and academic attention. Examples of proprietary platforms include both Force.com and facebook.com. Both of these platforms allow individuals or enterprises to upload applications that will run within the respective application - therefore by providing a platform that others can leverage easily, they are no longer burdened with the cost and effort associated with having access to such significant systems.
4. Storage - Cloud based storage is the exposure of storage services on the cloud. One such storage service provider is the end-user focused Dropbox[6], another is the enterprise focused Amazons S3[7]
5. Infrastructure - Cloud infrastructure is the delivery of computer infrastructure (typically a platform virtualization environment, but not necessarily) as a service. Hence it is often referred to as Infrastructure-as-a-Service (IaaS).

Together, these segments represent a new paradigm that can make true systemic changes to societies. Just as today's power generation industry consists of large centralised power stations distributing their power via vast high capacity grids, cloud computing consists of large centralised computing power distributed via the Internet. Where individuals, governments and commercial enterprises needed to own, control, maintain, secure, etc their own IT hardware, or even outsource those operations for their own IT isolated functions, cloud computing liberates its users from this burden. Cloud computing enables users to effectively outsource much of the non-strategically sensitive operations to external third parties so they can focus on other truly strategic operations. Moving from one cloud computing provider to another is just a matter of moving bytes from one provider to another - just as we can use any the electricity socket in our house to power any appliance we buy, cloud computing allows businesses and individuals alike use any cloud computing provider without fear of incompatibilities (clearly standardisation is an ultimately important issue).

Cloud computing liberates users so that no longer are they tied to using personally owned programs stored on personal computers/servers. Data is not stored on disparate devices where it was created, but instead data is stored centrally and accessible from any authorised Internet enabled device. The geographical location of where we access our data or consume services provided by servers becomes irrelevant - liberating us from the geographical shackles. The cloud is built on thousands of computers and servers, all interconnected and accessible via the Internet. Data can be combined in ways never possible before. GPS data combined with data on shopping patterns of entire cities, countries, or the whole world. Data on shopping patterns combined with photos, combined with videos, combined with online banking, etc, etc. Combinations of data that provide cloud based services that many of us find hard to even visualise at this point. Collaboration which was in the past very difficult and rigid becomes second nature for the coming generations of our citizens.

From a more personal/consumer oriented perspective, the popularity of devices such as the Apple iPhone or Android mobile devices indicates the general public's ability and willingness to embrace cloud computing. Without the cloud these devices would be significantly limited, and their use today has already influenced how we communicate, socialise, consume, etc. In Denmark for example, Internet is offered for free on a number of public bus routes, which enables passengers to do everything from reading the news, to listen to online radio stations from around the world. The service is also used by the bus itself to plot its location on Google maps in real-time.

5.4 Cloud Computing as a Green IT Initiative

Now that cloud computing has been defined, and hopefully its disruptive impact as potential societal changer has been highlighted, the question of how 'Green' cloud computing is can be addressed. Cloud computing's potency as a Green IT initiative is often attributed to one single underlying enabling technology - that of Virtualization. Virtualization is given credit for a whole array of energy and emission saving outcomes. Virtualization, it can be argued, is largely responsible for cloud computing's direct and indirect impacts on emissions of green house gasses but not for its systemic impacts.

5.4.1 Virtualization

It was mentioned earlier in this chapter that you would be forgiven for thinking cloud computing really is not that revolutionary and that we have been doing this for decades. One of the core ingredients that has made cloud computing financially viable and technically attractive is the use of virtualization. During the 1960s and 1970s IBM had pioneered virtualization as a rationing device within their mainframes - the large processing capacity of mainframes were divided up using virtualization into smaller virtual machines. This method of carving up the processing capacity of the mainframes allowed it to perform multiple functions at once.

As the dominance of the mainframe/time-share paradigm dwindled, so did the usage of virtualization. Throughout the 1980s and 1990s while the client/server paradigm dominated virtualization was rarely used. Instead, enterprises commonly opted for a one server per application model to divide up their total processing capacity, mitigate risk to ensure business continuity. This had a number of important impacts:

1. Low CPU Utilisation. In a paper published by HP Laboratories, a study of six corporate data centers found that most of the 1,000 servers co-located within were using just 10-35% of their processing power (Andrzejak et al., 2002). This is in-line with a similar study by International Data Corporation (IDC). In a 2002 report, IBM estimated that the average capacity utilisation of desktop computers was just a mere 5% (Berstis, 2002). All of this wasted capacity still requires power and cooling, as well as administration.
2. Increasing Physical Infrastructure and Maintenance Costs. Figure 5.2 illustrates that not only has this problem existed for a long time, but the problem is accelerating (and is forecast to continue). The data used to derive this graph comes from IBM Corporate Strategy analysis of IDC data, September 2007.

   The figure shows that capital expenditure is relatively constant (falling marginally over time) power and cooling costs will increase by 400% by 2010 but is dwarfed by server management and administrative costs. With a growth rate of 687.5% since 1996 the cost of managing such complex IT systems is growing quicker than the other two components and already dwarfs the other two components.

   Clearly then, there is a real and substantial cost associated to the management of the ongoing accumulation of IT hardware.
3. Reduced Fail-over and Disaster Protection Options. In today's real-time works and tighter Service Level Agreements (SLAs), there is an ever increasing pressure to improve uptime, resilience and strategies for when problems do occur. As the amount of physical hardware has grown in our enterprises, governments and society in general we have seen not just complexity increase, but along with it, the difficulty of ensuring an adequate quality of

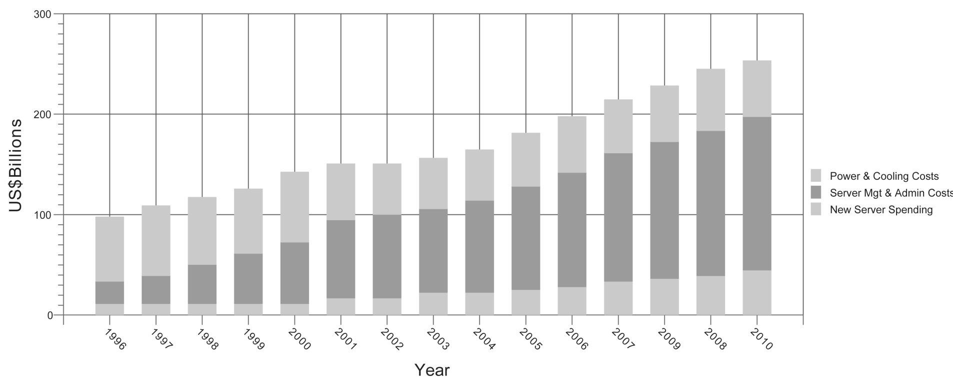


Figure 5.2: Global Annual IT Spending (Estimated US$B 1996-2010). Source: IBM Corporate Strategy analysis of IDC data, September 2007

service without huge financial investment.

4. High Maintenance Clients (PCs). As the PC has inherited a lot of the processing responsibility in the client/server paradigm, the amount of maintenance required to ensure a fully operational enterprise has increased significantly. This is of course significantly influenced by the distributed nature of the clients in this paradigm.
5. Higher Power Usage. According to IDC[8], a server operating at 10% utilisation still requires the same amount of power and cooling as a server operating at 75% utilisation. At the time when the report was released, for every $1.00 of capital expenditure on new servers, the average enterprise spends $0.50 on power and cooling. The question of energy elasticity is one which is discussed later in this chapter, however the issue of the correlation between CPU usage and power consumption is one which has improved in recent years. Nevertheless, lacking virtualization does, as will be proven, result in far higher power consumption.
6. Higher Cooling Costs. This point is related to the one above - lacking virtualization, the amount of hardware running is far greater and results in far greater heat being disbursed. This adds an extra requirement of either re-designing the server to respond better to

ambient cooling, or alternatively cooling the environment which the servers operate within.

There have been many solutions proposed to solve the problems with the dominance of the non-virtualized client/server paradigm, however most only address one or two of the problems and leave the others unsolved. Virtualization goes the furthest to solve or significantly mitigate each and every one of them however.

The basic concept of computer virtualization is best explained by viewing a computer as consisting of a number of layers. On the bottom you have your hardware (the hard drive, CPU(s), memory, network interface cards (NICs), etc). On top of the hardware layer lies the Operating System layer which controls, manages and co-ordinates the hardware. Finally on the top are the programs/application which are installed. This is the traditional (and by far still the most common) configuration of a computer. The operating system which is installed monopolises the hardware management tasks and any changes in the hardware needs to be configured (either manually or automatically) in the operating system. The point being that your operating system and all the programs you have installed are tied to the hardware - this represents tight coupling between the layers and is one of the core reasons for problems listed above.

Rather than tightly coupling your operating system with the underlying hardware, virtualization provides a method of de-coupling these two layers. Virtualization accomplishes this by adding a new layer of abstraction between the hardware and the operating system. This 'small' change provides the system with a huge amount of additional flexibility.

First of all, for the first time, we have a coherent solution to enable Server Consolidation. Server consolidation is the most commonly touted benefits of virtualization and is the act of migrating numerous small servers serving independent purposes to fewer powerful physical servers running multiple virtual machines concurrently. Looking back at the impacts of not leveraging virtualization listed previously, server consolidation alone addresses many of the problems.

Consolidation enables higher CPU utilisation by creating an elastic environment within which each virtual machine can run within. Once consolidation is successfully completed, virtual machines which use only a fraction of the available CPU time allow more CPU intensive virtual machines to use that spare processing capacity. This helps achieve higher utilisation rates without sacrificing performance. The result on green house gas emissions is that since these larger more powerful servers possess many power efficiency benefits, they typically consume far less power and of course therefore are responsible for less CO_2 emissions.

One strategy is to conduct consolidation through the use of a unique class of computing hardware - the Blade System. A blade system consists of a blade enclosure and numerous blade servers. A blade server is a computer server with a minimalist attitude towards hardware and possesses a modular design which is optimised to space as much physical space as possible. While a standard rack-mount server can operate independently with (at least) a power cord and network cable, blade servers can not operate unless housed in a blade enclosure. The reason being that blade servers have many components removed to save on physical space, minimise power consumption and other considerations. They do however contain all the functional components to be considered a computer. A blade enclosure, which can hold multiple blade servers (16 blades for example could be housed in one blade enclosure), provides common services such as power, cooling, networking, various interconnects and management. By utilising blade servers, you can stack more servers in the data center rack[9]. If a blade system is used as the basis for consolidation, then the energy savings can in some circumstances be substantial.

Consolidation also facilitates far greater cost control. There are potentially large savings in physical infrastructure (improving the return on investment of new hardware) and maintenance costs at the expense of potentially higher risks associated to single points of failure (all of which can of course be mitigated). Cooling one large server is also far easier than cooling many less efficient independent servers. As you create more virtual machines, the amount of cooling required only increases marginally due to the increase in load, whereas a new physical server purchased each time would demand far more cooling. This has direct implications for the amount of CO_2 released attributable to the ongoing functioning of a server.

Virtualization also enables far greater energy elasticity then sharing spare CPU time between virtual machines as mentioned earlier. Virtualization makes it possible to dynamically expand and contract the number of physical servers running at any given time. With the right architecture, platform, management and expertise it becomes possible to dynamically scale a cluster of servers based on real-time load requirements. During the night for example, virtual machines can be automatically consolidated onto a skeleton environment and then scaled out again during business hours. As virtual servers are moved off physical servers, those physical servers can be turned off and turned back on again when scaling out. All this can be accomplished in an unattended automatic fashion without 'turning off' any of the virtual machines. This very impressive possibility has direct implications for power consumption, cooling requirements and hence CO_2 emissions.

Revisiting the impacts of not leveraging virtualization in the client/server paradigm, we can now see the benefits of a virtualized environment:

1. Higher CPU utilisation due the ability to now consolidate virtual machines to fewer physical machines without compromising on the stability of independent systems.
2. There is likely to be lower physical infrastructure and maintenance costs due to a reduction in the amount of power consuming units.

3. Improved failover and disaster protection options due to the decoupling of software and hardware. Virtualization enables entire virtual machines being backed up and recovered rather than individual files on those servers.
4. Lower power usage due to both consolidation of hardware and the possibility of building dynamic infrastructure with highly elastic power consumption patterns.
5. Lower cooling costs once again due to consolidation of hardware.

Lower maintenance clients (PCs) was omitted from the list above as virtualization alone does not impact on the clients access it.

5.4.2 Cloud Computing

Virtualization is one of, if not the most significant, enabler of cloud computing. Without virtualization cloud computing would be financial unsustainable and technical challenging to say the least. The use of virtualization on the cloud has the effect of emphasising all the benefits of virtualization possess alone. Virtualization induced consolidation only goes so far since it is typically done on a per-enterprise level. Furthermore however, cloud computing stands to influence how we live our lives, in many respects changing society. Changes of this nature are referred to as societal changes and represent potential savings in green house gasses that far outweigh any potential saving from IT directly or indirectly.

Currently there is substantial discussion surrounding cloud computing's merits as a green initiative. It would be of interest to collect the opinions of perhaps the Chief Technology Officer's (CTO) of various enterprises to determine the general opinion of cloud computing's green merits. The CTO would be a good choice as a respondent since, while they are focused on the technology of an enterprise, they also hold other high level non-technical responsibilities. Consequently CTO's should in theory have the right mix of responsibilities, experience and information to form an informed opinion on the merits of cloud computing as a green IT initiative. In fact there has been numerous studies of this nature, and according to some of those sources, CTO's are not yet convinced of the green benefits of cloud computing. One such source is a major player in the cloud computing space - Rackspace, Inc. They hold an annual survey to gauge the occurrence of and nature of enterprises' environmental strategies. They found that cost savings and consolidation (in the context of virtualization) are driving the green IT agenda at the moment - largely discounting the green potential of cloud computing. Some of the main results of the 167 enterprises that took part in the 2009 survey are:

- 54 percent stated that cloud computing is now part of their overall environmental strategy.
- 21 percent of IT managers believe that cloud computing is a much greener alternative to traditional computing infrastructures.
- 35 percent said they were not convinced of the green benefits of cloud computing.
- 19 percent felt that the true green benefits of cloud computing have not yet been realised.
- 7 percent admitted that cloud computing was critical to their company becoming greener.
- 14 percent are currently evaluating cloud computing and its environmental benefits.
- 13 percent have considered the benefits of cloud computing as part of their overall environmental strategy.
- 20 percent would be interested in learning more about the green benefits of cloud computing.

Based on these results, the report identified three categories (or Green Personas as they are referred to):

The Cynics	The Middle Ground	The Greens
- Believe the green movement is marketing hype.	- Believe the green movement is trendy.	- Are convinced by the effects of CO_2 on earth.
- Are skeptical of vendors promoting green(er) technologies.	- Not convinced of all the green initiatives in the market place.	- Select potential vendors based on their green credentials.
- However, most are willing to recycle and generally keep the world a pleasant place to live.	- Will pursue simple initiatives to promote being green over financial savings.	- Actively pursue green accreditation and believe they have a personal responsibility.
- Are more concerned with money and quality of service more than reducing green house gases.	- Want to do the right thing but are lacking the resources to take it further.	- Evaluate “green best practices” at all levels of their business.
~25%	~50%	~25%

While Rackspace’s respondents took the survey with the assurance of anonymity, it is a safe assumption that those who did respond where quite tech-savvy. Nevertheless, these results points to a state of affairs which can be generalised to a far wider audience of IT users. The majority are moderate/middle ground and then there are minorities at each extreme. The cynics looking for more scientific evidence, and the greens wholeheartedly convinced.

Of particular interest on the question of whether CTO’s are convinced of the green merits of cloud computing, as shown above, is that only 21% are of the opinion that cloud computing is a much greener alternative to traditional computing infrastructures. I take that as evidence that we are still at the very beginning of the evolutionary jump to cloud computing.

Given the overview of Cloud Computing and its core enabling technology of virtualization, how does cloud computing impact on society to make it greener? The answer is best explained in three dimensions - direct, indirect and systemic.

5.4.3 Direct Impact

The direct impact of cloud computing relates to the reduction in CO_2 emissions directly based on its usage. As usual, the direct impacts are the most obvious and in cloud computing's case they are due to significant reductions in privately owned hardware and higher utilisation of cloud resources. This is due to the leveraging of 'cloud based' centralised third parties who are capable of providing IT capabilities as a service to masses of customers simultaneously. The direct result of this is a drop in global electricity consumption attributed to powering the hardware as well as that attributed to cooling the hardware.

As cloud computing's usage becomes more mainstream, the multitenant nature of the paradigm means hardware utilisation continues to go up. Due to the limited elasticity of today's IT hardware the higher the utilisation the better as far as energy consumption goes.

This is however a contentious issue, as some people believe you are merely moving power consumption from one location to another. While this is true, the net result however should result in far less power consumption thanks to the higher utilisation and reduction of redundant systems duplicated throughout our societies.

5.4.4 Indirect Impact

The indirect impact of cloud computing relates to the reduction in CO_2 emissions attributable to its usage rather than its operation. Businesses will be able to focus more on their core business rather needing to dedicate so many resources to running their IT infrastructure and services. Time to market for new goods and services will be faster, customer service efforts will become more common place and stronger. Furthermore, and more to the point, a whole array of new services will be spawned offering the same thing that used to be done internally, but now to anyone willing to pay. All of these benefits stem indirectly from the usage of cloud computing and benefit the environment at the same time by not requiring additional hardware owned and controlled by each individual.

5.4.5 Systemic/Societal Impact

Since the computing requirement at the desktop becomes far less, when and where we work and play becomes less restrictive. The current generation of smart phones such as those running the Android operating system are a great example of how liberating it can be using cloud computing. A society built around offices and meeting rooms can be broken down to employees that will be able to work where they want and leverage crystal clear, lag free video conferencing.

There is a filter down effect resulting from these types of possibilities. For example due to the diminished requirement to sit in front of a desktop at work, etc the necessity of commuting to work every day diminishes, as does the need to live in high density cities. The burden on our streets and public transport diminishes, and the CO_2 emission reductions follow.

Adrian Sobotta
Copenhagen, Denmark - September 2009

Adrian is one of the founding editors of this book and President of The Greening IT Initiative (A non-profit organisation dedicated to increasing awareness of the power of IT to reduce greenhouse gas emissions). He has been working in the IT industry for over 10 years acting primarily as an IT Architect for various multinational firms. He holds a bachelor degree in Commerce which he obtained at The University of Sydney (Australia). He also holds a Master's of Science degree in Information Technology, which he obtained at the IT University of Copenhagen (Denmark). He is a successful entrepreneur having started a number of innovative businesses in various countries. Adrian has been lucky enough to live, work and study all over the world. Throughout his travels he has had the pleasure of working with a large number of talented people and has been an *integral part of a number of business ventures involving emerging Internet technologies.*

Notes

[1]For more details on Moore's Law, see references section for full reference to Schaller (1997)

[2]See references section for full reference to Jaffe and Stavins (1994).

[3]See references section for full reference to Amos et al. (1999)

[4]If you are unfamiliarly with Twitter, browse to `http://twitter.com`

[5]Salesforce.com is both a cloud based application and a platform

[6]Dropbox enables users to store files online (in the cloud) and synchronise these files between any number of clients running various operating systems. Users pay for the amount of data stored in cloud on Dropbox's servers.

[7]Amazon S3 (Simple Storage Service) is a cloud storage provider which opened to the public in the US during March 2006 and in Europe during November 2007. This service enabled users to store unlimited amounts of data and only pay for what they use. The service facilitates storage and retrieval via web services.

[8]Matt Healey, Cushing Anderson and John Humphreys. IBM virtualization Services. White Paper, Oct. 2008

[9]A rack is a standardised cabinet which houses industrial computer servers designed specifically to maximise the number of servers per square meter in the data center, management of those servers and efficient airflow for cooling.

CHAPTER 6

Thin Client Computing

6.1 Thin Client Computing Is Nothing New!

They say everything comes around full circle if given enough time and Information Technology is no different in that respect.

Before I embark on the subject of Thin Client Computing and Desktop Virtualization please indulge me in a short trip down memory lane to the powerful power hungry mainframes of the 1970's, 80's and 90's. It was during the eighties that I embarked on my IT career as a trainee mainframe operator working for Her Majesty's Treasury at Chessington Computer Center, in Surrey, England. The center was an old world war two Royal Air Force base which had been converted for civilian use after the war. The main building was the size of a large air craft hanger and housed the ICL mainframes, paper tape/card readers, reel tape drives and a library of ten's of thousands of reel tapes. Like any mainframe operator at the time, my first job was that of "tape monkey"loading and unloading endless amounts of reel tapes as online data was too expensive.

The energy these facilities used was enormous by today's standards, but yet my Microsoft XBOX 360 games console now boasts more processing power and storage capability than the mainframes of the eighties. However, this era did introduce me to a number of concepts which have been making a comeback in the guise of Thin Client Computing and desktop virtualization.

The first concept was that of devices effectively known as "dumb"terminals that were used between the seventies and nineties to connect mainframe users to their mainframe computers via RS232 cables.

The second concept to prove nothing is really new is the ICL mainframe operating system called VME, which stood for Virtual Machine Environment. Now where have I heard that before?

It is good to see we are recycling ideas from the seventies!

The actual term Thin Client is said to have been coined in 1993 by Tim Negris who was the Vice President of Server Marketing at Oracle. Wikipedia claims he was working with company founder Larry Ellison at the time on the launch of Oracle 7. Oracle wished to differentiate their server-oriented software from Microsoft's desktop-oriented products.

Negris's buzzword was then made popular by its frequent use in Ellison's speeches and interviews about Oracle products and the Thin Client was born.

The term Thin Client stuck for a number of reasons. The earlier term "graphical terminal"was chosen to contrast such terminals with earlier text-based terminals. The term also conveys better the fundamental hardware difference that thin clients can be designed with much more modest hardware because they perform much more modest operations.

These generally consisted of powerful central computers that handled all data processing. Users of these computers had dumb terminals that could only handle simple text entry and display with no mice. These dumb terminals communicated directly to the central mainframe for almost everything they did.

One beauty of this set-up is that support costs were minimal; in fact, modern IT helpdesks or service desks were relatively unheard of as there was no need to have engineers running around fixing problems. Either it was a programming problem or some piece of hardware or you replaced the dumb terminal. My favourite trick at the time and a catch all resolution was to turn the dumb terminal off and back on again. It resolved 99% of all problems.

Thin Clients have been hyped a number of times in the media to challenge the dominant PC market but this has failed to happen a number of times.

In 1996 CEO of Oracle, Larry Ellison, said during a press conference: "The era of the PC is almost over, and the era of the thin client is about to begin", which echoed declarations similar to ones often made by the CEO of Sun, Scott McNealy, around the same time. Almost 14 years later, thin clients command only a fraction of the desktop market.

Some vendors are saying that with the increased availability of Web applications, growing network bandwidth and the promise of cloud computing we will see the thin client overthrow the PC as king of the desktop again. Wyse Technology and Hewlett Packard forge the way controlling 51% of the Thin Client global market between them.

In 2005 Wyse's CEO at the time, Dr. John Kish, said: "Thin clients eventually will make up 85% of the desktop market". Considering that thin clients still account for about 2% of today's desktop market that still seems a long way off at the moment.

When I asked Tarkan Maner,the current President and CEO of Wyse for a quote for this chapter of the book in 2010 he said: "By, 2015, I predict 50% of all Enterprise Desktop PC's will be based on Thin Clients - that is about 40 million Thin Clients of 80 million Enterprise Desktop P.C's"

The thin-client market has had its fair share of missed opportunities. About eleven years ago, when the most "inexpensive" PCs cost more than US$1,000, thin-client vendors enticed businesses with US$500 price tags. But in recent times PC prices have continued to drop; some now sell for as low as US$250. The lowest-priced thin clients hover around US$150, and some thin clients still cost more than US$500.

Meanwhile, network-bandwidth limits and applications that don't run well over a network, and unwillingness by many to give up the addiction of the desktop PC has hindered the thin client momentum to challenge the PC market.

The fundamental approach behind thin-client computing is simple. Instead of running all applications locally on PCs (Fat Clients) with all of the associated challenges and costs, applications run centrally and simply deliver screen updates and inputs to clients. If the concept sounds familiar, that's because it is effectively mainframe computing and dumb terminals on steroids.

In 1986 along came the Personal Computer (PC). Suddenly data was being held on computers running on people's desks. It seemed the age of centralised computing was over as users got used to graphical displays and being able to perform a number of tasks with just one computer rather than different dumb terminals for different applications.

6.2 Thin Client Market

It is estimated that 3,500,000 Thin Clients were shipped worldwide in 2008 compared to 290 million PC's in the same period. This works out as 1.2% when compared to PC's shipped worldwide. However, you have to remember that most of those PC's are for the home, education and small business markets. When you look at the medium to large enterprises then it is said that Thin Clients account for between 5% and 10% of the enterprise desktop market. It is anticipated that the Thin Client market will slightly drop in 2009 to around 3 million units shipped before rising to over 4 million devices in 2010. By the year 2011 analysts predict a massive 300% growth to 12 million devices per annum, followed by another 60% growth to 20 million in 2012 and 25% growth the following year to take it to 25 million devices shipped worldwide in 2013. Even at 25 million units shipped worldwide per annum in 2013 it would only account for 8.6% of the 2008 figures for PC shipments.

The worldwide install base is harder to work out. Wyse Technologies claim to have the largest install base of around 7 million. Given that the average life span of a Thin Client is 6 years, I have estimated the worldwide install base is around 20 million which is just 2% when compared to the reported 1 billion PC's currently in use around the world.

HP (Hewlett Packard) including Neoware & Compaq brands	29% of World Wide Market
Wyse Technologies	22% of World Wide Market
VXL	Less than 5% of World Wide Market
IGEL	Less than 5% of World Wide Market
Fujitsu Siemens	Less than 5% of World Wide Market
Devon IT	Less than 5% of World Wide Market
Sun Microsystems Sunray	Less than 5% of World Wide Market
Computer Lab	Less than 5% of World Wide Market
Teco	Less than 5% of World Wide Market
NComputing	Less than 5% of World Wide Market
HCL Peripherals	Less than 5% of World Wide Market
Hopen	Less than 5% of World Wide Market
Athena	Less than 5% of World Wide Market
Changchum Xingyu	Less than 5% of World Wide Market
Net voyager	Less than 5% of World Wide Market

Table 6.1: Thin Client Market Share

Table 6.2 lists other thin client manufacturers.

6.3 The Software

In 1995 a company called Citrix released a product called Winframe, again this was a deliberate play on the mainframe name and stood for Windows-Mainframe and it was literally intended to be that. Users could have slightly-less-dumb terminals on their desks and connect to powerful central servers that ran lots of user sessions. All the data

Cherry Pal	CLI	Motion
Optoma	Blueshark	Ipex Thin Office
Wonderware	Concept	Black Seal
Thincco	Routel	Xeratus
Compumaster	Acropolis	Novatium
CDG	NEC	DLoG
BosaNova	I-O	Konton
B & R	DSP	10ZIG
Airspeak	Maxspeed	QSR
TeleVideo	Thinix	Redline
AT Labs	Clear cube	Thin space
WebDT	Rangee	LISCON
Dell	IBM	Axel
Boundless	Symbio	Linware (Germany)

Table 6.2: Other Thin Client Manufacturers

and processing stayed in the computer room away from user's desks - all the user saw was the display of a Windows computer as if it was running on their PC just like normal.

Centralising servers and server support leads directly to higher utilisation levels, which reduce costs and environmental impact. Longer lifetimes of windows based terminals reduce capital expenditure. Reduced power consumption directly lowers energy costs, and indirectly lowers cooling requirements, which leads to lower carbon emissions and therefore lower electricity bills.

No remote servers, no desktop configuration, no need to redesign and integrate e-mail architectures. In many cases, the end-user can connect the device and be working within minutes, without doing any configuration themselves. Just give remote access into your servers and it's done.

Naturally, it is not a one-size-fits-all solution. Users will generally not have access to floppy and CD/DVD drives although it is technically possible through USB pass through. Nor will they be able to install applications. Server security and resilience is more important than ever. A server failing will affect everyone connected to that server. In the past thin client was not suitable for users using highly graphical

Environments such as CAD (computer aided designed). Legacy and bespoke applications may require redesign and development.

6.3.1 Microsoft Terminal Services

Microsoft saw the potential of the new software from Citrix and rather than write their own software, they reached a deal with Citrix (helped by the fact that Microsoft had invested in Citrix early on) where Microsoft would licence some of the code from the Citrix system. This effectively gave Microsoft a cut down version of the Citrix system. Microsoft then couldn't lose, since if someone wanted to implement the Citrix system; they still had to purchase Terminal Services licences. A great business model and one that continues to this day.

For the more serious thin-client solution running a Windows environment, Citrix was always the choice, but Terminal Services offered a relatively straight-forward and cost-effective option, especially for non profit organisations where licensing costs are relatively small.

In recent years tools have been developed to allow Terminal Services to share some of the higher services of Citrix, but at a much lower cost. These include load balancing based on server load, seamless applications (where an application appears on your normal desktop as an icon and runs as if it is installed as normal but is in fact running on a Terminal Server); and secure gateways to increase access security and encryption.

Terminal Services is based on the Remote Desktop Protocol (RDP) and is now even included in Windows XP, Vista and Windows 7 for remote access or support purposes allowing users the ability to let a remote technician take over their PC without installing additional software.

6.3.2 Citrix

The current version of the system from Citrix is called Xen App renamed from Citrix presentation server in 2007. As mentioned earlier, Citrix is generally targeted at the larger enterprise due to its greater scalability.

Xen App is based on the ICA (Independent Computing Architecture) protocol.

6.3.3 Browser Based Applications

Although you may not have considered it, many of the websites we use today are in effect thin client applications. Next time you enter your details into a web page, have a think about what is happening. You type some information into the page, click a button and the data goes off to be processed by some other computer. The results are then displayed back at your screen.

New technologies such as Ajax are being developed to help make using applications in a web browser as interactive as normal applications installed onto your computer. Most new line of business applications either have browser support or have moved completely over to being browser-based.

It's almost as if the browser (Internet Explorer, Firefox, Chrome, Safari etc.) has become the operating system in which applications can run. Now it (almost) doesn't matter whether you are running Linux / UNIX / Windows / Something Else - as long as you have a standard browser and your applications are written to those accepted standards, you should in theory be able to run whatever you need.

6.3.4 The Others

New Moon/Tarantella/Propalms: New Moon systems/ Canaveral IQ were created as a direct competitor to Citrix; these were later acquired by Tarantella, which was then acquired by Sun who rebranded the product as SGD-TSE. Sun was recently acquired by Oracle. The new moon systems Thin Client product was licensed by Sun to UK Company Propalms. The re-branded product is called ProPalms TSE and competes as a lower cost alternative to the Citrix Xen App product group.

Open Thin Client: Open Thin Client is a Free Open Source Thin Client Solution consisting of a Linux based operating system along with a comprehensive Java based management GUI and server component.

Linux Terminal Server Project (LTSP): The Linux Terminal Server Project adds thin-client support to Linux servers. A growing number of Linux distributions include LTSP out-of-the-box.

2X ThinClientServer, SoThin and Thin Launch Thin Desktop are products, which help convert existing legacy PC's into Thin Clients.

6.3.5 But Is the Future of Thin Client Computing in the Clouds?

Many people see the web as the future of computing in general - you can tell this by the likes of Google, Amazon and Microsoft jostling for position with the web-based applications.

But don't expect everything to change overnight! In the year 2000, at the height of the dot com boom everyone thought we would be using ASP's (Application Service Providers) for all our computing needs by now, and that internal IT departments would be long gone! It might be heading in that direction, but IT is still a pretty conservative world and big changes often take longer than analysts might think.

One of the biggest drawbacks with applications being hosted by external companies, is what happens if that company goes bust - if your software supplier disappears and you run everything on your internal servers, no problem - you have time to find a new supplier and you can make do with what you have. But if you can't access your corporate database because they haven't paid the electricity bill, you have a major business problem. Disasters such as Enron and Lehman Brothers have highlighted that even the biggest organisations can go bust.

So, for the near future it is likely that applications will continue to make better use of web technologies to make the desktop environment

(Windows, Linux, Apple Mac and Google Chrome OS) less and less important. Many applications will use a browser to run in, but will talk to internal servers, so organisations have control over their key data.

Technologies such as Terminal Services and Citrix still have a massive role to play. Most applications still do require installing and managing in the traditional way and many applications will take a lot of work to move away from the current architecture.

6.4 Thin Clients are Environmentally Friendly

The first and most obvious environmental element of a Thin Client is that it is energy efficient. Typically a Thin Client uses 10% of an average PC. Thin Clients' power consumption can range from 2 Watts to 30 Watts but average around the 15 Watts. A Thin Client called the Cherry Pal was released in 2008 that consumed just 2 watts.

Typically a PC consumes around 100 Watts, but this is variable and many manufacturers are improving their overall power consumption as Green IT projects develop.

The second less obvious energy efficiency is the length of time a thin client is left switched on. Many enterprises across the globe leave their PC's on overnight and weekends to allow the update of security patches, anti-virus updates and software releases.

There is also an end user reluctance sometimes, about the amount of time spent logging off and shutting down the PC or waiting for it to boot up and login the next morning.

This is not a problem with most thin clients; you can just turn them off by the power button and back on when you get back to your desk. This can reduce the time your desktop device remains on from 168 hours per week to less than 40 hours on average.

Perhaps the lesser known savings is the embedded carbon within the device itself. Hopefully it shouldn't come as a surprise that as the thin clients are smaller, lighter and less complex they require less raw materials in the form of metals and plastics, which reduces the embedded carbon when compared to the larger, heavier and complex PC (Fat Client).

The weight and size adds another dimension of reduction in carbon footprints in air freight and/or transportation from manufacturer to its final destination on the end users desk. These may be small, but when you multiply the figures by several million, it all adds up.

Finally, longevity thin clients should last twice as long as PC's because they have no moving parts, are left on less and software functionality can be improved by upgrading the back end server rather than the front end terminal. This also translates to hardware maintenance and engineer visits. Thin Clients tend to have a break down rate of less than 1% because of their lack of moving parts where a PC break down rate can vary between 5% - 10% when software corruptions are included. The carbon emitted in the logistics of sending out replacement parts, engineers travel and repairs, can soon add up.

Many thin client manufacturers now pay close attention to reducing the amount of packaging, removing paper manuals and making sure all packaging can be recycled.

The device itself can usually be recycled at end of life. Over 90% of materials can be recovered.

Some of the thin client manufacturers have also analysed their transportation hops and methods to reduce both cost and carbon footprint.

Perhaps the latest reason to implement and deploy thin clients, is the Desktop Virtualization market or sometimes called VDI (Virtualization Desktop Infrastructure).

6.5 But what is Desktop Virtualization?

Desktop virtualization is encapsulating and delivering either access to an entire information system environment or the environment itself to a remote device.

This device may be based upon entirely different hardware architecture than that used by the projected desktop environment. It may also be based upon an entirely different operating system as well.

Desktop virtualization is the use of virtual machines to let multiple network subscribers maintain individualised desktops on a single, centrally located computer or server. The central machine may be at a residence, business or data center. Users may be geographically scattered but are all connected to the central machine by a proprietary local area network (LAN) or wide area network (WAN) or the Internet.

Desktop virtualization offers advantages over the traditional model, in which every computer operates as a completely self-contained unit with its own operating system, peripherals and application programs. Overall expenses are reduced because resources can be shared and allocated to users on an as-needed basis. The integrity of user information is improved because all data is maintained and backed up in the data center. Conflicts in software are minimised by reducing the total number of programs stored on any given machine.

Despite the sharing of resources, all users can customise and modify their desktops to meet their specific needs. In this way, desktop virtualization offers improved flexibility compared with the simpler client/server paradigm.

Advantages Include:

1. Instant provisioning of new desktops
2. Near-zero downtime in the event of hardware failures
3. Significant reduction in the cost of new application deployment
4. Desktop image management capabilities
5. Normal 2-3 year PC refresh cycle extended to 5-8 years
6. Existing desktop-like performance including USB support
7. Ability to access the users' enterprise desktop environment from any device
8. Desktop computing power on demand
9. Multiple desktops on demand
10. Self provisioning of desktops (controlled by policies).

In my opinion there are currently only two serious players in the market, which are Citrix and VMware, although Microsoft will soon be challenging following the introduction of Windows 7.

6.5.1 Citrix Xen Desktop

Citrix Xen Desktop offers a more flexible way to deliver desktop applications to end users. The traditional application streaming product, XenApp, is still available as a standalone product, but all of the XenApp features and functions are also available in XenDesktop. Citrix has also extended the updated HDX technology to XenDesktop, offering the best balance of processing power versus performance.

An interesting new feature is Flex Cast, which allows IT administrators to centrally manage and deploy applications to users who are using any of XenDesktop or XenApps delivery methods. The benefit is that users can access applications regardless of where they are or the computer they are using. They could be using VDI from a remote workstation or streamed applications in another.

Citrix is not doing away with XenApp, the company appears to be positioning XenApp for scenarios where there are a number of concurrent users accessing a similar set of applications. Unlike XenDesktop, which is based on named users, XenApp is priced based on concurrent users. If you have ten concurrent XenApp licenses, any number of users can be given access to a XenApp application, but only ten concurrent users can be actively using the application at a time.

XenDesktop has three editions with pricing based on a named user basis. Standard edition is priced per named user and provides just virtual desktop. Enterprise Edition is also priced per named user and provides all of Citrix's VDI and application streaming functions. The Platinum edition is priced per named user and includes Citrix's security and optimisation product integration.

XenDesktop 4 is an important update not only for new and existing XenDesktop/XenApp customers, but for any company that is looking to reduce desktop management costs and deliver applications and desktops to users where ever they are. VDI and streaming applications was once only considered useful in fairly niche situations where you had lots of users with the same desktop, like a call center or financial company, and where you have reliable, high speed links to stream the apps over the WAN. However, with the increase in broadband nearly everywhere, even relatively high speed wireless, VDI and streaming applications are a viable option to distributing and managing remote user desktops. The combination of XenDesktop and XenApp is unique in IT.

6.5.2 VMware View

VMware describes View as 'The Next Generation of VDI, delivering rich, personalised desktops to any device with all benefits of centralised management'.

View was created using different technologies that are already found in other VMware products. Examples of technology used in

View include snapshotting as seen in VMware Workstation; VMware OS cloning as used in VMware ESX; and Tomcat which is used for the Web based administration console.

Managing View is fairly straightforward. It is quite easy to use once you are accustomed to the components and terminology used with this product.

VMware View only supports VMware Infrastructure unsurprisingly and is not a hypervisor independent product.

6.5.3 Thin Client Support

VMware View and Citrix Xendesktop support a wide variety of thin client devices: Energy consumption is a critical issue for IT departments today, whether the goal is to reduce cost, save the environment or keep your data centers running. In the United States alone, data centers consumed US$4.5 billion worth of electricity in 2006. Industry analyst Gartner estimates that over the next 5 years, most enterprise data centers will spend as much on energy (power and cooling) as they do on hardware infrastructure. A chilling thought.

Save Energy by Eliminating Server Sprawl and Underutilisation: VMware claim their customers reduce their energy costs and consumption by up to 80% through virtualization. Most servers and desktops today are in use only 5-15% of the time they are powered on, yet most x86 hardware consumes 60-90% of the normal workload power even when idle. Virtualization has advanced resource and memory management features that enable consolidation ratios of 15:1 to 20:1, which increase hardware utilisation to as much as 85%.

6.5.4 Reduce the Environmental Impact of IT

Beside cost savings, virtualization is positively impacting the environment. Gartner estimates that 1.2 million workloads run in VMware virtual machines, which represents an aggregate power saving of about 8.5 billion kWh-more electricity than is consumed annually in all of

New England, USA for heating, ventilation and cooling.

While this is a good start, there are plenty of opportunities for saving even more energy and money. Analyst firm IDC states that the un-utilised server capacity equates to approximately:

1. US$140 billion
2. 3 years supply of hardware
3. More than 20 million servers

At 4 tons of carbon dioxide (CO_2) annually per server, these un-utilised servers produce a total of more than 80 million tons of CO_2 per year. This is more than is emitted from the country of Thailand and more than half of ALL countries in South America.

6.5.5 Others in Virtual Desktop Infrastructure Space

6.5.5.1 Sun Microsystems Virtualbox

Sun Virtual Box Enterprise-Class is an Open Source Desktop and Laptop Virtualization, which has been Downloaded by more than 11.5 million users, which is Licensed in an Open Source Edition under GPLv2. Supported Hosts: Sun Solaris OS, Windows, Linux, Mac OS X. Supported Guests: Practically any x86-based OS.

6.5.5.2 Microsoft Hyper-V

Hyper-V virtualizes the system resources of a physical computer. Computer virtualization allows you to provide a virtualized environment for operating systems and applications. When used alone, Hyper-V is typically used for server computer virtualization. When Hyper-V is used in conjunction with Virtual Desktop Infrastructure (VDI), Hyper-V is used for desktop virtualization.

Windows Server 2008 server virtualization using Hyper-V technology is an integral part of the operating system. Windows Server 2008 R2 introduced a new version of Hyper-V.

6.5.5.3 CentOS with Virt Manager

CentOS is an Enterprise-class Linux Distribution derived from sources freely provided to the public by Red Hat. CentOS conforms fully with the upstream vendors redistribution policy and aims to be 100% binary compatible.

CentOS is developed by a small but growing team of core developers. In turn the core developers are supported by an active user community including system administrators, network administrators, enterprise users, managers, core Linux contributors and Linux enthusiasts from around the world.

6.5.5.4 Red Hat SolidICE VDI

Linux distributor Red Hat has the Solid ICE desktop virtualization platform that it acquired when it bought KVM hypervisor maker Qumranet in 2008.

Red Hat Enterprise Virtualization (RHEV) hypervisors and management tools for servers and desktops as well as embedding the KVM hypervisor inside its Red Hat Enterprise Linux (RHEL).

The SolidICE virtual desktop infrastructure tools based on the KVM hypervisor are integrated into the RHEV Desktop edition, and will consist of a bare-metal or type 1 hypervisor for PCs and the tools to manage desktop operating systems and their virtualization layers.

In the original SolidICE VDI tools, the Spice, which is short for Simple Protocol for Independent Computing Environment, was an alternative to Microsoft's Remote Data Protocol used for linking PCs to remote servers. SolidICE lets users access their remote PC instances running on servers through RDP or through Spice. It was specifically intended to do a better job rendering multimedia (graphics, video, and audio) than RDP does, and to use much less resources on the servers that back-end the VDI setup.

The table below lists yet more market participants in the virtual desktop infrastructure space.

Leostream	Ericom Web Connect	Systancia
Moka Five Suite	Ncomputing	Panosystem
Parallels VDI	Virtual Computer NxTop	Ring Cube vDesk
Userful	Wanover	Quest vDesktop

Table 6.3: Other Thin Client Manufacturers

6.6 The Reed Thin Client Case Study

Reed delivers managed IT services across the Reed Group of companies, across a network of over 3,000 IT knowledge based users in UK, Europe, Asia and Australia.

The decision to implement thin client computing was driven by a goal of achieving real reductions in energy consumption from IT; and a separate goal on increased operational efficiencies while improving the quality of IT provision.

The 12 month project delivered clear ROI in key areas: reduced hourly power consumption by 5.4 million kWh of power; reduced annual IT spend by 20% and delivered greater flexibility and security through use of Wyse thin client terminals, centralised data and applications, consolidated data center infrastructure and virtualization software.

6.6.1 Innovation

Few other major corporate companies have chosen to switch from a PC to a thin client computing model on such a large scale. The project saw the complete replacement of all 5,000 desktop PCs with a thin computing solution based on Wyse thin client terminals; and new data center infrastructure based on 64-bit blade servers, Citrix XenApp, Xen Desktop and VMware virtualization software.

This change delivered major energy consumption savings and enabled greener working practices for all staff. Previously PCs had to be left turned on 24x7 to allow overnight software patching. With thin clients there is no need for this practice and the changes are applied centrally on Wyse management software. The faster start-up time of the Wyse terminals mean staff switch off their terminals at lunchtime and the end of their working day.

Thin clients delivered other benefits including remote working with staff able to log onto their personal settings at any thin client terminal in any office; and the elimination of local workstation storage and centralised storage of data and applications meant critical information was secure and always backed up.

Reed uses its new thin computing infrastructure to transform how it delivers computer services internationally. With its UK-based central data center running 24X7, Reed can provide IT services via Wyse thin clients to its Australia operations on the same servers at a time when those servers would otherwise be standing idle because it is night time in Western Europe.

The choice of more energy efficient servers meant lower heat emissions, enabling the data center to operate at a higher temperature and thus reduce the need for air conditioning. - Further helping to cut electrical consumption.

6.6.2 Future Growth

Thin computing model on a large scale makes it much easier for Reed to respond to future expansion nationally and internationally. This was demonstrated when Reed was able to establish a new remote office in Hong Kong in less than four weeks because of the more flexible IT infrastructure available.

6.6.3 Management

Reed recognised that the decision to go for thin computing had to be carefully managed with both the board and staff. A three month trial demonstrated to the board that the solution was easy to set up and manage, in addition to being economic and environmentally-friendly to run.

But Reed's IT division also had to convince the end-users. "We had a lot to prove: taking away someone's PC and replacing it with a thin terminal is quite a dramatic move for most people to become comfortable with, and we were expecting a lot of resistance".

Reed worked in close collaboration with HP, Citrix, VMware, Netapp & Wyse to implement the solution within as short a timeframe as possible. Reed replaced all of its 5,000 PCs in 10 weeks. A swift and smooth implementation helped to win over staff.

6.6.4 Excellence

Within a year of migrating to a thin computing model, Wyse thin computers have helped Reed achieve its goal of significantly reducing its carbon footprint.

In replacing the PCs with thin terminals across all locations, Reed witnessed a dramatic reduction in energy consumption - approximately 5.4 million kWh of power - one of the main causes of carbon emissions. These, combined with halving the number of storage drives and reducing the number of servers by a factor of 20, have resulted in a 20% reduction in Reed's annual IT budget.

Cutting our IT budget by 20% through thin clients, virtualization, as well as achieving reduced energy consumption was a tremendous result for us, not only have we met our objective to significantly reduce our carbon emissions, but we have also discovered a more cost-efficient way of operating and growing our business, which will continue to reduce our operating costs for years to come.

Sean Whetstone
London, UK - December 2009

Sean is Head of IT Services for Reed Global. He has worked in the IT industry for 22 years (20 of them for Reed). Reed successfully reduced its *carbon footprint by 2,500 tonnes of CO_2 per annum in 2006 by rolling out new Thin Client IT infrastructure. Sean is a regular speaker at conferences about Thin Client technology, Efficient Computing and virtualization issues. He presented a Green IT case study with Global Action Plan at the House of Commons, London. Winner of City of London Resource Conservation Award at the London Sustainable City Awards 2008. Winner of Computing Magazine for Green Project of the Year 2008, and Signed up to EC Code of Conduct for Data center Energy Efficiency. Winner of Mayor of London Green 500 Trailblazer, Engager & Platinum Awards in June 2009.*

CHAPTER 7

Smart Grid

From modest beginnings, the power generation industry has in relative terms evolved quite quickly into what we see today. However, while the technology has surely improved, fundamentally little has changed for many decades - power is generated in large centralised power stations and distributed to the consumer via a series of wires called an Electrical Grid, Power Grid, or shortened to just "The Grid". The evolution of the industry started with small, privately owned and maintained generators, but in the interest of efficiency, energy security, economies of scale / cost, business agility, providing the building blocks for a sustainable society, etc, governments have been eager to encourage and legislate to allow larger power plants and more extensive grids. In more recent history, many developed countries have turned to privatising their government owned power generation companies and liberalising the industry. Consequently, responding to the prospect of additional customers demanding ever more electricity, the private sector has also played its part in building the utilities sector as we know it.

We have all enjoyed the fruits of a truly impressive example of humans' ability to harness the electron. The scale and impressiveness of the electrical power grid has warranted the often quoted description of it as being "the worlds largest machine". For most of us though, the question of where the electricity comes from is rarely asked. In 2003, the National Academy of Engineering took on the monumental task of identifying the simple most important engineering achievement of the 20^{th} century. The short list included an estimated twenty feats of engineering that have affected virtually everyone in the developed world. The eventual winner and "most significant engineering achievement of the 20^{th} century" was electrification, as made possible by the grid.

However, as we reflect back on the 20^{th} century and marvel at our own accomplishments, the power generation industry has also become the single biggest emitter of CO_2. During November 2009 the European Environment Agency (EEA) released data detailing the CO_2 emissions by sector from all 27 EU member states at that time. The complete data is included below in Figure 7.1. As you can see, the data shows that in 2007 (the latest year in the report), the Public Electricity and Heat Production sector accounted for 26% of all CO_2 emissions. The next largest emitter was the Transportation sector (freight and passenger), which accounted for 17%. Other studies indicate even higher levels of CO_2 emissions by the Public Electricity and Heat Production sector. Therefore while the creation and on-going operation of the power generation industry is a truly impressive feat, it has also become the single largest culprit of humanity's influence on climate change.

This chapter explores the problems with the current grid and power industry as a whole and how information technology can and is being used to not just transform the industry into one which is responsible for less CO_2 emissions, but which is also changing society to be more eco-friendly, secure, sustainable and symbiotic.

7.1 Today's Grid - Systemic Problems

In many countries across the globe demand for electricity has steadily grown from the early 1980's. This growth has been spurred by population growth (which by the 1980's saw the Baby Boomers reaching

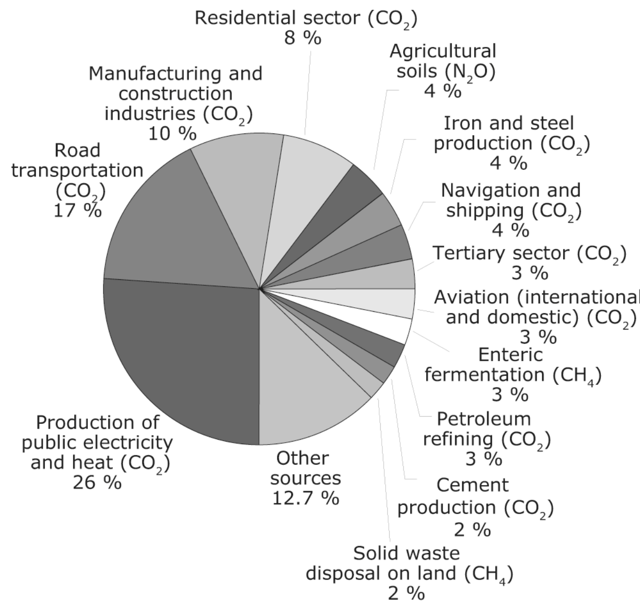


Figure 7.1: European Environment Agency, Greenhouse gas emissions in the EU-27 by main source activity, 2007

their mid-twenties), larger dwellings (both Australia and the United States culturally desire large plots of land and large houses), larger TV's, more air conditioners, more computers (IT of course shares some of the blame), etc. According to some estimates in the United States the growth in demand for electricity has outstripped transmission growth by almost 25% every year since 1982. Despite this however, expenditure on R&D is among the lowest of all industries.

According to a paper prepared for the United States Department of Energy (DOE) by Litos Strategic Communication, which outlined the state of the smart grid industry in the US, R&D expenditure as a percentage of revenue by Electric Utilities is less than 2%. In contrast however, Energy and Management Services enjoys 12% of its revenue spent on R&D. Clearly therefore the industry invests in R&D, but not in the area of the utilities (including the grid). This has resulted in a chronic underinvestment in transmission and distribution infrastructure. In the US, while there are hundreds of thousands of high-voltage transmission lines criss-crossing the country, only 1,075 additional kilometres of interstate transmission lines have been deployed between 2000 and 2009.

The impact of this long term underinvestment has resulted in a grid, which lacks efficiency, flexibility, reliability, resilience, viability/transparency, ability to control costs, and relies on a model of large centralised power plants. Unfortunately it is the environment bares the brunt of these systemic problems.

7.2 What Are Our Options?

To solve the problems of our ageing grid we need a solution that delivers a transformed grid which:

1. Is more efficient and provides for further future efficiency improvements that have not yet been discovered.
2. Is reliability.
3. Is self Healing.
4. Significantly improves the transparency of the health of the grid.
5. Significantly improves the problem of it being difficult and costly to integrate less reliable, renewable resources of energy.
6. Improves energy security for a nation/region.
7. Enables a Distributed vs a Centralised architecture.

Transforming the globe's power grids into a smarter version of its former self is a monumental task. To highlight just how large a task it is - the US government has approved a stimulus package to help facilitate the introduction of the technology needed to enable a smart grid. This stimulus package equates to more than US$10 billion!

The reason such a large investment is necessary is because while there have been huge strides in IT that have changed (hopefully for the better) almost all sectors of the economy and all corners of our societies, the electric grid has remained 'dumb'. The focus has not been on efficiency, flexibility, compatibility with renewable energy sources, etc. To some extent the opposite is true - by keeping the grid relatively 'dumb' means far less investment needed to go into ensuring quality of service. Making the grid smarter represents a capital investment which may not be as profitable as their existing grids. As a result, utilities have not invested in smart technology and instead continue to build huge energy plants to follow their traditional business models.

In Europe the numbers are similarly large - The European Utilities Telecom Council estimates the building of Europe's smart grids will require €150 billion (about US$222.84 billion).

Pricing carbon goes a long way to actually making a business case for a smarter grid. As the price of carbon becomes more tangible, there will be an incentive to make the improvements in efficiency, flexibility and interoperability.

7.3 Smart Grid

As is expected, the definition of what constitutes a smart grid is still evolving. In exactly the same manner as was explained in the Cloud Computing chapter, depending on your perspective smart grid means different things. At the highest level, the core objectives of a smart grid are to:

1. Ensure the reliability of power supply to levels not achievable before.
2. Maintain the affordability of electricity.
3. Reinforce a nations' / regions' global competitiveness.
4. Enable the accommodation of renewable and traditional energy sources.
5. Potentially reduce a nations' / regions' greenhouse gas emissions.
6. Facilitate advancements and efficiencies yet to be envisioned.

The Union of the Electricity Industry-EURELECTRIC is the sector association, which represents the common interests of the electricity industry at pan-European level, plus its affiliates and associates on several other continents. Their definition of Smart Grid is as follows:

> *A smart grid is an electric network that can intelligently integrate the behaviour and actions of all users connected to it - generators, consumers, and those that do both - in order to efficiently ensure sustainable, economic, and secure electricity supply.*

According to the U.S. Department of Energy however:

> *A Smart Grid uses digital technology to improve reliability, security, and efficiency of the electric system: from large generation, through the delivery systems to electricity consumers and a growing number of distributed generation and storage resources.*

Both the European and US definitions recognise that a smart grid is a combination of two dimensions: kWh and bytes. They both also address security of energy supply / security and recognise the evolution towards an increased role of renewable resources and distributed generation. They also both point out that producers and consumers alike are stakeholders in the smart grid and optimisation of both is desired. Both definitions stress the importance of efficiency: certainly an easier low-hanging fruit for the U.S., which still remains one of the most energy intensive (and least efficient from an energy production and distribution viewpoint) developed economies, but extremely valuable also for the EU.

So how do we achieve these objectives? What information technology is required? What architectural changes are required to the grid? The good news is that the technology to achieve most of a fully functioning smart grid exists today. In fact there are already smart grids in operation today (such as in Italy, thanks to the Telegestore project). As pointed out earlier, it was the business case/incentive which was missing and why the smart grid was not pursued earlier. Furthermore, not only does the technology exist, the actual hardware required can be borrowed and modified from other industries - so the requirement to develop building blocks specifically for smart grids does not exist. For example the telecommunications and manufacturing industries both have developed and commercialised much of the required technology already. Unfortunately though, there is no single technology which is a silver bullet, and instead a smart grid requires an array of technologies with different purposes to be deployed.

According to the U.S. DOE, the technological drivers of smart grids are:

1. **Integrated Communications** - Integrated communications connect components to an open architecture for real-time information and control, to allow every part of the grid to both "talk" and "listen". To fulfil the core objectives (especially, but not exclusively the objective of *ensuring the reliability of power supply to levels not achievable before*) as stated above, this communication needs to be real-time. A real-time integrated communications infrastructure would then enable real-time control of resources (producers and consumers) connected to the grid. While none of the following are required to build a smart grid, they are all ingredients that support the reaching of the core objectives above - Remote Terminal Units (RTU's) capable of responding to load variations on the grid, systems capable of supervising, integrating and controlling the RTU's, systems capable of distributing load (either positive or negative) automatically, power-line carrier communications, fiber-optics, and other wireless and wired high-speed digital communication methods.

2. **Sensing and Measurement** - Sensing and measurement technologies support faster and more accurate response, such as remote monitoring, time-of-use pricing and demand-side management. By accurately sensing and measuring the state / health of the

grid, consumers and producers of electricity can independently and automatically decide when to activate / deactivate. This technological diver can be sub-divided into two parts:

a) **Smart Meters** - There is a common misunderstanding that Smart Grid equals Smart Meters. I attribute this misunderstanding on the focus of the mass media on these exciting devices, however, to reiterate, they represent just one ingredient in a smart grid. They are not necessarily required to make a smart grid, nor do they necessarily require a smart grid to function. However they both compliment each other to enhance their respective feature sets.

   I prefer to see Smart Meters as a category of smart grid enabled devices - not just a digital meter in the fusebox. In essence a Smart Meter is a device, which enables utilities to remotely record customers electricity usage, and in turn enables consumers to see how much electricity they are using and even act on data received from the utility. Not only can the customer see how much electricity they are using currently, smart meters typically also show patterns of usage over time - allowing certain Smart Meters called 'Smart Sockets' to automatically turn on/off appliances based on the consumers preferences. These devices therefore enable both the utilities to gain further insights into usage patterns of the grid, but also enables consumers to change their own power usage patterns to avoid periods when, for instance, electricity is more expensive than desirable.

b) **Frequency Modulation Measurement Devices** - These devices are capable of measuring the changes in frequency on the grid and can react accordingly automatically.

3. **Advanced Components** - Advanced components apply the latest research in superconductivity, fault tolerance, storage, power electronics and diagnostics. There are a large (and growing) list of

advanced components, which both strengthen a smart grid and are enabled by smart grids. Some of these components are discussed later in this chapter and all have a huge potential to change societies in an environmentally positive manner.

4. **Advanced Control Methods** - Advanced control methods monitor essential components, enabling rapid diagnosis and precise solutions appropriate to any event. For example control systems, analytic algorithms and and operational automated control devices such as SCADA gateways.

5. **Improved Interfaces and Decision Support** - Improved interfaces and decision support amplify human decision-making, transforming grid operators and managers into knowledge workers.

7.3.1 Smart Grid as a Green Societal Transformer

Considering all the technological drivers of a smart grid, it should be clear that fundamentally it is Information Technology which will make a smart grid function. With smart meters, RTU's, high-speed networks, monitoring systems, metering data collectors, etc deployed and implemented, it's what is done with this information which is what is ultimately important and truly astounding. All the technological drivers enable a smart grid, but none of them directly 'create' one. To this end, I assert that it is information technology applied to creating a smart grid, which can deliver a fully functioning Smart Grid delivering all the objectives listed earlier in this chapter. Information Technology is what pulls all the individual ingredients together and co-ordinates their proper operation.

The direct impact of a smart grid, optimising electricity production and consumption and the direct CO_2 emission reduction is just the tip of the (quickly melting) iceberg. The use of electricity has become such an integral part of every day life in the developed world that changing how we use electricity also changes how we live our lives - hence why there is such a massive and disruptive potential to changing energy production and consumption patterns. The good news is that many of these disruptive potential changes enhance our lives rather than degrade them.

7.3.1.1 Virtual Power Plants

Traditionally, the central power control of a power utility is constantly monitoring and adjusting the amount of power its power plants are generating. When the decision is made, for instance that more power is required, the central power control instructs the power plant to ramp up its production to match the differential between demand and supply. While this is a very simplified explanation of the real-world operation of a power plant, the point being made here is related to it sending one command to one power plant. While the current popular architecture of a grid is heavily in favour of centralised (as opposed to de-centralised) power plants, the central power control knows that if it wants to modify the power produced by power plant X, it sends a command directly to that power plant.

As outlined above however, the vision of a smart grid is to enable the integration of renewable energy sources to the grid. Many of these energy sources have three problematic characteristics, which the fossil fuelled power plants do not possess - they are unpredictable, difficult to harness and result in contributing only 'small' amounts of power, and are harder to maintain.

1. **They Are Unpredictable** - For example, on a cloudy day photovoltaic cells may supply their full potential of electricity when direct sunlight is available and then suddenly deliver very little electricity as clouds pass over. At least with photovoltaic cells you do know that they definitely will not work at night, however even that level of certainty is not assured with renewable energy sources. Windmills harnessing the power of wind for instance may deliver no power during the day when power demands are

highest, only to start supplying power at night.

2. **Relatively Small** - Individual fossil fuel power plants can have the capacity to generate power in the magnitude of megawatts or even gigawatts. Ignoring hydroelectric power plants, most renewable energy sources are nowhere near capable of generating this much power using current technology.

3. **Harder to Maintain** - I recently took a tour of the Avedøre power station in Copenhagen, Denmark - an inspirational power plant indeed. While I was there some maintenance was being undertaken and as a result the plant was not capable of generating at its full potential. The good news however was that because the plant is centralised, the maintenance can be scheduled, undertaken and completed in a controlled environment. Maintaining smaller distributed power generators using renewable energy sources is more difficult and time consuming.

Therefore, to give the central power control a manageable task, there needs to be a system to abstract away all the detail of the thousands of small producers distributed throughout the land where they have the best access to their renewable energy source. Build on top of a smart grid, a Virtual Power Plant (VPP) is an information technology system which does exactly this - from the central power controls perspective, they just see one or more large power plants which they can control as they usually would.

A VPP enables a whole array of possibilities for optimisation of both power production and consumption as not only producers of power can be integrated into it, but also consumers of power. For example, the power utility could use the VPP and smart grid to adjust the thermostat of your heater or air conditioner to avoid blackouts or shed load off the grid.

7.3.1.2 Improved Grid Reliability

According to a Lawrence Berkeley National Laboratory report, the annual cost of power interruptions (such as blackouts) in the United States is an estimated US$80 billion per year. With total annual electric industry revenues at approximately US$326 billion, these costs represent a significant burden on consumers. Reliability improvements could significantly reduce these costs. The U.S. Department of Energy estimates are even higher - "Today's electricity system is 99.97 percent reliable, yet still allows for power outages and interruptions that cost Americans at least $150 billion each year - about $500 for every man, woman and child." A common, proven and feasible method of increasing reliability is to build diversity, flexibility and redundancy into a system. The same holds true for the grid.

Since a Smart Grid is distributed, flexible, self-healing, etc society will be able to use the cost savings of having fewer outages to help pay for the additional costs stemming from the additional complexities that arise with a Smart Grid.

7.3.1.3 Enhancing Customer Choice

Customer choice is certainly not something the power generation industry is known for, not because the industry avoids engaging its customers, but for example to maximise economies of scale, the products need to remain undifferentiated. This has helped to keep costs low and infrastructure standardised. However, thanks to Smart Grid this has changed significantly. Smart meters provide customers with features such as real-time or near real-time data of power usage, power outage notification, and power quality monitoring. They also provide a solution to a previously difficult problem - communicating real-time price information to consumers. By deploying Smart Meters into residence and office buildings, customers will be able to adjust their power consumption patterns depending on their tolerance for paying for electricity. Furthermore, customers can set their appliances to automatically turn on/off when the smart meter indicates the price has gone above/below a given threshold. By adjusting customers usage patterns a whole array of new 'smart grid/meter enabled appliances' will be developed. Dishwashers, washing machines, dryers, boilers, electric car recharges etc can turn themselves on when the customers' time, price, etc preferences are met.

So when once the customer had zero choice, thanks to Smart Meters and the Smart Grid, customers have now been empowered with choice thanks to the new found grid transparency.

7.3.1.4 Green Buildings

With the real-time data expressing the current state of the grid enabled on a smart grid, 'Green Buildings' are able to automatically adjust air-conditioning, blinds, air-vents, speed (and hence power usage) of elevators, recharging of uninterruptible power supplies, etc to minimise costs and reduce the load on the grid at peak times. Furthermore these buildings would be capable of returning excess power (from sources such as photovoltaic cells on the roof) back to the grid.

7.3.1.5 Energy Security

Since a smart grid enables a distributed grid rather than relying on the more centralised architecture common today in most countries' grids, energy security is vastly improved. Unlike most of the developed world, Denmark's grid is already significantly decentralised. The decision to move to a decentralised grid was strongly influenced by the 1973 oil crisis at which time Denmark was heavily dependent on imported oil. The crisis resulted from the Organization of Petroleum Exporting Countries (OPEC) deciding to reduce exports to many nations by 5 percent every month until Israel evacuated the territories occupied in the Arab-Israeli war of 1967. The reaction from Denmark was that being so vulnerable to foreign energy sources was a significant threat to their own stability and from a strategic and financial perspective was an undesirable position. To mitigate the risk of future shocks to society, the decision was made to become energy independent, and today Denmark is a net exporter of energy.

A smart grid promotes energy independence by enabling the use of distributed renewable energy sources close to their point of consumption and within the nations borders.

7.3.1.6 Plug-in Electrical Vehicle

Another very obvious way in which a smart grid can help transform society is to enable the usage of Plug-in Electric Vehicles (PEV). As alluded to earlier, one 'problem' with electricity is that it is difficult to store and instead, the power generation industry is (out of necessity) forced to focus on generating the power necessary to fulfil demand right now.

PEVs and smart grids however can alleviate this to some degree. Imagine PEVs not as cars with batteries in them, but instead imagine them as a battery with wheels. We would finally have an economical and functional way of using renewable energy sources, which provide electricity at erratic times. During the night for example there may be vast amounts of wind and wave energy, which would otherwise go wasted. Instead of just 'throwing away' this potential electricity, we could store it in the PEV's batteries. Society would now have the means of storing renewable energy.

Furthermore, if the cars are plugged in, the grid can also borrow electricity from the car if load on the grid is too high for short periods of time. This goes one step close to optimising an entire nations electricity usage.

Adrian Sobotta
Copenhagen, Denmark - November 2009

Adrian is one of the founding editors of this book and President of The Greening IT Initiative (A non-profit organisation dedicated to increasing awareness of the power of IT to reduce greenhouse gas emissions). He has been working in the IT industry for over 10 years acting primarily as an IT Architect for various multinational firms. He holds a bachelor degree in Commerce which he obtained at The University of Sydney (Australia). He also holds a master's of Science degree in Information Technology, which he obtained at the IT University of Copenhagen (Denmark). He is a successful entrepreneur having started a number of innovative businesses in various countries. Adrian has been lucky enough to live, work and study all over the world. Throughout his travels he has had the pleasure of working with a large number of talented people and has been an integral part of a number of business ventures involving emerging Internet technologies.

CHAPTER 8

How IT Contributes to the Greening of the Grid

The original purpose of this article was to explore the challenges of realising an interoperable and secure Smart Grid in the U.S., which NIST has undertaken. When I was approached by the Greening of IT collective, I saw an opportunity to present Smart Grid in a different light and was struck by the role that IT plays in its "greening". For instance, the structure of the electrical system has not changed much since it was first developed: it is characterised by the one-way flow of electricity from centralised power generation plants to users. The smart grid will enable the dynamic, two-way flow of electricity and information needed to support growing use of distributed green generation sources (such as wind and solar), widespread use of electric vehicles, and ubiquitous intelligent appliances and buildings that can dynamically adjust power consumption in response to real-time electricity pricing. This "bidirectional flow" will be rendered possible largely by information technology, and a suite of IT standards that will provide the smart blueprints for the many devices and software that need to be rolled out before the new grid can truly smarten up. The realisation of the smart grid is a huge undertaking requiring an unprecedented level of cooperation and coordination across the private and public sectors. And while I will not opine on IT's own greening, I believe it safe to say that a robust, interoperable framework of IT standards will be critical to making a smarter, greener power grid happen.

8.1 Revisiting the Problem

In chapter 7 we looked at the goals of Smart Grid and the broad issues facing its deployment. Let me briefly recap that discussion and the concepts that were introduced - but this time with a US slant.

8.1.1 Characteristics of the Present U.S. Electric Grid

The electric grid in the U.S. is owned and operated by over 3,100 electric utilities which are interconnected nationally through ten Independent System Operators (ISO) / Regional Transmission Organizations (RTO) that coordinate the bulk power system and wholesale electricity market.

The structure of the present electric grid was designed to support a one-way flow of electricity from centralised bulk generation facilities through a transmission and distribution network to customers. Most electricity is generated by coal, natural gas, nuclear and hydroelectric plants whose output under normal conditions is predictable and controllable. Demand for electricity varies considerably according to time of day and season. Generating capacity must be provided to handle peak periods. During periods of low demand, that generating capacity is idle. Some generation facilities, which cannot be dispatched on demand, serve as "spinning reserves", operating continuously even if their output is not needed to satisfy demand.

The transmission and distribution networks that carry electricity from generating plants to the customer have limited capability to monitor and report on their condition in real time. Advanced sensors called phasor measurement units (PMU) that can measure the condition of transmission facilities are not yet widely deployed. At the distribution level, in many areas, the only indication that an electric utility receives of an outage is the customer trouble report. There is limited ability to remotely re-route power around a failed line.

Customers receive limited information about their own energy use that is helpful in monitoring and reducing their energy consumption. In most cases that information is limited to monthly usage readings. “Smart meters” that capture electricity usage data in near-real time and can transmit the data electronically to the utility and the customer are just beginning to be deployed.

8.1.2 Why is the Smart Grid Needed?

Fossil fuels that are burned to produce electricity represent a significant source of greenhouse gas emissions that contribute to global warming. Most electricity is generated from coal, oil and natural gas. On a global basis in 2007, 68% of electricity was generated from these sources. For the United States, the proportion was somewhat higher: 72%. In the United States, electric-power generation accounts for about 40 percent of human-caused emissions of carbon dioxide, the primary greenhouse gas. If the current power grid were just 5 percent more efficient, the resultant energy savings would be equivalent to permanently eliminating the fuel consumption and greenhouse gas emissions from 53 million cars. The need to reduce carbon emissions has become an urgent global priority to mitigate climate change.

Many nations that rely heavily on imported oil are concerned about the security of their energy supply. While oil represents less than 2% of the fuel used to generate electricity in the U.S., transportation is heavily dependent on oil. Substituting “green” electricity for oil to provide heating and to power transportation has a double benefit by reducing carbon emissions while also increasing the security of energy supply.

Modern society has become highly dependent on a reliable electrical system. Interruptions to power supply are estimated to cost the U.S. economy $80 billion annually. With the pervasive application of electronics and microprocessors, reliable and high quality electric power is becoming increasingly important. However, the basic architecture of the aging electrical system has changed little over the last century. Improvements to the reliability and quality of electricity supply are needed to meet the demands of 21^{st} century society.

In summary, as was stated in chapter 7, the development of the smart grid is intended to support the following goals:

1. Greater efficiency and provide for further future efficiency improvements that have not yet been discovered.
2. Greater reliability.
3. Be Self Healing.
4. Significantly improve the transparency of the health of the grid.
5. Significantly improve the problem of it being difficult and costly to integrate less predictable, renewable resources of energy.
6. Improve energy security for a nation/region.
7. Enabled a Distributed vs a Centralised architecture.

8.1.3 Vision of the Smart Grid

While definitions and terminology vary somewhat, all notions of an advanced power grid for the 21^{st} century hinge on adding and integrating many varieties of digital computing and communication technologies and services with the power-delivery infrastructure. Bi-directional flows of energy and two-way communication and control capabilities will enable an array of new functionalities and applications that go well beyond "smart" meters for homes and businesses. Following are some additional descriptive characteristics of the future smart grid:

1. High penetration of renewable energy sources: 20% - 35% by 2020
2. Distributed generation and microgrids
3. "Net" metering - selling local power into the grid

4. Distributed storage
5. Smart meters that provide near-real time usage data
6. Time of use and dynamic pricing
7. Ubiquitous smart appliances communicating with the grid
8. Energy management systems in homes as well as commercial and industrial facilities linked to the grid
9. Growing use of plug-in electric vehicles
10. Networked sensors and automated controls throughout the grid

Developing and deploying the smart grid is also expected to have a positive effect on the economy by creating significant numbers of new jobs and opportunities for new businesses. A consultant study performed for the GridWise Alliance estimates that 280,000 new jobs will be created during the early deployment of the smart grid in the U.S. (2009-2012) and 140,000 new jobs in the steady state (2013-2018). The numbers represent new jobs in electric utilities, their contractors and supply chain, as well as new businesses enabled by the smart grid.

8.2 Smart Grid National Policy in the United States

The electric grid is often described as the largest and most complex system ever developed. The effort required to transform this critical national infrastructure to the envisioned smart grid is unprecedented in its scope and breadth. It will demand unprecedented levels of cooperation to achieve the ultimate vision. In the United States, the Energy Independence and Security Act (EISA) of 2007, states that support for creation of a smart grid is the national policy. Distinguishing characteristics of the smart grid cited in the act include:

1. Increased use of digital information and controls technology to improve reliability, security, and efficiency of the electric grid
2. Dynamic optimisation of grid operations and resources, with full cyber security

3. Deployment and integration of distributed resources and generation, including renewable resources
4. Development and incorporation of demand response, demand-side resources, and energy-efficiency resources
5. Deployment of "smart" technologies for metering, communications concerning grid operations and status, and distribution automation
6. Integration of "smart" appliances and consumer devices
7. Deployment and integration of advanced electricity storage and peak-shaving technologies, including plug-in electric and hybrid electric vehicles, and thermal-storage air conditioning
8. Provision to consumers of timely information and control options
9. Development of standards for communication and interoperability of appliances and equipment connected to the electric grid, including the infrastructure serving the grid

In the United States, the transition to the smart grid already is under way, and it is gaining momentum as a result of both public and private sector investments. The American Recovery and Reinvestment Act of 2009 (ARRA) included a Smart Grid Investment Grant Program (SGIG) which provides $3.4 billion for cost-shared grants to support manufacturing, purchasing and installation of existing smart grid technologies that can be deployed on a commercial scale.

8.3 Standards Framework for the Smart Grid

A significant aspect of the EISA legislation is the recognition of the critical role of technical standards in the realisation of the smart grid.

Nearly 80% of the U.S. electrical grid is owned and operated by about 3100 private sector utilities and the equipment and systems comprising the grid are supplied by hundreds of vendors. Transitioning the existing infrastructure to the smart grid requires an underlying foundation of standards and protocols that will allow this complex "system of systems" to interoperate seamlessly and securely. Establishing standards for this critical national infrastructure is a large and complex challenge.

Recognising this, Congress assigned the responsibility for coordinating the development of interoperability standards for the U.S. smart grid to the National Institute of Standards and Technology (NIST) in the Energy Independence and Security Act of 2007. NIST, a non-regulatory science agency within the U.S. Department of Commerce, has a long history of working collaboratively with industry, other government agencies, and national and international standards bodies in creating technical standards underpinning industry and commerce. The DOE announcement instructs grant applicants that their project plans should describe their technical approach to "addressing interoperability," including a "summary of how the project will support compatibility with NIST's emerging smart grid framework for standards and protocols."

There is an urgent need to establish standards. Some smart grid devices, such as smart meters, are moving beyond the pilot stage into large-scale deployment. The DoE Smart Grid Investment Grants will accelerate deployment. In the absence of standards, there is a risk that these investments will become prematurely obsolete or, worse, be implemented without adequate security measures. Lack of standards may also impede the realisation of promising applications, such as smart appliances that are responsive to price and demand response signals. In early 2009, recognising the urgency, NIST intensified and expedited efforts to accelerate progress in identifying and actively co-ordinating the development of the underpinning interoperability standards.

NIST developed a three-phase plan to accelerate the identification of standards while establishing a robust framework for the longer-term evolution of the standards and establishment of testing and certification procedures. In May 2009, U.S. Secretary of Commerce Gary Locke and U.S. Secretary of Energy Steven Chu chaired a meeting of nearly 70 executives from the power, information technology, and other industries at which they expressed their commitment to support NIST's plan.

Phase 1 of the NIST plan engaged over 1500 stakeholders representing hundreds of organisations in a series of public workshops over a six month period to create a high-level architectural model for the smart grid, analyse use cases, identify applicable standards, gaps in currently available standards, and priorities for new standardisation activities. The result of this phase, "Release 1.0 NIST Framework and Roadmap for Smart Grid Interoperability" was published in September 2009.

Phase 2 established a more permanent public-private partnership, the Smart Grid Interoperability Panel, to guide the development and evolution of the standards. This body is also guiding the establishment of a testing and certification framework for the smart grid, which is Phase 3 of the NIST plan.

8.4 Smart Grid Release 1.0

8.4.1 Reference Model

The smart grid is a very complex system of systems. There needs to be a shared understanding of its major building blocks and how they inter-relate (an architectural reference model) in order to analyse use cases, identify interfaces for which interoperability standards are needed, and to develop a cyber security strategy. The reference model identifies seven domains (bulk generation, transmission, distribution, markets, operations, service provider, and customer) and major actors and applications within each. The reference model also identifies interfaces among domains and actors and applications over which information must be exchanged and for which interoperability standards are needed. The reference model is being further developed and maintained by a Smart Grid Architecture Committee within the Smart Grid

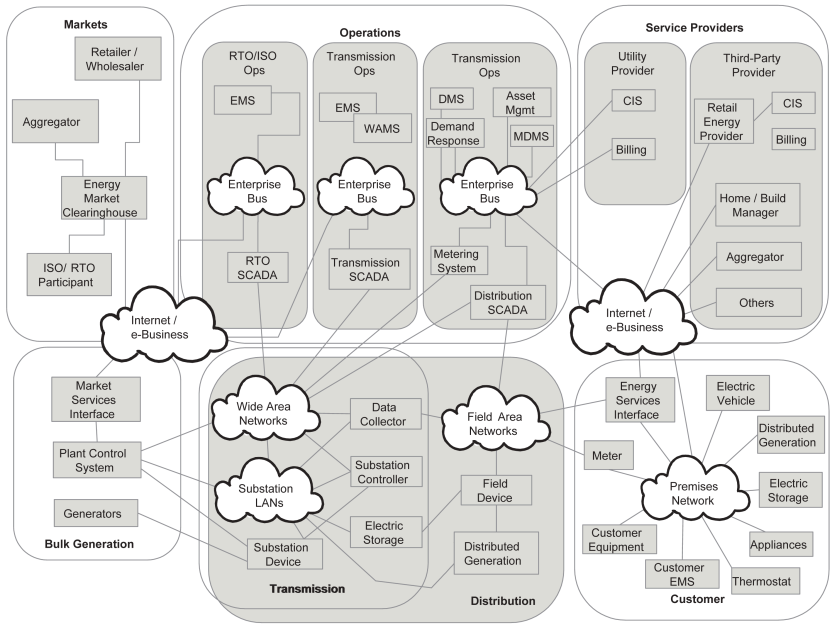


Figure 8.1: Smart Grid Conceptual Reference Diagram

Interoperability Panel.

One aspect of the reference model related to metering is the distinction made between the "meter" and the "energy services interface." At a minimum, meters need to perform the traditional metrology functions (measuring electricity usage), connect or disconnect service, and communicate over a field area network to a remote meter data management system. These basic functions are unlikely to change during the meter service life of 10 years or more. More advanced functions such as communication of pricing information, demand response signaling, and providing energy usage information to a home display or energy management system are likely to undergo significant change as innovations enabled by the smart grid occur and new applications appear in the market. The reference model associates these functions with the energy services interface to allow for the possibility of rapid innovation in such services without requiring that they be embedded in the meter.

8.4.2 Initial Standards

The Release 1 framework identifies 75 existing standards that support smart grid development. The standards address a range of functions, such as basic communication protocols (e.g. IPv6), meter standards (ANSI C12), interconnection of distributed energy sources (IEEE 1547), information models (IEC 61850), cyber security (e.g. the NERC CIP standards) and others. The standards identified are produced by more than 25 different standards development organisations at the national and international level, such as IEC, ISO, IEEE, SAE, IETF, NEMA, NAESB, OASIS, and many others.

8.4.3 Roadmap

In the course of reviewing the standards during the NIST workshops, 70 gaps and issues were identified pointing to existing standards that need to be revised or new standards that need to be created. NIST has worked with the standards development community to initiate 16 priority action plans to address the most urgent of the 70 gaps.

An example of one of these issues pertains to smart meters. The ANSI C12.19 standard, which defines smart meter data tables, is one of the most fundamental standards needed to realise the smart grid. Unless the data captured by smart meters is defined unambiguously, it will be impossible to create smart grid applications that depend on smart meter data. The existing ANSI C12.19 standard defines over 200 data tables but does not indicate which are mandatory. Different manufacturers have implemented various subsets of the standard, presenting a barrier to interoperability. In addition, the standard permits manufacturer-defined data tables with proprietary functionality that is not interoperable with other systems. To address this problem, one of the 16 priority action plans defined in the NIST roadmap was established to update the ANSI C12.19 standard to define common data tables that all manufacturers must support to ensure interoperability.

Manufacturers require lead-time to implement the revised standard. In the meantime, smart meters are in the process of being deployed and public utility commissions are concerned that they may become obsolete. To address the issue, NIST requested the National Electrical Manufacturers Association to lead a fast-track effort to develop a meter upgradeability standard. Developed and approved in just 90 days, the NEMA Smart Grid Standards Publication SG-AMI 1-2009, "Requirements for Smart Meter Upgradeability," is intended to provide reasonable assurance that meters conforming to the standard will be securely field-upgradeable to comply with anticipated revisions to ANSI C12.19.

Other priority action plans that are underway to accelerate and coordinate the work of standards bodies include:

1. Standard protocols for communicating pricing information, demand response signals, and scheduling information across the smart grid
2. Standard for access to customer energy usage information
3. Guidelines for electric storage interconnection
4. Common object models for electric transportation
5. Guidelines for application of Internet protocols to the smart grid
6. Guidelines for application of wireless communication protocols to the smart grid
7. Standards for time synchronisation
8. Common information model for distribution grid management
9. Transmission and distribution systems model mapping
10. IEC 61850 objects/DNP3 mapping
11. Harmonise power line carrier standards for appliance communications in the home

8.4.4 Cyber security

Ensuring cyber security of the smart grid is a critical priority. Security must be designed in at the architectural level, not added on later. A

NIST-led Cyber Security Coordination Task Group consisting of more than 400 participants from the private and public sectors was formed to develop a cyber security strategy and requirements for the smart grid. Activities of the task group included identifying use cases with cyber security considerations; performing a risk assessment including assessing vulnerabilities, threats and impacts; developing a security architecture linked to the smart grid conceptual reference model; and documenting and tailoring security requirements to provide adequate protection. Results of the task group's work are described in a publication NIST IR 7628.

8.5 Evolution of the Standards Framework

The reference model, standards, gaps and action plans described in the NIST Release 1.0 Smart Grid Framework and Roadmap provided an initial foundation for a secure, interoperable smart grid. However this initial document represents only the beginning of an ongoing process that is needed to create the full set of standards that will be needed and to manage their evolution in response to new requirements and technologies.

In Phase 2 of the NIST smart grid program, a public-private partnership, the Smart Grid Interoperability Panel (SGIP) was formed to provide a more permanent organisational structure to support the ongoing evolution of the framework. The SGIP provides an open process for stakeholders to participate in the ongoing coordination, acceleration and harmonisation of standards development for the smart grid. The SGIP does not write standards, but serves as a forum to coordinate the development of standards and specifications by many standards development organisations. The SGIP reviews use cases, identifies requirements, coordinates and accelerates smart grid testing and certification, and proposes action plans for achieving these goals.

The SGIP has two permanent committees. One committee is responsible for maintaining and refining the architectural reference model, including lists of the standards and profiles necessary to implement the vision of the smart grid. The other permanent committee is responsible for creating and maintaining the necessary documentation and organisational framework for testing interoperability and conformance with these smart grid standards and specifications. The SGIP is managed and guided by a Governing Board that approves and prioritises work and arranges for the resources necessary to carry out action plans. The Governing Board's responsibilities include facilitating a dialogue with standards development organisations to ensure that the action plans can be implemented.

The SGIP and its governing board are an open organisation dedicated to balancing the needs of a variety of smart grid related organisations. Any organisation may become a member of the SGIP. Members are required to declare an affiliation with an identified Stakeholder Category (twenty-two have thus far been identified by NIST and are listed in the box). Members may contribute multiple Member Representatives, but only one voting Member Representative. Members must participate regularly in order to vote on the work products of the panel.

8.6 International Collaboration

Many countries have begun or are planning to modernise their electric grids. The United States' electric grid interconnects with Canada and Mexico, and the equipment and systems used in the grid are supplied by companies that address a global market. Therefore a major goal of the NIST program is to utilise international standards wherever possible, and to ensure U.S. participation in the development of smart grid standards by international organisations. The NIST program works closely with IEC Strategic Group 3 on smart grid, and looks to various IEC TCs, such as TC57, which is working on a Common Information Model for the smart grid, to provide key parts of the NIST Smart Grid Framework. Other international organisations whose standards

Table 8.1: Smart Grid Stakeholder Categories

Appliance and consumer electronics providers	Power equipment manufacturers and vendors
Commercial and Industrial equipment manufacturers and automation vendors	Professional societies, users groups, trade associations and industry consortia
Consumers - Residential, Commercial, and Industrial	R&D organisations and academia
Electric transportation industry Stakeholders	Relevant Federal Government Agencies
Electric utility companies - Investor Owned Utilities and Publicly Owned Utilities	Renewable Power Producers
Electric utility companies - Municipal	Retail Service Providers
Electric utility companies - Rural Electric Association	Standard and specification development organisations
Electricity and financial market traders (includes aggregators)	State and local regulators
Independent power producers	Testing and Certification Vendors
Information and communication technologies (ICT) Infrastructure and Service Providers	Transmission operators and Independent System Operators
Information technology (IT) application developers and integrators	Venture Capital

play an important role in the NIST framework include IEEE, IETF, ISO, ITU-T, SAE and others.

The process of international harmonisation is also facilitated through bilateral communication and information exchange. To encourage international harmonisation, participation in the NIST Smart Grid Interoperability Panel is open to organisations outside the U.S.

8.7 Conclusion

Realisation of the smart grid represents one of the greatest engineering challenges of the 21^{st} century. Its development and deployment in the U.S. is being accomplished within a national policy framework enacted in federal legislation. A robust foundation of standards is critical to achieving an interoperable and secure smart grid. This foundation is being developed through an innovative public/private partnership model, and a heavy reliance on information technology. Smart Grid is definitely an example of a "greening" that could not be achieved without resorting to IT.

Dr. George Arnold
Gaithersburg, MD, United States of America - April 2010

Dr. George Arnold was appointed National Coordinator for Smart Grid Interoperability at the National Institute of Standards and Technology (NIST) in April 2009. He is responsible for leading the development of standards underpinning the nation's Smart Grid. He served as Chairman of the Board of the American National Standards Institute (ANSI), a private, non-profit organisation that co-ordinates the U.S. voluntary standardisation and conformity assessment system, from 2003 to 2005. He served as President of the IEEE Standards Association in 2007-2008 and Vice President-Policy for the International Organization for Standardization (ISO). Dr. Arnold received a Doctor of Engineering Science degree in Electrical Engineering and Computer Science from Columbia University in 1978.

CHAPTER 9

The Green IT Industry Ecosystem

9.1 Action!

Greening IT does not happen by itself. It needs involvement and resources: people, time, money, influence, organisational structures, and support by political institutions, non-governmental organisations and the general public. Indeed, support builds up, and in recent years, many formal and informal groups have been formed whose main focus is aspects of greening IT.

In my opinion, the term “Green IT” should not only be applied to technical or organisational attempts to lower energy usage or material use of IT. Rather, I will also include efforts to improve the working conditions in the IT sector, especially the early steps of the production chain, such as mining and chip manufacturing, and to prevent illegal export of e-waste or recycling of those materials under unacceptable conditions that put the workers, very often kids, in danger.

This chapter will concentrate on some globally active, some European and, as Germany is the country I come from and know best, in particular some German organisations and groups, initiatives and projects.

Green-IT-Organisations and projects should not only be categorised according to their geographical scope. Another relevant distinguishing characteristic is the nature of their organisers and members: Some organisations and projects are organised and promoted by national or international governments. What they do may sooner or later lead to regulations, like the European Ecodesign directive or EuP regulation, but also often leads to legally non-binding agreements where participation is voluntary, like for example the European Codes of Conduct. Other organisations are mainly initiated by the IT and electronics industry, mainly to deal with complaints of the general public and NGOs, for example regarding unfair working conditions in mining and electronic industries. Last but not least there are NGOs and projects addressing the general public and not being organised by IT companies, which form a third group of organisations/projects that can be identified.

9.2 History: It began in the 80s!

Many people think that Green IT is a purely new idea, born in the third millennium - but that is wrong. While I only know some of the German part of the story, there is a whole chapter about that in this book (2). Around 1990/91, I was an editor with the 'Elektronik Journal' and very interested in ecology, when I heard about a big study by VDE/ITG. The ITG (Society for Information Technology) within VDE (Association of electrical, electronic and IT technology) was formed in the late 1980s.

During the 80s, the green movement was strong in Germany, and it influenced public discourse. Influenced by that spirit, one of the first projects ITG started was research on what IT and electronics could do for environmental protection and environmental science. The project resulted in three books, each several hundred pages thick, covering each and every aspect of the topic as it was seen at that time.

The most important themes then were environmental management of companies and landscapes as well as software to support this, expert systems, geographical information systems, new types of sensors that reacted to very low amounts of poisonous materials and so on. There was also a whole volume on logistics, vehicle technology and traffic management - including a detailed description of hybrid cars and hydrogen cars. Very familiar, it seems. But other ideas like Smart Grid (see chapter 7) were not discussed in the late 80s.

The project and its results were presented at a press conference in 1991 in Bonn that was attended by approximately 30-40 journalists, one of them me. I reported extensively in the 'Elektronik Journal' and 'Umwelt Journal', and continued to follow the public discussion, but unfortunately the public shifted its attention to other issues during the following years. Developments went on, but were mostly discussed among specialists at universities.

It took about fifteen years until "Green IT" suddenly popped to the top of the IT industry agenda (and my agenda) again. Meanwhile, the Internet had occupied the world as an indispensable resource of information for everyone. Digitisation of almost everything advanced. More and more data piled up. PCs and servers became stronger and stronger - and needed more and more electricity.

9.3 Comeback in the 21st Century

During the 90s everybody was more interested in the falling of the Berlin wall and the stock exchange, but the patterns of public attention changed again around the change of the millennium. Still, there was a lot going on in the background throughout the 1990s. A lot of the history of science around the energy used by computers is to be found in a paper by, Jonathan Koomey, an American scientist from Lawrence Berkeley National Laboratory and Professor at Stanford University, published in February 2007. It states that research around that topic started in the 1990s after the first version of the Energy Star label was implemented.

During the 90s and the first years of the new millennium, there were some studies based on IDC data that covered the energy use of servers worldwide. Koomey, in his 2007 paper, presents astonishing data about the power consumption of servers nation- and worldwide (http://enterprise.amd.com/Downloads/svrpwrusecompletefinal.pdf). The numbers were much higher than anybody had expected.

But research was also done by IT practitioners. Here, Kenneth G. Brill played a key role. He founded Uptime Institute about 25 years ago (http://www.uptimeinstitute.com). Approximately 100 US and EMEA data centers have joined Uptime Institute. The Institute since its foundation steadily develops groundbreaking new ideas and concepts on data centres.

Around 2004-2005, Brill did calculations on the efficiency of data centres in relation to power usage. A basic rule of all IT so far is or was Moores Law. Moores Law roughly says that the numbers of transistors on an integrated circuit and hence its capabilities doubles every second years. This means, that also efficiency of IT more or less doubles every second years. And that means that it is not so important if these chips also use a little more energy if only the total increase in efficiency by the new generation, is not to be eaten up by some other effects, such as energy and other operating costs.

But that, Brill found, was exactly what happened: Due to rising energy prices, rising system complexity and exploding amounts of digital data, the additional efficiency added by each new chip generation was more and more consumed by additional operating cost. If this trend continued as projected, very soon there would be no more economic sense in buying new computers and building new data centers. In 2006, Uptime Institute made energy scarcity and the insatiable thirst of underused IT systems the topic of its annual congress.

Additionally, the practical implications of theory already began to show: Some data center managers experienced that they ran out of energy: Their energy needs expanded so quickly with all the new and power-hungry equipment they bought that they had to integrate a new and very expensive electricity supply into their existing or new data centers. In some cases, the electricity provider informed data center management that a certain data center would only get a limited amount of electricity and not more, because the resources were simply not there. The providers made it clear to the horrified managers that the only way to get more electricity would be to move their data center to some other place, where electricity was not an issue.

9.4 IT Managers Demand Better System Use

Until then, the most used and recommended solution for any problem (slow servers, slow storage, growing amounts of data, new applications) was to buy new hardware. And so, the utilisation of servers or storage was often only 10 to 20 percent or even lower, the same for storage. Virtualization of anything besides the mainframe was a very immature technology, and not yet used very much. But now, buying new hardware became simply too expensive. This was not only due to electricity, but also due to administrative costs: every new server or storage array resulted in five or six or even ten times its price in operating costs, including management, support, energy and space, and users were no longer prepared to accept these preconditions. They started to demand new solutions with better usage and less administrative costs. Vendors had to react. And so they did, massively. Often with glossy brochures and marketing hype.

So, Green IT became the topic of the day for a while. By the end of 2009, however, attention for Green IT went on a downward slope. This had to do with the economic crisis, but also with an audience overfed with marketing slogans without substance. A lot of users are now almost allergic to the term Green IT, because it has been misused for marketing purposes so often.

On the other hand, more and more IT managers understand that the ideas of Green IT are substantial and unavoidable, especially in terms of climate change, carbon credits and so on. So I am sure it will stay and grow, as it has clear economical and ecological benefits.

In the following sections, I will look at organisations that deal with Green IT, starting with those active on a global scale and ending with those in Germany.

9.5 Worldwide Organisations - Industry Driven

9.5.1 Green Grid

The most important vendor driven organisation in Green IT is The Green Grid (`http://www.thegreengrid.org`). Founded around 2006, the Green Grid's founding members were mostly suppliers of data center equipment: servers, storage, cooling, UPS systems, enclosures and so on.

The Green Grid has developed into a center of gravity for different projects and organisations that deal with Green IT. For example, the abovementioned Uptime Institute is today one of the members as well as the European Code of Conduct for Data Centers.

The membership fee is between 25,000 (contributor) and 950 (Associate) US$/Year. The board members are Dell, IBM, Oracle, AMD, APC (Schneider Electric), HP, EMC, Intel and Microsoft. The Green Grid is associated with several other organisations that try to make IT greener, among them SNIA (Storage Networking Industry Association, `http://www.snia.org`), DMTF (Distributed Management Task Force, `http://www.dmtf.org`), and the Japanese Green IT Promotion Council (`http://www.greenit-pc.jp`).

Meanwhile, The Green Grid has developed a lot of helpful material for practitioners, for example a metric for measuring the efficiency of data centers or best practice guides for data center managers or the results of different data center centricvsurveys and analysis of data center related legislation. The organisation has spread to Asia and Europe. The European headquarter is in London. All material can be downloaded free of charge from its web site.

9.5.2 GeSI (Global E-Sustainibility Initiative)

Another globally active and vendor driven organisation is GeSI (Global eSustainability Initiative, http://www.gesi.org). The members of GeSi are mainly networking and telecom companies, but Sun, HP and Microsoft are also parts of the members that consists of about 20 organisations today. The Carbon Disclosure Project and WWF (World Wildlife Fund) are associate members. ITU (International Telecommunication Union (http://www.itu.org) and UNEP (UN Environmental Program, http://www.unep.org) support the organisation. Membership fees are not disclosed on the web site, interested companies or organisations have to send an application to the secretary of GeSi.

GeSi was founded in 2000, but one did not hear much from it until 2006, when the Smart 2020 report was published together with other organisations (Source: http://www.smart2020.org). It dealt with the chances to save carbon dioxide by intelligent IT use.

In 2008, GeSi also published a report about "Social and environmental responsibility in metals supply to the Electronic Industry" (Source: http://www.gesi.org/LinkClick.aspx?fileticket=anlAuBauWU8\%3d\&tabid=60). Consequently, GeSi developed a methodology for companies to steer and judge the social responsibility within their supply chain. Companies can join the web-based system E-Tasc (http://www.gesi.org/ToolsResources/ETASC/tabid/133/Default.aspx) since 2007. More than 300 have signed up so far.

In the run up to the Copenhagen Climate Change conference (COP15), GeSi held a side event at the Barcelona Talks, where the chances of Green IT to lower carbon dioxide outputs were discussed.

9.5.3 Green Data Project

Green data project (http://www.greendataproject.org), founded 2007, is driven by two industry groups who try to develop standards for data management: Data Management Institute (DMI) and Archive

Management.org (AMO). Two more founding members are Toigo Partners International, according to the website of Green Data Project an IT consumer advocacy, research, publishing and consulting firm from the US, and their test lab TPI.

Exploding data volumes and data mismanagement are some reasons for endlessly growing storage and energy needs in data centers and IT in general, and it is a main purpose of the project to develop best practices against this. Anyone can join the project; there is no membership fee, just a registration process. Vendors can become a sponsor, which means they have to pay. There are two classes of sponsorships with different pricing.

Green Data Project opposes a lot of vendors who state their products to be "green technology", although they are not or only to a very limited extent. So far, this attempt does not seem to render too much success, as the web page on which Green Data project wants to present best practice guides for Green IT, is more or less empty.

9.5.4 GSI (Green Storage Initiative)

In the wake of the discussion around tremendous energy costs for storage systems, the main association of the worldwide storage industry, SNIA (Storage Networking Industry Association, `http://www.snia.org`) reacted. It founded Green Storage Initiative (`http://www.snia.org/forums/green/`).

According to its web site, the initiative wants to conduct research on power and cooling issues confronting storage administrators, to educate the vendor and user community about the importance of power conservation in shared storage environments, leverage SNW (Storage Networking World) and other SNIA and partner conferences to focus attention on energy efficiency for networked storage infrastructures. It wants to provide input to the SNIA Green Storage Technical Working Group on requirements for green storage metrics and standards and to promote the results of its work.

From my own experience, I know that GSI has highly experienced specialists, who are influential in IT companies, but these people work for vendors - as in most of the above-mentioned organisations. It is hard to evaluate how big the influence of especially European IT users is within GSI. At least, SNIA has a European branch. GSI has developed Green Storage Tutorials, best practices guides for storage and data managers that can be downloaded free of charge (`http://www.snia.org/education/tutorials/2008/spring#green`).

Membership of GSI is only granted after an application. There are three different classes of members with different rights: Strategic Members are allowed to vote on GSI affairs and pay US$9,000 a year. Associate Members without the right to vote pay US$4,500 a year. Individuals and Non-profit Institutional Members get away with US$300 a year.

9.5.5 EICC (Electronic Industry Corporate Citizenship)

EICC (`http://www.eicc.org`) is an organisation of electronic industry companies who want to improve working and environmental conditions in the electronics supply chain. As such, it cooperates with organisations that look after similar subjects like GeSi.

Companies have to apply for membership. Fees are not published on the website, but a phone call to the organisation's office showed that there are two membership classes: one for companies, which report annual revenue below US$10 billion (they pay US$15,000 a year) and bigger companies (they pay US$25,000 a year).

Applying companies have to complete the application form. Members have to actively take part in the work of the EICC and to agree to the EICC Code of Conduct. It deals with working conditions, health, safety, management practices and environmental behaviour. It can be downloaded in a lot of languages besides English, mostly of countries where electronic equipment is produced. They have to apply this Code at least within their organisation and their first tier suppliers instead of a company specific Code of Conduct. Company specific Codes of Conducts are permitted additionally only if they are in accord with the operating principles of the organisation.

Members have to supply data concerning their progress towards the goals of the organisation and to use tools that the organisations make available to reach them.

Besides, EICC organises conferences and workshops, for example on improving the working conditions within the supply chains of rare earth minerals used in the production of electronics, for example tantalum that belongs to the rarest materials on earth. The goal is to establish a sustainable supply chain, where labour rights and environmental protection regulations are respected.

EICC has installed a carbon reporting process for companies from the electronics industry that tracks emissions of electronic companies and direct suppliers with an online system. A total of 21 electronic companies participated in that system until June 2009. More recent numbers are not available. The organisation also publishes a monthly newsletter.

9.5.6 Climate Savers

Not originally Green IT centered, but nevertheless important, is the Climate-Savers-network (`http://www.worldwildlife.org/climate/climatesavers2.html`), organised by the WWF (World Wildlife Fund). Member companies, among them many big IT players, such as IBM, Nokia, HP and Nokia Siemens Networks, try to reduce their carbon footprints by reporting their emissions and taking steps to emit less greenhouse gases. These steps may involve IT. Among them, HP is the only company that joined a close partnership with WWF Climate savers, explicitly looking for IT innovations that could reduce carbon dioxide emissions.

9.5.7 Green Electronics Council

Green Electronics Council (GEC, http://www.greenelectronicscouncil.org) is an American non-profit initiative founded in 2005. It is part of the International Sustainable Development Foundation (ISDF) (http://www.isdf.org) based in Portland, Oregon. Its focus is on electronics and sustainability. The organisation says it wants "to redesign our relationship to electronics". Its main project is EPEAT (http://www.epeat.net), an online certification system that evaluates products like computers, laptops and the like, according to environmental criteria. Products certified can get a bronze, silver or gold certification. The database is free of charge and can be used as a source of information by procurement professionals worldwide. Three people are managing this project professionally, and GEC has a Board of Councillors of four people, scientists and other experts, with deep knowledge on Green IT and electronics recycling. Right now, GEC is not a membership-based organisation, but the team is considering how to change that. Interested parties who also work with sustainable electronics and recycling are encouraged to contact GEC.

9.5.8 Green Touch

For a while the networking community has been discussing the immense energy use of surfing and other activities on the Internet. Now, a new industry-driven organisation, Green Touch (http://www.greentouch.org) wants to change all this.

Its goal is nothing less than to make the Internet 1,000 times more energy efficient. Bell Labs (ex Lucent, ex AT&T, today Alcatel-Lucent), known for their massive patent output, are taking a leading role in this effort to make worldwide digital communication sustainable. Other major contributors are the MIT (Massachusetts Institute of Technology) Electronics Lab and leading science institutions from France and Australia.

Additionally, a lot of the global IT providers take part in the initiative. So far, there has not been any output, but as Green Touch was founded only weeks ago, this would be expecting too much.

9.6 Worldwide - Driven By The General Public

9.6.1 Greenpeace

Greenpeace is, as everybody might know, not a Green IT-only organisation and definitely not IT-vendor driven, but should be mentioned here because the organisation publishes the often cited Guide to Greener Electronics (`http://www.greenpeace.org/international/press/reports/searching-for-green-electronics`). It can be downloaded for free. Regularly, the evaluations of Greenpeace lead to reactions and adaptations of the industry, although the judgments of the report are sometimes heavily doubted by the criticised companies. Still, Greenpeace represents an indispensable force of public interest on the way to greener electronics worldwide.

Greenpeace pushed the discussion about illegal E-waste export and other waste-related problems of the industry and will hopefully continue to do that.

9.6.2 Good Electronics

Good Electronics (`http://www.goodelectronics.org`) is a worldwide organisation that coordinates of a lot of other activities around working conditions, E-waste-treatment, sustainability within and of IT and electronics industry. The organisation's coordination point is hosted by SOMO (Centre for research on multinational corporations, `http://www.somo.nl`) in Amsterdam, The Netherlands. Additionally, Good Electronics has a steering committee and a network of participants consisting of human rights organisations, labour rights organisations, environmental organisations, trade unions, universities and individuals from Brazil, Canada, China, Congo, Europe, Hong Kong, Hungary, India, Indonesia, Malaysia, Mexico, Thailand, The Philippines, Singapore and the USA.

The steering committee consists of the following members: CAFOD (UK), CEREAL (Mexico), Interfaith Center on Corporate Responsibility ICCR (USA), the International Metal Workers Federation, IMF (Switzerland), Silicon Valley Toxics Coalition SVTC (USA), Electronics Take Back Campaign (USA), SOMO (The Netherlands) and TIE ASIA (Malaysia). There are several dozens of member organisations worldwide.

Good Electronics publishes a (more or less) monthly newsletter with a lot of interesting links to text and multimedia sources on the web. It also publishes a lot of useful stuff itself. The most recent bigger publication is "Reset", a study on Corporate Social Responsibility in IT and electronic industry, its legal base, the state of affairs and how companies willing to do so can advance the situation within their sphere of influence, step by step. All publications are free and can be downloaded from the web.

Among the most interesting items on the website of the organisation, is a list of companies with information from media and other sources on the CSR behaviour of the respective company (`http://goodelectronics.org/companies-en`).

9.7 European Organisations and Initiatives - EU-driven

9.7.1 EU Codes of Conduct

There are two European Codes of Conducts important for IT-related industries. Both are managed and promoted by the Commission of the European Union:

1. The EU Code of Conduct for Broadband Equipment
2. The EU Code of Conduct for Data Centers

The EU Code of Conduct for Broadband Equipment resulted in guidelines on the maximum energy use of end user broadband telecommunication equipment (http://bit.ly/BfdH), which were published on November 18, 2008. Members that agreed to it so far are Telekom, Swisscom, Alcatel-Lucent, Huawei, Telia-Sonera, Telecom Italia, Thomson, and TDC Services.

The EU Code of Conduct for Data Centers is still in its beginnings. The reason for establishing it was that data centers use more and more energy. In some areas in Switzerland, mainly around Zürich, their energy consumption reaches double-digit percentages of the total amount of electricity available there. In London, data centers run into limits concerning the availability of energy resources and are asked to move outside the most crowded city spaces.

Data centers that become members of the Code of Conduct commit themselves to saving energy by using and installing certain technologies and best practices that are listed in the Best-Practices-paper published on the web.

To ease the beginning, companies have to fulfil very limited preconditions, one of which is to install measuring equipment and report the energy use of the member data center regularly, and at least once a year. Every year, members are supposed to improve their energy efficiency. To do so, they can implement new technologies or practices from the Code of Conduct.

In doing so, they are allowed to label the participating data centers with a Code of Conduct label for marketing. For data centers, membership is free. But cost may arise for necessary investments - for example in measurement equipment, implementing new practices and reporting. Vendors can also participate, but only as endorsers.

So far, only 18 data centers in Europe have signed up (December 2009). 57 IT companies and other interested parties have become endorsers. The EU representative Paolo Bertoldi, who is responsible for the project, believes the reason for the slowly growing number of members is the financial effort and the time needed to implement the first steps of the program before the first money is saved. Also, lacking information about the project is a problem in some EU member states.

Lately, a new and finalised version of the Code of Conduct has been published on the web together with other documents, e.g. an application form for data centers, a Best-practice-guide etc. (address see above).

9.7.2 EU Energy Star

The Energy Star Project (`http://www.eu-energy-star.org`) is run by EU and US government agencies in common. On one hand, Energy Star wants to motivate vendors to improve the energy efficiency of their products; on the other hand, it wants to enable private people, companies and the public sector to buy the most energy efficient IT equipment.

For that purpose, Energy star publishes new rules for the different kinds of equipment regularly and revises them every few years or even quicker. For example, in 2009 a new guideline (v. 5.0) for displays came into force, documents on servers and on enterprise storage were published and new guidelines on computers were adopted. Equipment that conforms to energy star regulation is registered and labelled with the Energy Star Label by the vendor. After that, it is listed in the databases on the Energy Star web site. The database shows a list of different categories of equipment (from computers to gaming consoles) and its energy efficiency values. Another list contains appliances only tested against older versions of the specifications. As Energy Star has quite a high reputation, a lot of vendors try to guarantee Energy-Star-conformity of their products.

Important dates and documents are published in the news section of the Energy Star website. Energy star can be regarded as one of the most efficient programs to raise the energy efficiency of IT equipment.

9.8 EU - Driven By General Public

9.8.1 MakeIT fair

MakeIT fair (http://www.makeitfair.org) is a European project concentrated on consumer electronics that receives funding from the European Commission, but is not organisationally linked to it. The campaign is steered by Dutch SOMO (Centre for Research on Multinational Companies, http://www.somo.nl) that has itself strong links to Good Electronics (see above), procureITfair and pcGlobal (see below).

Different from many of the other organisations, it is strongly influenced by church organisations, Northern and Eastern European organisations and especially addresses young people.

Project partners of MakeITfair are SwedWatch and Fair Trade Center from Sweden, finnWatch and finnish Association for Nature Conservation from finland; Germanwatch and Verbraucher Initiative from Germany. Different from many other projects, there are also organisations involved from the countries, where electronics or raw materials are produced: ACIDH from the DR Congo, CIVIDEP from India and SACOM from China. Organisations from different European countries support the campaigns of the project. Some examples: BDKJ - Bund der Deutschen Katholischen Jugend (Germany), Church of Sweden, Ecumenical Academy Prague (Czech Republic), Gemeindejugendwerk (Germany), KARAT (Poland), an organisation that focuses on gender equality, Morgen (The Netherlands), a student organisation for sustainable development, Entwicklungspolitisches Bildungs- und Informationszentrum (EPIZ, Germany), just to name a few. On their website, one finds some of the publications also offered for download by Good Electronics or procureITfair, but also additional material, for example on working conditions in the electronic industry in Central and Eastern Europe. The web site also contains an information section with detailed information about the materials used to produce PCs, mobile phones and - astonishingly - cars and how much of it is recycled. Additionally, they supply information about where the materials come from.

One of the latest campaigns of MakeITfair is a web application enabling its users to estimate in detail the carbon footprint of the consumer goods they buy. 2008, MakeITfair directed an action towards the makers of cell phones. Sending them thousands of postcards, they demanded fair production conditions from them and their suppliers.

In May 2009, the project brought together NGOs and representatives of 24 IT companies. They discussed how to make the IT production chain more sustainable. The project produced a report (`http://bit.ly/beUaPK`) and will go on working on that topic.

MakeITfair directs itself towards young customers and their teachers. Because of that, the website of the project contains an education section with interactive teaching materials (Teacher 's Manual). The most interesting of it is Webquest, an interactive online quiz for the 14-16 years old crowd. It deals with the issues of MakeITfair in seven European languages:

first, visitors get information related to production chains and working conditions in the electronics industry. They may also look at multimedia material. After that, they answer questions about that information and put their answers into a work sheet on the web, respond to an online quiz or write a story concerning these issues. MakeITfair also offers a special blog for young people and organises a roundtable for youngsters from all over Europe every year. In 2009, it took place in Amsterdam.

9.9 German Initiatives and Organisations - Government and Industry Driven

In Germany, many projects around Green IT are joint initiatives supported by leading IT vendors, science institutions and the federal government. Because of that, industry and government section are presented together.

9.9.1 Green IT Allianz

The most important official project around Green IT in Germany is Green IT Allianz, a joint effort of IT and software producers who have facilities in Germany, science institutions,

industry and user associations and political actors like the Bundesministerium für Wirtschaft (Federal Ministry for Economy). The ministry itself promoted the foundation of the initiative in 2008. It is a part of its action plan Green IT. The German federal government wants Germany to take a leading role in greening IT. Other parts of this action plan is government aid for the project "IT goes green", which belongs to the federal environmental innovation program, the initiative E-Energy to develop and implement smart grids for electricity and building a national network of competency among science institutions dealing with Green IT.

The goal of Green IT Allianz is to bring together all stakeholders and to find ways to make IT more sustainable by inventing innovative ways to reduce carbon footprint by IT use and also in its production, usage or recycling. The industry association BITKOM (Bundesverband Informationswirtschaft, Telekommunikation und Neue Medien e.V.) coordinates Green IT Allianz. The initiative does not have a budget of its own so far. It is supposed to finance itself by voluntary contributions from its members, mainly consisting of working time, travel expenses and phone bills. It is to be seen if this leads to good results.

The alliance has organised itself in six working groups:

1. IT as enabling technology for other branches to reduce carbon footprint (Leader: Fujitsu Technology Solutions). Its goal is not only to find innovative uses for IT but also to make estimations on their business potential.
2. Masterplan Green IT (Leader: Borderstep Institut für Innovation und Nachhaltigkeit): Borderstep is a science institution funded by the federal government to promote initiatives around sustainability. The group wants to develop a strategic masterplan for

IT use as a means to reduce carbon footprint and other negative outcomes of economic activity.

3. Software and Green IT (Leader: Sun Microsystems): The group wants to find out the potentials of software to reduce the energy and carbon use of IT, by reducing the necessary hardware resources to use software.
4. Green within IT (Leader: IBM/BSH Bosch Siemens Hausgeräte): The group wants to define best practices for IT users and to develop benchmarks that measure advancements in reducing the energy and resource use by IT.
5. Resource Efficiency in and by IT (Leader: Infineon): The group wants to develop a matrix of evaluation for ITC solutions with respect to resource efficiency.
6. Communications (Leader: Millennium Institute). The group is supposed to publish the results of the different working groups to a wider public.

First results were presented during Cebit 2009 and Cebit 2010. Hopefully, the special show on Green IT will become a regular part of Cebit. BITKOM has already published some very good material around Green IT, among them a guide on how to measure energy use of data centers or best practice guides on different matters, e.g. on server virtualization. They may be downloaded from the website of Green IT Allianz.

9.9.2 Cool Silicon

Cool Silicon (`http://www.cool-silicon.de`) is a joint scientific initiative that wants to reduce energy use of IT by better design, better software and better electronics. It is supported by the federal government of Germany. About thirty companies, eight non-university science institutions, four universities, the city of Dresden, the German country Saxonia and the Technology Center Dresden support the project. It consists of three sub-projects:

1. Cool Computing tries to develop more efficient IT architectures by developing innovative hard- and software. In detail, one group within the project is working on different mask designs in chip production that will allow for denser chip structures without lowering energy efficiency. The other group is working on software for high performance computing that enables more efficient use of the massively parallel hardware infrastructure. Knowledge on how to better parallelise software could finally lead to a much more efficient use of parallel processors as they are now commonplace even in desktop computers. first results will be reached 2011, a computer based on the new mask technologies is supposed to be shown 2013.
2. Cool Reader: The project wants to develop and build an energy-autonomous newsreader that is supplied with electricity by integrated thin layer solar cells. The appliance would enable the replacement of physically distributed paper-based newspapers and journals by offering these media online in an as-printed-fashion over a broadband connection. This would lead to massive energy savings, as newspaper production and distribution in Germany uses as much energy as is produced by a nuclear power plant. A pilot sample is planned for 2012.
3. Cool Sensornet: The project is connected to the goal of the European airplane producer Airbus to reduce the fuel use of its jets by half by 2020. For this purpose, Airbus will massively increase the integration of innovative lightweight materials, mainly carbon fibres, into the airplane. To monitor these components continually, the working group wants to develop a new kind of sensor network. The sensors are supposed to work for 30 years, they will not need an external energy source and will work wirelessly. They consist of analogue and digital modules, an energy supply and a communication module. Within the airplane, the sensornet will continually check the vibrations within the carbon fibre parts and

detect any anomalies way before a problem may occur. This kind of sensor network, once it is developed, may also be used to check the blades of windmills in energy plants or to check offshore oil platforms. first results are to be presented in 2012.

9.9.3 E-Energy

E-Energy is a project of the German Federal Ministry of Economy (BMWi). Its goal is to develop Smart Grid technologies and projects that implement them. Smart Grid (see chapter 7 in this book) is understood as an electricity infrastructure able to incorporate and control energy from different and distributed resources. A Smart Grid can by means of ICT switch on and off end-user equipment within the limits the end-users defined to balance energy demand and supply in the network. By this, end-users can demand low tariff energy in a differentiated tariff system, which is also to be implemented during the years to come. The functioning of a Smart Grid depends on the massive use of ICT technologies. So far, in Germany, six model project regions of different character (rural, city, mixed etc.) have been defined. Within these regions, different aspects of smart grid technology are to be implemented and tested. The projects are funded with €140 million by the Federal Government.

1. eTelligence (Project Coordinator: EWE AG): Implementation of a Smart Grid in a region of low density population. E-DeMa (Project Coordinator: RWE): Implementation of a Smart Grid in a part of the Rhine-Ruhr-Region. The project concentrates on the development of intelligent controls for electricity demand and intelligent distribution structures for electricity. This is to be reached - among other measures - by the implementation of smart meters.
2. MeRegio (Project Coordinator: EnBW AG): MeRegio means Minimum Emission Region. The project wants to reduce the regional

output of carbon dioxide by use of ICT. The project is developing an emission certification and also implementing the latest and most advanced technologies for online production of energy. Definition of best practises and standards is another important part.

3. Modellstadt Mannheim (Project Coordinator: MVV Energie AG): The project concentrates on a densely populated region with a lot of renewable and decentral energy sources. The project wants to integrate several kinds of energy sources and uses (electricity, gas, water, heat), that are to be connected via a broadband power line. Hereby, the distance between the locations of energy production and energy use is supposed to be minimised.
4. RegModHarz (Project coordinator: RegenerativKraftwerk Harz GmbH & Co KG): The project wants to control the input of different kinds of regenerative energy into a smart grid by ICT and so to design a virtual power plant.
5. Smart Watts (utilicount GmbH & Co. KG): 15 local energy providers cooperate to build an "Internet of Energy". The project wants to develop smart meters in households and integrate them to form a home energy center, which enables the use of household appliances when there is plenty of electricity available or electricity is cheap. An important component of Smart Watts is EEBus, a universal communication interface for all electrical appliances. It is supposed to integrate those into the Internet of Electricity. EEEBus is to become a vendor-independent open standard. Its main qualities: easily integratable into existing infrastructures, low energy use, reasonably priced, accepted by end users.
6. E-DeMa (Project Coordinator: RWE Energy AG): The project concentrates on the Rhine-Ruhr-Area, an old industrial core area of Germany. Its focus is to build an energy marketplace and a so-called IKT Gateway that is to transfer data from the prosumers of electricity to the grid and back. 100,000 intelligent counters are to be installed in Mühlheim, one of the participating cities. The

project wants to test the marketplace as the exchange point between all stakeholders within the Smart Grid, where prices are made by demand and supply, information about prices is exchanged and new or old services are offered. Prices are to be used to steer demand and supply so that spikes and "valleys" in energy supply and demand are intelligently evened out.

The web site of e-energy contains in its "Wissenspool"-section a lot of information material, partly in multimedia format, that describe principles, functions and advancements of E-energy and smart grids.

9.9.4 Nachhaltiger Entwicklungsplan Elektromobilität (Sustainable Development Roadmap Electromobility)

The Electromobility roadmap and the projects associated to the roadmap (`http://www.bmu.de/verkehr/elektromobilitaet/doc/44798.php`) were initiated by the Federal Ministry for the Environment, Protection of Nature and Security of Atomic Power Plants. It is closely connected to E-Energy, as the batteries of electronic cars are seen as a major energy sink when too much energy is in the grid. The Roadmap wants to bring 1 million electronic cars on to the German streets by 2020. Different Federal Ministries fund the roadmap with €500 million. The first €100 million are paid until end of 2011. The funding supports the development and implementation of new drive technologies, energy storage and network infrastructure in field trials on private car traffic, logistics for goods and services by cars and trucks, battery recycling and hybrid busses.

9.9.5 Innovationsallianz Lithiumionen-Batterie (LIB 2015)

For sustainable Smart Grids and especially for "electromobility", the development of better batteries and energy storage is of paramount importance. That is why the companies BASF, BOSCH, EVONIK, LiTec, and VW obliged to invest €360 million. into the development of better lithium ion batteries in the coming years. The project is also funded by the German Federal Ministry for Education and Science (BMBF) with €60 million. The goal is to increase the energy density and the performance of lithium ion batteries by 500 up to 1,000 percent.

9.10 German Projects and Initiatives - Driven By The General Public

9.10.1 pcGlobal

Different from what the name suggests, pcGlobal (http://www.pcglobal.org) is a project of the German organisation WEED (Weltwirtschaft, Ökologiekologie & Entwicklung, http://www.weed-online.org) e.V. WEED has hundreds of members, but the work within pcGlobal is done by two people working full time in an office in Berlin. pcGlobal deals with working conditions; labour rights and greening the IT production chain of the IT and electronic industry in general.

The project is a member of the worldwide Goodelectronics network (see above). Among other things, pcGlobal has developed guidelines for green IT procurement of public institutions.

One of the most important current activities of pcGlobal is the campaign procureITfair (http://www.procureITfair.org). The campaign is organised by WEED/pcGlobal and several European organisations. The web page of the campaign provides news and information concerning the compliance of different vendors to labour rights and environmental legislation. Through this, it wants to help especially big buyers of electronic and IT equipment to make the right purchasing decisions with respect to these aspects.

In 2009, the campaign launched a company monitor on the web (http://procureitfair.org/companies-en). It lists big IT players alphabetically and then shows the latest news about each of these companies related to the topics of the campaign. The news items are cited from the media or other sources and evaluated thumbs up or down.

The publicity of the campaign rose strongly due to the widely cited report "The Dark Side of Cyberspace", recent edition published in February 2009. In 2009, there were also three more publications, the latest a follow-up on a report about the dissatisfying working conditions at two suppliers of mobile phone components in China ("Mobile Phone Production in China", Dec. 2009). These two companies supply four leading mobile phone vendors.

In July 2009, the campaign published a best practice guide to professional IT purchasers in big organisations. It shows how to consider sustainability criteria in every step of the purchasing process. A similar guide was published in Dutch in September 2009.

9.10.2 DUH - Green Electronics

Green Electronics (`http://www.duh.de/715.html`) is a federal-government-sponsored project of Deutsche Umwelthilfe e.V. (`http://www.duh.org`). It consists of an online communication platform around Green IT, informs consumers about energy efficiency of electronic and IT appliances and tries to motivate vendors to design more ecofriendly appliances. The most prominent part of the work of Green Electronics was a monthly price for a Green-IT-project that ran for some time until the summer 2008. The winner was published on the web.

Ariane Rüdiger
Munich, Germany - December 2009

Ariane is an accomplished and highly respected researcher, analyst and journalist with over 20 years experience reporting on various issues in the IT industry. Her fields of expertise include Sustainable Information Technology, Telecommunications and Renewable Energy to name just a few. Ariane has been published by many well known publications (primarily in Germany) and has intimate knowledge of the IT industry which allows her to analyst and report from not just a technical perspective, but from an economic perspective too.

CHAPTER 10

Out of The Box Ways IT Can Help to Preserve Nature and Reduce CO_2

So "green" goes pop! Suddenly, green seems to be the solution for every problem in the world (from layoffs to climate changes). Therefore, technology could not be far from that reality - and Green IT is the name given to explain that phenomenon in the binary world.

According to the Green IT Promotional Council in Japan, the definition of Green IT entails energy saving in IT devices as well as using IT devices to save energy in society.

According to some members on Greenpeace's online forum however, such Green IT concept is a myth, as computers will always be "pollution beasts" due to the amount of harmful, toxic materials that most PCs are constructed with. Furthermore, when a PC is thrown into a landfill, these toxic materials can have potentially adverse affects on the environment.

Battles apart, I personally believe that IT can provide many other solutions that go far beyond the noticeable ones, such as Cloud Computing (see chapter 5) or Smart Meters (see chapter 7); both of which are good examples of using IT devices to save energy. One of those out of the box solutions is illustrated by a recent announcement by Microsoft Japan, which will start to offer refurbished license agreements for those PCs that are built from recycled parts. Microsoft's problem is that most of the users remove the whole hard drive (which includes Windows operating system (OS)) before they dump the machine in a 're-selling' shop or ship it to land-fills in China. A computer without an OS is like a car without an engine, there is nothing controlling the hardware and it is effectively non-operational. Therefore, the new owner of the recycled machine has to buy a new license, which can be more expensive than the recycled machine itself, or possibly illegally copy and install an unofficial version that consequently makes Microsoft loose money. By offering a more affordable license, Microsoft makes an effort to avoid the PC being dumped to a land-fill because of a lack of the OS; thus keep the business happily running as usual. Microsoft's strategy at the same time saves the environment from the toxic materials and energy wasted that it would have taken to make a brand new computer. It is a Win-Win strategy for business and environment.

There are a number of other creative possibilities, such as applying successful Internet business models in favour of a greener world via IT - could they play an important role in the near future and help to Preserve Nature and Reduce CO_2 Simultaneously? Sure they can.

Let's take a look at some business models that were heavily influenced by the popularity of the Internet:

- Brokerage Models (reads eBay) help bring together 'buyers' and 'sellers' and facilitate recycle programs that for instance would take into consideration the location factor between the two, and consequently reduce the need of long distance travel for delivery, which overall contributes to CO_2 reductions.
- Furthermore, Demand Collection systems (known by the patented 'name-your-price' model, pioneered by Priceline) could again play a positive role in bringing down prices on Green IT

devices.

- Lastly, the Community model (reads Facebook, Mixi, LinkedIN among others) could, for example, speed up the green innovation creation and implementation by sharing knowledge/learning over the Internet.

But perhaps the biggest contribution of IT will come from the Internet itself.

10.0.3 Can the Web Save Us From Global Warming?

In one word - Yes!

According to the recently published book, *Hot, Flat and Crowded* by Thomas L. Friedman (Friedman, 2008), the challenge ahead of us is to create a system that takes into account the three main points of climate change:

1. Speed (we must move fast in our actions if we want to have a chance to stop global warming)
2. Protection (we have to stop what we already have from being destroyed)
3. Innovation / education (we have to intensify our knowledge sharing in order to achieve breakthroughs to create a new generation of the Earth's guardians)

How could we build such a system in a very short time? Well, maybe the answer is that we do not need to build one from scratch, but utilise what we already have. That is, we need to utilise the Internet's capabilities.

Looking at the Internet as a Green IT technology makes good sense. The Internet and the provided online services today, daily saves us from snail mail, going to the bank and a number of other time and energy consuming activities - thus making daily routines and tasks more efficient. Yet, the Internet has a far greater potential than optimising processes and saving energy.

Thinking along the lines of Green IT, the Internet can for instance be used for environmental protection. Engaging in the protection issue, a businessman, a native Brazilian tribe leader and a group of rubber tappers built one of the most forward-thinking initiatives in Amazon Rain forest protection - the "Yorenka Atame Forest University". A university, which is located literally in the middle of the Amazon Forest, accessible only by boat, forms a center where the Amazon's stakeholders share knowledge, later applying what they learned back to the forest.

First of all, let's try to understand what the Amazon is and represents to our planet. The Amazon jungle is the world's largest tropical rain forest. The forest covers the basin of the Amazon River, which is the lifeline of this natural O_2 factory and the world's second longest river. Further, the Amazon hosts the greatest diversity of plant and animal life on Earth. Statistically speaking, 1/5 of the entire world's plants, birds and about 1/10 of all mammal species can be found here. Amazon's territory belongs to nine nations. In the case of Brazil, the Amazon deforestation is happening quickly, mostly in the states that border the forest. From the state of Rondonia to the state of Maranhao you would notice what is referred to as an "arc of destruction" in Brazil's country map. Any effort to stop that is welcomed; a University to perpetuate those efforts even more. Therefore, the "Yorenka Atame Forest University" was set up with a unique vision: that the forest itself teaches us how to preserve the forest.

The challenge faced by the "white men" was how to introduce useful resources, such as technology (video cameras, computers and Internet) without jeopardising the traditional culture of the native Brazilians. After a long debate, it was decided to implement the technologies. The wise decision started to show results and illustrates how the Internet could play an important role in the protection of our global resources.

In 2004, a Peruvian "wood hunter" group got into the area. In the past when such invasion occurred, the only way out would be to engage in deadly combat, which usually contributed to the native Brazilians dropping in numbers. Yet, this time using the 'new technologies', the native Brazilians started sending out e-mails that reached the mass media and the government and in a couple of days a military force came to the rescue of the native Brazilians. The Internet became the point of communication not only among the tribes (some of the tribes live hundreds of miles apart), but also with the world.

So, if the Internet (reads IT) works for nature protection, could it also work in other areas like Innovations and Educations? The answer is another "yes". The millions of Websites focusing on green issues provide valuable innovation and education resources and tools that enable anyone to re-think, re-create and react on our climate change challenges.

Another example of how the Internet can be such a powerful tool was the website tweetsgiving.org that raised over US$10,000 in just 48 hours through the power of Twitter[1] and other social media. Collectively, 336 contributors raised enough money to fund a new classroom for a school in Tanzania. If the Internet can help build schools in Africa and protect the Amazon rainforest there is in principle no limit to how the Internet could help us promote environmental protection, and not least to reduce the threat of climate change by promoting reductions of greenhouse gas emissions.

The Internet can positively contribute to a greener society. What we may see next is actually the "Web Green point zero" approach where the connectivity of the new Internet contributes to making the world a greener place.

Behavioural change is an important ally in the fight against climate change, and it is something that needs to happen before our societies can become greener, and engage on the path to a Low-Carbon society. Yet, it is always a discussion as to who has the responsibility to take the first steps: Politicians, business or consumers? Endless discussions keep actions on paper, and not implemented in real life. Often a group of concerned consumers or even some green businesses will make the first move, and spur interest amongst a wider group of people. Here, the Internet is a perfect tool to spread the word, campaign, collect support etc. amongst grass-roots, when we're up against hard economic interests.

Use of the Internet demands electricity. In fact, energy costs are becoming an increasingly important part of data center's operating costs (see chapter 4). We, as consumers do not notice it, as our electricity consumption is relatively low. But the large Internet enterprises such as Google, Microsoft, Amazon and eBay are using huge amounts of electricity - thus keeping up operating costs.

With the expansion of Internet usage for various purposes, not least for environmental protection, it is important to keep operating costs as low as possible, to make sure the required services are continuously provided. Keeping costs low can involve a number of Green IT activities, such as implementing more energy efficient technology to simply reduce energy consumption.

Yet, looking at the vast electricity consumption from an environmental perspective, not only the amount of electricity consumed becomes important, but even more so from which energy source the electricity is generated. The energy source also heavily influences the price of the electricity.

Think of a situation where carbon is priced accordingly to its environmental impact, thus internalising all costs - electricity prices would go up if it came from a fossil energy source, whereas it would fall if it was based on renewable energy. We could argue that for keeping costs down it is important to locate your data center in an area with vast flowing and cheap electricity - based on a renewable resource like hydro power. Today there is no internalisation of costs on fossil fuels and therefore they are generally cheaper than renewables. What needs to happen is a price to be put on carbon - e.g. as part of a new global deal on climate change. From one day to the next, this would force up the price of fossil fuel based electricity and make renewables the cheaper alternative.

Not only Information Technology, but Environmental Technology in general plays a crucial role in achieving reductions of CO_2 emissions, and the most well-known of those technologies today is Clean Technology[2].

Clean Technology is a good example of how to generate economic activities without touching a forest's leaf and its future expansion - it is one of the possible solutions to keep the Amazon and its inhabitants alive and for us to keep enjoying our planet.

The Amazon just like any other place in the world is suffering from climate changes. However, we must also understand that climate change is about saving people and not our planet.

Let's take a step back and take a look on the climate change issue. It is theorised that the true age of the earth is about 4.6 billion years, formed at about the same time as the rest of our solar system. The first hominid, related to modern man but with less than one-third of the brain size, evolved about 5 million years ago. Archaic Homo sapiens, with brains similar in size to modern man, but with larger faces and bodies, first appeared 500,000 years ago. Modern Homo sapiens evolved about 200,000 years ago, which means our species is less than 0.01 percent the earth's age.

Since its formation, the Earth has gone through many transformations, from its atmosphere to its geography. Therefore, it is very audacious and pretentious that we (humans) would have the power to destroy our own planet.

The diverse interventions that we do in our own habitat affect our two essential survival elements: Air and water. As a result, in a few hundred years (if we are lucky), the result of our current acts will be the destruction of the human beings on Earth, and not the other way around.

Life in other forms will continue to exist or will adapt to the new reality (a planet with diverse gases in the atmosphere and temperatures several degrees over what we have now).

Just like a malignant tumour, nature uses its own weapons to combat human beings (just like chemotherapy): Typhoons, earthquakes, heavy rains and high temperature levels, just to name a few. How would we change that and become a benign tumour instead?

Initially, we have to understand that it is our own responsibility as humans (no matter the colour of our skin, creed, country, or place in society) to save our future generations as well as the 6.7 billion people alive today.

Additionally, we must keep protecting our environment (including air and water) as well as continuing the clean innovation of our technology, in order to hand down to our children a better world than the one we inherited.

The third and last point is to be aware of the wise words of Chief Seattle (a leader of the Suquamish and Duwamish Native American tribes in what is now the U.S. state of Washington.) who once said: ”When the last tree is cut, the last river poisoned and the last fish is dead we will discover that we can’t eat money”.

There is no magic solution. As previously said, we, as a unified civilisation, have to take responsibility and rethink, recreate and perhaps even more important react in order to create a greener Earth for all of us, and definitely IT, such as the Internet etc., will make a strong contribution to that.

So, the next obvious decision we have in our hands, is to make a new global deal on climate change - and as soon as possible.

However, with more and more companies and individuals pursuing green solutions in order to save the world, another question arises: How green are we?

The Japanese Ministry of Economy, Trade and Industry (METI)’s recent decision to treat biofuels as a source of greenhouse gases and require oil companies to cut emissions, reveals that there is a gap between the Kyoto Protocol's definition of "green" (where bioethanol and other biofuels are treated as zero-emission fuels) and our current reality where producing and transporting account for a considerable and increasing amount of emissions.

Therefore, a new trend is emerging in the business world - the triple green: Green energy, green recycling (nothing new here) and now, green manufacturing. The holy commandment is: Clean and Green mass production, can you do it?

Take the solar industry, for example. Every less gram of silicon means not only reduced expenditure on silane (a chemical compound), but also on water consumed in the process of etching the wafer slices. That means a lower cost end-product, which in turn increases the consumer's adoption (due to the lower price), and a more overall environmentally friendly approach - the ideal win-win scenario as we make steps towards global mass-production levels on renewable solutions.

But wait! Can the same concept be applicable in our own lives? How green are we? Or even, who is greener: My neighbour who drives a hybrid car and is a vegetarian, or my friend who rides a bicycle and is carnivore? Could we use the triple green approach in a personal level as well?

The answer is a resounding "Yes". Let's take a moment to analyse our own triple green bottom line. Green energy in this case would mean measuring and keeping track of our own carbon footprint, and there are a number of websites to help calculate this. If we are doing well in this area, we would move to green recycling, which would be much more than just putting the right garbage in the right trash-can every Monday through to Saturday. In my definition that would mean reflecting how good you are on reusing things and avoiding unnecessary buying. Do you really need that Avocado Slicer?

Last but not least is the green manufacturing concept, and again my personal definition would be a bold approach more into the direction of how good are you in terms of transmitting your eco-values on a daily basis. In the end, we (as evolving beings) must have as a minimum common goal: Bequeathing our children a better world than the one we inherited.

But before we start pointing fingers as a generation, we have to keep searching for solutions, and questioning each one of them in order to avoid "green blindness".

An Einstein quote illustrates well the importance of questioning: "The important thing is not to stop questioning. Curiosity has its own reason for existing."

Hopefully, our questioning will bring better and true answers to our sustainable challenges in the future.

Flavio Souza
Tokyo, Japan - October 2009

Flavio Souza holds a double master degree (e-business and MBA) from the International University of Japan (IUJ), Niigata. He has over 15 years of experience working in marketing and hi-tech business areas at global corporations in his native Brazil, Europe and Japan. Souza is also the founder of Green IT group - GreenITers.

Notes

[1] Twitter is a social networking and microblogging website - `http://twitter.com`

[2] Includes renewable energy (wind power, solar power, biomass, hydropower, biofuels, etc.), information technology, green transportation, electric motors, green chemistry, lighting, and many other appliances that are now more energy efficient. It is a means to create electricity and fuels with a smaller environmental footprint.

CHAPTER 11

From KPIs to the Business Case - Return on Investment on Green IT?

As sustainability, carbon reduction, and climate change initiatives become more widespread, CIOs are likely to be called upon to develop and report sustainability performance indicators, especially those with direct and material financial implications. These indicators are essential to meeting evolving disclosure requirements and effectively managing sustainability programs. Key performance indicators (KPIs) are the backbone of balanced scorecards, dashboards, and any other fancy technology you can imagine. It is state of the art or best practice to have those tools. While it may be tempting or even irresistible to create visual metaphors, more often than not these are misused, without an understanding of what actually constitutes a good KPI and delivers long-term value to the organisation.

11.1 Key Performance Indicators

My goal in writing this piece is to give you a solid platform for understanding and applying performance management principles based on

KPIs. Rather than simply provide a list of possible KPIs, I would like to involve you in the process of creating and developing an understanding of them. In this way, you will then be able to assess whether certain KPIs are helpful or not. I find this to be a more sustainable and efficient way of using your intellect.

11.1.1 What Are Key Performance Indicators?

A myriad of tools and methodologies, including sophisticated software, are available for measuring and applying performance management. The basic underlying principles or objectives of these systems are all the same: producing data in a meaningful way, thereby enabling management to make informed, fact-based decisions. Key performance indicators are related to goals or objectives. KPIs are used to assess current performance and provide a means for tracking performance against that goal or objective. Each KPI is based on a metric, making it a quantifiable measurement. Not every metric makes a good KPI. Good KPIs are based on the organisation's critical success factors and aligned with corporate principles (e.g. corporate social responsibility, corporate governance). They differ for each organisation and industry. Specific green or sustainability KPIs can be similar for different organisations and industries (i.e. reducing the carbon footprint of Information Communication Technology (ICT)) or a green procurement policy might be alike, although they are weighted in different ways. Whichever KPIs are selected, they must reflect the organisation's goals and align with critical success factors. If the organisation's goals and principles change, the KPIs must transform as well. At the same time, the definition of the KPI and how it is measured should not change often.

In performance management, one of the basic rules in defining goals is to apply the principle of setting specific, measurable, aligned, realistic, and timely (SMART) goals. Take it another step, add two more considerations, and create even SMARTER goals: the addition of "ethical" and "recorded" to the model makes it even smarter!

11.1.2 Do I Need Those?

Once you have a set of KPIs, you can use them in different ways: for forecasting and long-term analysis of specific developments, discovery of deviations, or as performance management tools. Applied correctly, KPIs can be used for setting organisational, departmental, and individual/personal goals. KPIs give the organisation or individual a clear picture of what is important and how it will be measured. With the focus on KPIs, everyone knows what he or she needs to make happen. Consider also linking incentives to reaching KPIs, making them public and transparent. In this way, they become motivational tools. On the downside, poorly selected and defined metrics (i.e. unachievable goals) will result in low participation and dissatisfaction among the participants.

11.1.3 Quantifiable and Key to Organisational Success

A KPI of any value needs to be quantifiable. A generic goal like "become more green" is useless as a KPI, without understanding the scope and applicability. What does it mean, exactly - should the staff wear green body paint, or should the company logo be green? Should bonsai trees be placed on every desk? It is important to define the KPI in a sustainable way. The definition should have a long-term view - for example, "reducing the percentage of Cathode Ray Tube Monitors - the bulky old monitors (CRTs) in use" rather than "no CRTs." Next, a target needs to be defined for the KPI. First, baseline the KPI measuring points. For instance, we know that the installed base of CRTs is around 25%. Now define specific and measurable targets, such as "1st year: percentage of CRTs installed <15%; 2nd year: percentage of CRTs installed <5%; 3rd year: percentage of CRTs installed <3%."

Experience Factor: Don't over KPI yourself; execute a top-down approach. Three to five KPIs for every objective and level (organisational, departmental) should suffice. Less is more.

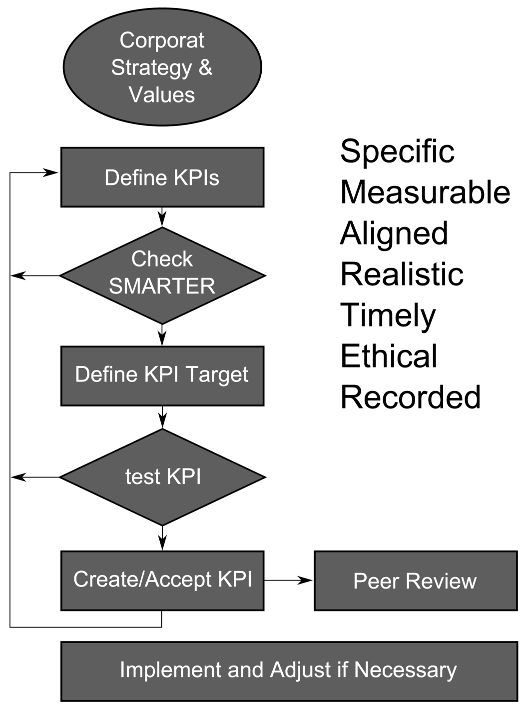


Figure 11.1: SMARTER

Additionally, ask yourself the following questions:

- **Objective:** What I am trying to achieve? (Multiple KPIs per objective; each objective will have different strategies on how to achieve it)
- **Indicator:** What I am going to measure? (Baseline and definition of course of development action)
- **Measures:** How I am going to measure? (Qualitative, quantitative data related to processes, input or output)
- **Targets:** What are the expected results? (Minimum/maximum or stretch target)
- **Results:** What have I actually achieved?

Remember...A fool with a tool is still a fool.

11.1.4 What Are Others Doing?

What are others doing? In a response to the PUBLIC CONSULTATION on Information and Communication Technologies Enabling Energy Efficiency from the European Commission, DG INFSO ICT for Sustainable Growth - Unit H4, Google is supporting four key areas of leadership for the European Commission and EU governments:

Encourage technology innovation - make renewable energy competitive and mainstream The problem with renewable energy is the economy of scale. Today, only 7% of energy consumption in the European Union comes from renewable energy. This is due to low supply, combined with high production costs and, hence, high consumer prices. Europe's goal of using up to 20% of renewable energy in the overall consumption by 2020 requires an efficient public private partnership.

Establish and foster energy efficiency standards Collaboration between industry and government is crucial to achieving better and more efficient use of energy within the ICT sector and beyond. Industry possesses the technical know-how to develop initiatives, while government is best equipped to direct energy policy. A range of industry firms (Dell, EDS, HP, IBM, Lenovo, and P&G, among others) and environmental and consumer organisations (Environmental Protection Agency, the World Wildlife Fund) aim to set a new 90% efficiency target for power supplies. If achieved, greenhouse gas emissions would be reduced by 54 million tons per year (CSCI Initiative, `http://www.climatesaverscomputing.org/`).

Use the Internet as a catalyst for efficiency and platform for information transparency The Internet serves as the backbone to economies around the world. The availability and reach of online information has become an important source for decision making by industry, government, and citizens. Already, Web-based word processors, e-mail, spreadsheets, and presentation packages that allow for more efficient collaboration between people - known as Software as a Service (SaaS) -

are revolutionising public services and business delivery. The Internet has become a platform of information transparency. For example, the United Nations' Environment Programme has created the online Atlas of our Changing Environment, which illustrates phenomena such as the deforestation in Brazil or the shrinking of Lake Chad in Africa on Google Earth.

Set standards for business to become carbon neutral Widespread carbon emission reductions by businesses will be an outcome of ongoing legislative proceedings at the EU level.

Google itself has implemented a number of internal policies in order to achieve carbon neutrality. The baseline for the policies is defined by metrics based on calculated emissions: fuel use, purchased electricity, business travel, construction, employee commuting, and manufacture of servers globally.

A three-step approach has been taken in order to achieve carbon neutrality:

1. Increase the energy efficiency of operations;
2. Use and create clean and renewable sources of energy; and
3. Implement high-quality carbon offset projects.

11.1.4.1 Efficient Computing

Google desires to be a leader in energy efficiency. Google's data centers are said to use half as much energy as a typical industry data center, while powering the same amount of computing. Apparently, these improvements have been achieved through the use of increasingly efficient power supplies and evaporative cooling technology. The application of these measures has cut the company's power consumption by more than 50% (Google press release Mountain View, California (August 19, 2008) Philanthropic arm Google.org, announced $10.25 million in investments in a breakthrough energy technology called Enhanced Geothermal Systems (EGS)). Google has also started to share what they have learned about efficient computing. In 2007, Google helped found the Climate Savers Computing Initiative. The goal of this industry-wide consortium is to reduce computer power consumption by 50% by 2010.

11.1.4.2 Green Buildings

Google has established policies to follow responsible environmental practices. All of Google's main buildings in Mountain View, California, use sustainable building materials that are environmentally friendly and healthier for employees (Cradle-to-Cradle-certified products, fresh air ventilation, and PVC- and formaldehyde-free materials). They also gradually retrofit the global offices with high-efficiency lighting, thereby improving the use of natural light, and optimise building control systems. They plan to reduce and eventually eliminate the use of incandescent light bulbs in the global offices and replace them with more efficient fluorescent bulbs. Google uses motion sensors and other lighting controls to decrease power usage and expand the use of power management software for desktop computers.

11.1.4.3 Solar Panel Installation

Google is also enthusiastic about using more renewable power. Last summer, Google switched on one of the largest corporate solar installations in the United States (Mountain View headquarters). The solar panels produce 1.6 MW of electricity, enough to power approximately 1,000 average California homes. The photovoltaic panels cover the rooftops of six buildings and two carports at headquarters. The electricity produced offsets approximately 30% of peak electricity consumption for those buildings. The system is expected to break even in 7.5 years.

11.1.4.4 Renewable Electricity Cheaper Than Coal (RE<C)

Google believes that, in order to avoid devastating climate change, business cannot deliver low-cost, clean, renewable energy soon enough. Unlimited production of electricity from renewable sources

Figure 11.2: © Google, Carport Solar Panels

will not make a difference unless it is cheaper than electricity from coal. In the fall of 2007, Google launched an initiative called RE<C, which aims to create utility-scale renewable electricity that is cheaper than coal. Google has established an internal research and development group with dedicated engineers that will focus on renewable energy technologies. Google.org, Google's philanthropic branch, has also invested $30 million to date in renewable energy technologies (solar, thermal, and high-altitude wind technologies).

11.1.4.5 RechargeIT Initiative

RechargeIT is a Google.org initiative that aims to reduce CO_2 emissions. It wants to accelerate the adoption of plug-in hybrid electric vehicles and vehicle-to-grid technology in order to cut oil use and stabilise the electrical grid. The overarching vision is that one day thousands of cars will be plugging into a green grid. Google operates a fleet of plug-in hybrids to measure their performance and demonstrate the capabilities. The cars, known as the GFleet, are available for employees at headquarters at no charge. They are powered by solar carports on campus. Google.org announced a EURO 6.3 million request for investment proposals from companies developing plug-in and related technologies. Additionally, Google.org granted more than EURO 630,000 to this project.

Figure 11.3: © 18.06.07 Google, Brin and Page "refuelling" a RechargeIT Car

11.1.4.6 Green Employee Benefits

Google encourages its employees to make the best use of company resources and facilities. There is an extensive shuttle system in the San Francisco Bay Area, transporting more than 1,500 staff to and from work, which runs on biodiesel. The Self-Powered Commuter (SPC) programme for employees donates EURO 60 to the charity of choice for every employee that cycles or walks to work every 20 days. Employees purchasing a hybrid vehicle receive a subsidy toward purchase. Last year, all European employees received a free bicycle to encourage the use of non-polluting forms of transport.

Employees at various Google offices around the globe have established "green committees" to brainstorm ideas and research how to make the company greener. Google encourages these initiatives and implements internal green policies and campaigns encouraging the sensible use of PC energy, paper, and lighting and the responsible disposal of waste.

From Google's example, you can see that KPIs are manifold and come from different areas. The following graphic depicts the product lifecycle and areas of possible KPI definition/ application.

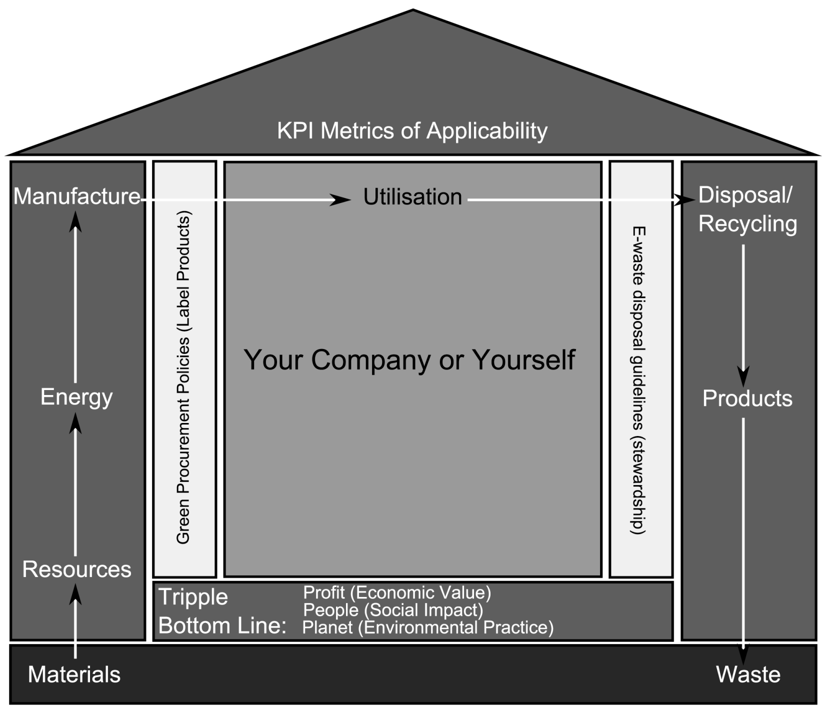


Figure 11.4: KPI Metrics of Applicability

With Figure 11.4, I want to introduce you to the concept of spheres of influence. Typically, your sphere of influence is based on your competency within your role in an given organisation. A CIO's sphere of influence is higher around strategic ICT decisions. A system administrator's sphere of influence is focused on systems and technology. A company's influence is typically directed by the triple bottom line. The triple bottom line and the CSR principles encourage you to consider economic value, social impact, and environmental practices within your decisions. I deliberately widened the triple bottom line in the graphic. I wanted to incorporate the product lifecycle from an environmental practice perspective into the company's corporate governance. In practical terms, this indicates that it matters where things come from, what they are made of, how much energy has been used to produce them, how and where they are manufactured, their internal use, and how they disappear - in other words, how they are recycled and where the waste ends up. To me, this is exactly what green thinking is about. In the future, I can even imagine the extension of social impact in an end-to-end view. Analogous to the former example, I would hope that companies, too, will eventually care who manufactured the product and under what conditions, laws, wages, and secure handling, etc. But this is for the longer term.

Is this relevant to KPI creation and applications? Yes, it is! You can set KPIs for your spheres of influence or you can extend your sphere of influence because you think it is important or relevant. Think outside the box!

Experience factor: In my experience, most companies are quite capable of defining and managing KPIs within the operational areas. Now, as they cultivate a more environmentally friendly attitude, companies are looking into what can be done differently or in addition to what they are already doing. For most companies, I have supported the development of green procurement policies or eWaste disposal guidelines.

Every activity that a business performs has an impact on a social, economic, and environmental level. These impacts are often not obvious or immediate; they may be merely hidden or indirect and only appear when you take a more holistic view. From an environmental perspective, the whole lifecycle of a certain product or service is relevant. The lifecycle looks at the total interrelationship - from raw materials to manufacturing, to the product throughout its use, and from disposal through recycling to create new raw material. Products have different environmental impacts at different stages of the lifecycle. Aluminium, for instance, has an negative environmental impact when the raw material is extracted, but it is relatively benign when used or recycled. On the other hand, a printer will have its main impact during its utilisation, because of the consumption of consumables - paper, in this instance. For a washing machine, the same principle applies, due to its use of electricity, water, and washing powder during the utilisation period of the lifecycle.

In the realm of information technology, it is important to assess the impacts of the products in use. From a risk and financial perspective, it is becoming relevant to consider the entire lifecycle of the products you utilise. As legislation changes and mandates the recycling of specific products in a controlled fashion, there is already a financial impact - when you want to recycle CRT monitors, for instance. Usually, you have to pay more to dispose of these products. This means that if your products get recycled incorrectly and end up dumped in Third World countries, the company may find itself in a reputational and financial disaster.

Experience factor: Most organisations rely solely on the recycling label provided by the manufacturer. As with all things, an organisation needs to be diligent in its handling and try to see past the label. Closing one's eyes or referring to the business partner as the one at fault does not work in the long term. By putting provisions, RFQs, RFTs, and recycling/ disposal contracts into tender, you can be assured that the legal side is covered, if not the moral one.

When defining objectives and, subsequently, KPIs in the extended spheres of influence with the intention of making an allowance for the full product lifecycle, you will discover that these areas are filled with labels of all kinds, either for energy consumption or not consumption, materials used, toxicity, recycling, etc. The crux with these labels is that you don’t know whether they are credible or not. This area is also the battlefield of "greenwashing": the means of presenting a product in a specific light or focus with attributes it doesn’t really possess. More about greenwashing later in this chapter.

True story: One client proudly stated: "Our servers are powered by 100% “Green Power”; therefore, we produce 0% CO_2 emissions." This one made me really think. It went on to say that the company hadn’t chosen the cheapest solution, only the best (greenwashing?). I will spare you this nonsense. First of all, everything that turns, moves, lights up, makes sounds, etc., creates emissions. The above logic, when applied to a washing machine, would mean that I am green when I am using “Green Power.” What about the water usage the cleaning detergents, heat dissipation, and the recycling/disposal at the end of the lifecycle? Do you think it is true that the company produced no emissions? In this case, the statement referred to an offset, which makes the first part of the statement true, but the second part is false. Out of the three general options for reducing greenhouse gas and being environmentally friendly - becoming more efficient, using less, and offsetting - offsetting is the easiest to start with, but it is not the most effective.

11.1.5 Strategies and policies with an ICT focus

Green ICT strategy: One of the greatest challenges in integrating “green” into the business agenda and developing a green ICT strategy is how to connect boardroom policies on corporate social responsibility (CSR) and green IT in practical terms. A carefully created green IT strategy can help to reduce a company’s negative impact on the environment, while adding value to the overall business strategy. A thorough green IT strategy should consider an end-to-end view, incorporating the complete lifecycle of assets. Demonstrating care and commitment to the environment eventually raises a company’s public profile and reputation with stakeholders. The greening of IT operations can support the three crucial aspects of sustainability for an organisation - economic, environmental, and social - the so-called "triple bottom line." With the triple bottom line in mind, there is a real opportunity to think outside the box and execute true leadership and innovation in adopting principles outside the standard spheres of influence (see also Figure 11.4).

11.1.5.1 "Greenwashing"

Occasionally a word or expression becomes so overused that it loses any real meaning, and people become cynical or sarcastic about its usage. There is an argument that this is exactly what has happened to the word "green" in the business world. As it is likely to be affixed to just about any business term imaginable - green this and green that - my observation is that people are starting to suffer from a sort of "green fatigue." I personally consider greenwashing to be a part of this problem.

Historically, "greenwashing" is a term derived from "whitewashing." Most everyone is familiar with the expression "whitewashing", which is defined as "a coordinated attempt to hide unpleasant facts, especially in a political context." Greenwashing is based on the same premise, but in an environmental context. Some say it is whitewashing, but with a green brush. When a company or organisation spends more time and money claiming to be green through advertising and marketing than it does actually implementing green business practices, that's greenwashing.

There are many definitions and opinions of what constitutes greenwashing. The definition I like most is one from *CorpWatch*:

> ***green*wash****: (gr en-wosh) -washers, -washing, -washed 1.) The phenomenon of socially and environmentally destructive corporations attempting to preserve and expand their markets by posing as friends of the environment and leaders in the struggle to eradicate poverty. 2) Environmental* ***whitewash****. 3) Any attempt to* ***brainwash*** *consumers or policy makers into believing polluting mega-corporations are the key to environmentally sound sustain-*

able development. 4) Hogwash.

True story: The story of McDonald's going green was news all over Europe. Apparently, McDonald's is changing its traditional red backdrop in the company logo to a deep hunter green, in order to promote a more eco-friendly image in Europe. By the end of 2009, about 100 German McDonald's restaurants will have made the change. In Great Britain and France, some franchises have already started using the new colour scheme: green behind the golden arches. Is this greenwashing, or not? Jumping on the marketing bandwagon? I suppose that there is more to the story than just changing the logo, but, unfortunately, this has been placed in the foreground. Martin Nowicki, the spokesman for McDonald's in Germany, told the Associated Press: "This is not only a German initiative but a Europe-wide initiative."

The following tables (11.1, 11.2 and 11.3) highlight some KPIs for consideration.

11.2 Green Procurement

With combined purchasing power it is possible to influence both the price and the availability of goods and services in the marketplace. Organisations are in a position to influence the demand for environmentally preferable goods and services, as well as the ability of industry to respond to the escalating use of environmental standards in international markets. By integrating into procurement the application of environmental performance considerations, organisations can achieve better and more environmentally friendly solutions or products. It is seen as best practices - reducing the environmental impacts of operations and promoting environmental stewardship - to integrate performance considerations into the procurement process.

Table 11.4 lists the procurement success factors identified as being important in the extended context of corporate social responsibility. Success factors are strongly related to the mission and strategic goals of your business or project. The content of the table lists guiding prin-

Table 11.1: KPIs for consideration (part 1 of 3)

Area	Strategic Objective	KPI	Description	Evaluation on [RAG]		
				Red	Amber	Green
ICT	Datacenter	Datacenter power usage effectiveness (PUE)	PUE is calculated by dividing the total power usage of a datacenter by the power usage of IT equipment (computer, storage, and network equipment as well as switches, monitors, and workstations to control the datacenter).			
ICT	Datacenter	% of servers located in datacenters	Percentage of servers located in datacenters.			
ICT	Datacenter	Data Center Infrastructure Efficiency (DCiE)	In datacenters, the DCiE shows the percentage of electrical power that is used by IT. Then 100% - DCiE is the amount that is used by all other equipment, for example cooling and lighting.			
ICT	Infrastructure	Watts per Active Port	Watts per active port is the total of the power consumed by all the networking infrastructure (routers, switches, firewalls, etc.) divided by the total number of active ports.			
ICT	Infrastructure	Average % of CPU utilization per server	Average percentage of utilization of CPU of system during the measurement period.			
ICT	Infrastructure	Average % of memory utilization	Average percentage of utilization of memory capacity of system within measurement period.			
ICT	Infrastructure	% of "dead" servers	Percentage of “dead” servers i.e. servers that are not used based on for example hardly any CPU utilization.			
ICT	Infrastructure	Number of alerts on exceeding system capacity thresholds	Number of alerts/events on exceeding system capacity thresholds. For example, when CPU or memory utilization thresholds on systems are exceeding the set warning limits. Increasing number of alerts may indicate that system capacity nears its maximum.			

ciples for the development of your green procurement policy.

Important: To ensure all considerations are taken into account, all equipment must be procured through a central procurement unit. Before the procurement policy will be enforced, all the procedures

Table 11.2: KPIs for consideration (part 2 of 3)

Area	Strategic Objective	KPI	Description	Evaluation on [RAG]		
				Red	Amber	Green
Operat	Supplies	% recycled printer paper	Percentage of recycled printer paper in use.			
CSR	Operations	% of energy used from renewable sources	Percentage of energy used from renewable sources ("green energy").			
CSR	Human Resource	Carbon footprint	Measures the impact that activities have on the environment measured in units of carbon dioxide.			
CSR	Facilities	% of total power that is "green" power	Percentage of total power that is "green" power.			
CSR	Human Resource	% of employees using public transport	Percentage of employees using public transport.			
Operat	Facilities	Total on-site energy	Total on-site created energy (in Gigajoule) in measurement period (e.g. monthly, quarterly, yearly). This is energy that is created for example in the manufacturing process and that can be (re)-used.			
Operat	Facilities	Average electrical consumption	Average electrical consumption in KWH per measurement period (e.g. daily, monthly, quarterly).			
Operat	Facilities	Total Energy Use	Total energy use (in Gigajoule) in measurement period (e.g. monthly, quarterly, yearly).			

from an Information and Communication Technology (ICT) perspective must be followed. Figure 11.5 details the relationship between the procurement policy and the ICT Chief Information Officer (CIO's) responsibility.

As ICT is the main contributor to carbon emissions, it makes good business sense to reduce these emissions through a proactive approach. Products that consume less energy or that are right-sized to the purpose will save substantial costs within the lifecycle (electricity consumption, consumables such as paper or toner) and avoid costly dis-

Table 11.3: KPIs for consideration (part 3 of 3)

Area	Strategic Objective	KPI	Description	Evaluation on [RAG]		
				Red	Amber	Green
CSR	Operations	Greenhouse gas (GHG) emissions	Greenhouse gas (GHG) emissions within measurement period.			
Operat	Finance	Energy saved due to conservation & efficiency improvements	Amount of energy saved due to conservation and efficiency improvements.			
Operat	Human Resource	Number of paper pages used per employee	Number of paper pages used per employee (e.g. per day)			
CSR	Human Resource	CO_2 Tons per employee	Measure the energy usage in terms of the tons of CO_2 produced by the business per employee.			
CSR	Ethics	% of suppliers screened on human rights	Percentage of significant suppliers and contractors that have undergone screening on human rights and actions taken.			
CSR	Ethics	% of employees who consider that their business acts responsibly	Percentage of employees who consider that their business acts responsibly in the society/community in which it operate.			
CSR	Ethics	% of eligible employees who signed the Business Conduct and Ethics Policy	Percentage of eligible employees who signed the Business Conduct and Ethics Policy.			
Financ	Procurement	% of procurement requests satisfied by preferred suppliers	Percentage of procurement requests satisfied by the preferred supplier list.			

posal and recycling consequences later on.

Electronics companies respond to consumer demand, over and

Table 11.4: Procurement Success Factors

Success Factors Procurement	Objective
Tender Process	• Contractual requirements • Supplier: – Environmental policy – Carbon footprint – Carbon reduction initiatives
Standards	• Energy Star ratings • Suppliers' equipment ratings • Certification (EPEAT, RoHS)
Equipment Selection	• Laptops/desktops vs. virtual desktops • Multi-function devices • LCD monitors
Carbon Offsets	• Carbon management principles
e-waste disposal	• Computers and peripheral devices • Mobile phones • Printer cartridges included • Buyback program
e-waste disposal	• Options for end of life • Equipment disposed of environmentally • Extend lifespan of equipment • Ensure does not go to landfill • Audit equipment disposal suppliers
e-waste collection	• Collect e-waste from within supply chain

above all other factors. Most of them do not believe that consumers really care whether or not their products are green. This is particularly so if it means they will cost more. Allowing consumers to distinguish between green products and those that are not, on the basis of a sound procurement policy, will change behaviour and improve the market with better and more environmentally friendly products.

Noteworthy: In the realm of Data centers, it is a generally known fact that the operational expenditures related to the use of a Server (OpEx) have surpassed the capital expenditures (CapEx) of the acquired hardware. This makes it even more important to incorporate

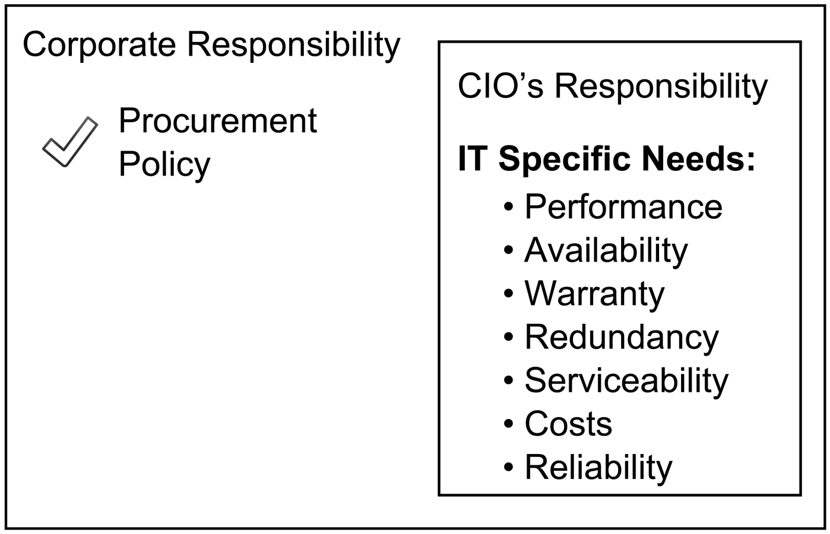


Figure 11.5: Procurement Policy

a holistic view on the lifecycle of ICT equipment and take operational aspects into consideration as well.

When you reach out for environmentally friendly or green products, you will discover a multitude of labels and products. The section on greenwashing delivers insight on how to unveil products for which the label promises more than the product itself delivers. Take these concerns into the procurement cycle (vendor evaluation part). Most electronics manufacturers like to talk about their "green" products, but as a matter of fact, electronics are still made with a lengthy list of toxic materials, which are problematic both in production and when the time comes to recycle or dispose of these products.

EPEAT (Electronic Product Environmental Assessment Tool) registry provides a "green label" by which computer companies can grade their products against some specific green criteria and score them as Bronze, Silver, or Gold. However, the use of the tool is aimed at institutional purchasers, not consumers, so many of the computers and other electronic products that consumers want aren't even on this list. Products are also ranked in EPEAT according to three tiers of environmental performance - Bronze, Silver, and Gold. All registered products must meet the required criteria and achieve at least Bronze status. Manufacturers may then achieve a higher-level EPEAT "rating" for their products by meeting additional optional criteria, listed as follows:

- Bronze: meets all 23 required criteria)
- Silver: meets Bronze standards, plus at least 50% of the optional criteria
- Gold: meets Bronze standards, plus at least 75% of the optional criteria

Most EPEAT criteria refer to environmental performance characteristics of the specific product, and these must be declared for each product registered. Some criteria relate to general corporate programs, such as a Corporate Environmental Policy or Environmental Management System. These corporate criteria apply to all of a given manufacturer's EPEAT-registered products, and participating manufacturers are required to declare to these criteria annually. EPEAT operates an ongoing verification program to assure the credibility of the registry. (`http://www.epeat.net`)

Greenpeace's Electronics Scorecard. Greenpeace uses a scorecard that grades companies' products against several criteria, although material selection is the important focus here. The guide ranks the 18 top manufacturers of personal computers, mobile phones, TVs, and game consoles according to their policies on toxic chemicals, recycling, and climate change. Each score is based solely on public information available on the company's website. Companies who are found not to be in compliance with their published policies will be deducted penalty points in future versions of the guide. (`http://www.greenpeace.org/international/campaigns/toxics/electronics/how-the-companies-line-up`)

Table 11.5 delivers input for possible provisions within a green procurement policy:

Table 11.5: Possible Provisions within a Green Procurement Policy

Relevance	Provisions for a green procurement policy or RFQ's/RFT's
ICT Specific	All desktops, laptops, and computer monitors provided are required to have achieved Bronze registration or higher under the Electronic Products Environmental Assessment Tool (EPEAT).
ICT Specific	Additional consideration will be provided for products that have achieved EPEAT Silver or EPEAT Gold registration.
ICT Specific	Suppliers may be required to and must be willing to provide reports quantifying the number of EPEAT registered products purchased under this contract.
ICT Specific	Enterprise Servers, printers, copiers, and fax machines must meet Energy Star criteria.
ICT Specific	All products must be listed in the corresponding Energy Star product list (`http://www.energystar.gov`) and EPEAT registry (`http://www.epeat.net`).
Packaging	Does your company offer to take responsibility for the recycling of the packaging waste associated with the products sold on this contract?
Packaging	Does your company offer to ship products on this contract in reusable shipping containers (such as durable racks) that can be returned to the vendor or manufacturer for reuse?
Vendor	Have you verified that all primary vendors and sub-vendors are not sending electronic equipment with leaded glass, mercury, beryllium, circuit boards, PCBs, or other hazardous components to solid waste landfills and incinerators (including waste-to-energy incinerators)?
Vendor	Do your contracts with primary vendors and sub-vendors specifically prohibit the use of incarcerated labour for disassembly or recycling?

11.3 Green e-Waste Disposal Guidelines

Continuing advances in technology mean that electronic products are becoming outdated more rapidly. This, coupled with lifecycle strategies for ICT components, means that more products are being thrown away, even if they still work. The lifecycle is the period of time during which information technology, hardware, and software remains useful. The refresh rate is the planned rate of replacement for information technology, hardware, and software. Within the lifecycle, you may reassign certain hardware. For instance, you can define shorter cycles for the primary use of the ICT components and then reuse the components in a secondary cycle. This extends the total time of use for the ICT components. When you define lifecycles, make sure you are covered by an appropriate on-site warranty and associated support levels. In the case of critical equipment, it may also be effective to retain on-site spares that can be used as replacements on short notice and returned to the manufacturer for repair. The timeframes in the warranties normally reflect manufacturers' normal and extended warranty periods for ICT equipment.

Table 11.6 represents typical lifecycles that many organisations have in place. The concept of having two distinct lifecycles for ICT equipment extends the hardware's use and assigns it in a secondary deployment to less critical roles in order to achieve full ROI and minimise expenditures on new hardware. Secondary deployment or reassigning can occur for a maximum period of two years. Well-defined lifecycles and disposal guidelines for ICT equipment ensure that you are delivering satisfactory performance to the business and acting diligently to manage the organisation's assets in the most efficient and effective way possible.

Table 11.6: Typical ICT Equipment Lifecycles

Equipment Type	Primary Deployment	Secondary Deployment
Workstations	3 years	2 years
Laptops	2 years	1 year
Servers	3 years	1 year
Switches & Routers	3 years	2 years
Printers	4 years	2 years
Mobile Phones, PDAs	2 years	1 year
All other IT equipment	3 years	1 year

True Story: You may remember this headline: NASA needs 8086 chips and shops on EBay for obsolete parts! In 1981, NASA sent up the first space shuttle, which used Intel 8086 processors for a host of diagnostic equipment. More than two decades on, these chips are still being used to make sure the shuttle's twin booster rockets are safe for blast-off. NASA is finding it increasingly hard to replace faulty chips. In the meantime, it has to rely on the old equipment to replace something that breaks. Until recently, replacement chips have been found in old medical equipment that NASA buys in bulk. Running low on these parts, NASA turned to the Internet as a last resort. Hold on!

Leave your old PC in the basement. The agency and its contractors do not buy equipment from individuals; instead, they use Web searches to find stockpiles of old parts, which they buy in bulk. "It's like a scavenger hunt," said Jeff Carr, a spokesman for the United Space Alliance, a Houston company that runs the shuttle fleet. This is an example of having a very admirable (sustainable, environmentally-friendly) lifecycle that has a downside as well.

There are a number of considerations one confronts when moving or disposing of computer hardware. Some, if not all ICT equipment may have sensitive data on the hard disk. This must be removed and, where appropriate, backed up and/or transferred. Merely deleting files is not sufficient to achieve proper wiping (erasing) of all data since data recovery software could be used to "undelete" files. Similarly, reformatting the whole hard disk may not prevent the recovery of old data as it is possible for disks to be "unformatted". In order to achieve proper cleaning of the hard disk and other data-carrying equipment, wiping based on the Department of Defense standard is recommended. There are a number of tools available to use when applying this standard. This is to satisfy the requirements of the Data Protection Act and to protect the company or individual from leakage of sensitive information. From an information security and regulatory perspective, nothing is worse than finding your data in the wrong place and hands.

Check for equipment with an OEM Microsoft Operating System license. This license is tied to the equipment with which it was supplied and therefore cannot be retained for use. Software purchased and licensed installed on the hardware is not transferable. All software must be removed from hardware that is being discarded.

Important: To ensure that these considerations are taken into account, all equipment must be scrapped through the ICT Services Department (CIO's responsibility). Before the disposal guidelines are applied, all the procedures from an ICT perspective must be followed. Only when the ICT equipment has been signed off by ICT (CIO) can it be moved into the reverse logistics process of disposal and recycling. Figure 11.6 explains the relationship of the disposal guidelines and the ICT's or CIO's responsibility.

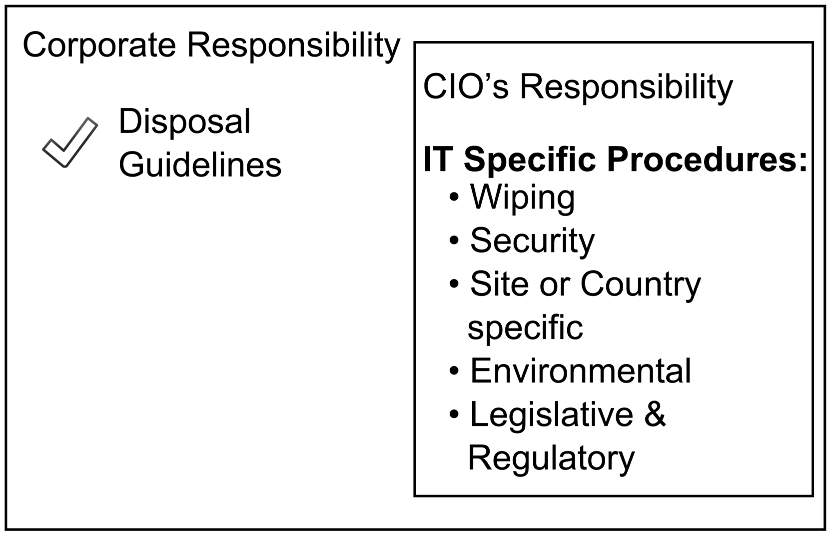


Figure 11.6: Disposal Guidelines

ICT equipment contains hazardous materials, such as lead, mercury, bromine, and cadmium. The substances that cause the most concern are the heavy metals like lead, mercury, cadmium and chromium (VI), halogenated substances (e.g. CFCs), polychlorinated biphenyls, and plastics. Circuit boards, for instance, contain brominated flame retardants (BFRs). During incineration, BFRs can give off dioxins and furans. Other materials and substances that can be present are arsenic, asbestos, nickel, and copper. These substances may act as a catalyst to increase the formation of dioxins during incineration. It's the organisation's responsibility to consult with ICT to select and approve external agents for the disposal of redundant equipment according to socially acceptable environmental guidelines. What are the steps to be taken? Establish and define standards, procedures, and restrictions for the disposal of non-leased ICT equipment in a legal, environmentally friendly, and cost-effective manner. The disposal of computer hardware must be recorded in the asset register, so the whereabouts of ICT equipment is under control.

Selecting a viable recycling or disposal partner is one of the most important steps one takes in making sure that e-waste is handled acceptably and in a socially responsible manner. Different government bodies have published regulatory frameworks for handling e-waste. Similarly, various trade and industry bodies are also working to develop the best practices to deal with ICT e-waste. It's important to scan the evolving code of practice and keep updating (once a year) the e-waste guidelines to maintain the best practices for disposal of ICT e-waste.

Experience Factor: Think about making provisions for disposal and recycling of ICT equipment in the procurement policy and in the RFQs or RFTs when buying new ICT equipment. Require compliance with your disposal guidelines and refer to suggestions made by the Electronics Take Back Coalition (`http://www.electronicstakeback.com/index.htm`). The coalition initiated a campaign aimed at protecting human health and limiting environmental effects in places where electronics are being produced, used, and discarded. The ETBC aims to place responsibility for disposal of technological products on electronic manufacturers and brand owners, primarily through community promotions and legal enforcement initiatives. Recycling and disposal are costly, and no one knows whether future regulatory requirements will make the process more expensive. Paying a small fee for recycling or disposal in the first place means avoiding financial risk later on.

The EU policy on e-waste, which can be found in the Waste Electrical and Electronic Equipment (WEEE) directive and the associated Restriction of the Use of Certain Hazardous Substances in Electrical and Electronic Equipment (RoHS) directive, can be used as references for establishing socially responsible recycling and disposal practices. The WEEE and RoHS directives aim to substantially reduce the amount of electrical and electronic equipment entering incinerators and landfills and to eliminate the hazardous substances these products contain. The directive requires EU member countries to have recycling systems for WEEE in place. There are different requirements for handling and disposing of materials in 10 WEEE categories. These range from small household appliances to medical equipment and large automatic dispensers. More information is available at the following Web site: `http://www.weeep.org/`.

Businesses and organisations in the United States can follow the e-Stewards Initiative developed by a group of leading North American electronics recyclers and asset managers. The e-Stewards claim to have developed an international standard, combined with ISO 14001, upheld by the environmental community and written in conjunction with industry leaders and health, safety, and technical experts. (`http://www.e-stewards.org`).

In November 2009, Representative Mike Thompson introduced House Resolution 938, calling for "a coordinated program for the reuse, recycling, and appropriate disposal of obsolete computers and other electronic equipment used by offices of the legislative branch using only those companies independently certified as meeting the e-Stewards Standard for Responsible Recycling and Reuse of Electronic Equipment (which forbids the export of e-waste to developing countries and use of prison labor)."

This report has covered a lot of ground in the reverse logistics process for recycling and disposal, and it may have given the reader some ideas about why this might be a very important item on the green and sustainability agenda.

Electronics recycling is an industry plagued with despicable practices, including dumping toxic e-waste in developing nations. It's very hard for customers to know whether a recycler is using such practices or to tell whether a recycler is ethical or not. Guiyu is often called the e-waste recycling capital of China. Much e-waste exported to China is sent to Guiyu, which is known as “the most polluted town in the world.” : - Fact Sheet 4 - International, Trends Shore Regional Organisation of Councils. Recently, Accra, Ghana (Africa) has also become an e-waste dump. Workers engage in highly dangerous practices, including soaking appliances in acid baths to extract valuable materials, conducted under alarmingly inadequate protective procedures.

The Basel Action Network (BAN), based in Seattle, Washington is classified by the Internal Revenue Service as a 501(c)3 charitable organisation of the United States, and it is based in Seattle, Washington. BAN’s mission is:

> *BAN works to prevent the globalisation of the toxic chemical crisis. We work in opposition to toxic trade in toxic wastes, toxic products and toxic technologies, that are exported from rich to poorer countries. Alternatively, we work to ensure national self-sufficiency in waste management through clean production and toxics use reductions and in support of the principle of global environmental justice - where no peoples or environments are disproportionately poisoned and polluted due to the dictates of unbridled market forces and trade.*

11.3.1 What is BAN doing?

- Toxic Trade - BAN serves as the information clearinghouse for journalists, academics, and the general public on the subject of waste trade. BAN maintains a website on international toxic trade that can be accessed at www.ban.org.
- Policy Advocacy - Recognised by the United Nations Environment Program as the leading organisation dedicated exclusively to issues of “toxic trade,” BAN is regularly invited to participate as an NGO expert at internal meetings and policy deliberations.
- Research - BAN conducts field investigations in developing countries as well as providing photographic and video documentation

of toxic trade.

- Campaigns - BAN works with NGO organisations around the globe in campaigns to counter any form of toxic trade.

Figure 11.7: Accra, Ghana. 2009 © 2009 Basel Action Network (BAN)

It is clear that the answer to our e-waste crisis lies not in finding new downstream hiding places. Nowadays it is cheaper and more convenient to buy a new machine to accommodate the latest software and hardware technology and their increasing demands for more speed, memory, and power, than it is to upgrade the old. This rapid “trash and buy” mentality comes with a monumental price that we as humans are just beginning to pay. We need to change the paradigm that has prevailed over the past decades. The desire for faster, smaller and cheaper must be governed by a new paradigm of sustainability that demands that our products are cleaner, long-lived, up-gradable, and recyclable. It is time to reinforce the call for sustainable production,

Figure 11.8: A view inside the burn houses where women sit by the fireplaces and cook imported computer parts. Guiyu, China. May 2008 © 2008 Basel Action Network (BAN)

environmental justice, and corporate and government accountability in order to achieve these goals.

11.4 Green IT Business Case

In the world of Green IT, or sustainable IT, there is a lot of "blarney" or "scuttlebutt." Labels and marketing phrases hammer the world in a never-ending fashion. Seeing behind this lack of information, or rather misinformation, flow is crucial. There is no such thing as zero CO_2 emissions or the complete absence of a footprint, specifically not in combination with electrical components and information and communication technology (ICT) infrastructure. Most of this publicising refers to the practice of "offsetting", which has a limited view of the broader scope of environmental issues. Videoconferencing, for instance, is not a zero-carbon-footprint solution. You might think so because you don't have to travel, but be assured that technology is necessary for videoconferencing, and this technology will subsequently create some form of emissions. From an efficiency perspective, videoconferencing is a great solution; it certainly creates fewer emissions and is very effective.

Table 11.7 outlines strategies for promoting environmental friendliness and sustainability, in preferential order. "less" is most preferred, followed by "efficiency" initiatives and the least preferred, "offset."

Table 11.7: Environmental Friendliness and Sustainability Promotion Strategies

Order of Preference	Objective	Description	Criteria
1	less	Less refers simply to using or creating less. From an environmental (not financial or operational) point of view, this is the most preferred approach.	Execute a frugal approach when it comes to consumption and infrastructure. Don't buy if you don't have to. Reduce your footprint (literally), shrink office space, recycle/reuse hardware, and share desks and hardware. Don't travel, etc.
2	Efficiency	Most of the projects with a solid ROI are within the efficiency realm. Bluntly, this means doing things better with what you have or changing the way things are done to make them better.	These strategies include the bulk of possibilities with economic impact: virtualization, higher server load, videoconferencing, data center, rightsizing, hot/cold aisles, air-conditioning, power-safe mode, CRT replacement, etc.
3	Offset	Offset is raising awareness; it is an honourable thing to do. But the question must be, do I really need this bailout from a financial and risk perspective?	Buy credits, assign a budget to the offsets, and play with scenarios. For instance, what would happen if a ton of CO_2 cost 10*or*100? Contemplate different offset costs for different geographical locations. Consider local legislation. Watch emission scheme developments. Involve the corporate CSR team. Model your tax strategy around offsets.

Creating less is by far the most sustainable approach. Emissions and products not created will minimise impact from a full lifecycle point of view. A product not created does not need to be recycled and disposed of at the end of its lifecycle. This is contrary to the general direction of common business, where "more" usually is better and defines the economic success of an organisation. Mature organisations are typically capable of realising projects in this area because tangible ROI or direct financial benefits are often hard to see. The benefits achieved are less tangible, i.e. reputation, CSR, competitive advantages, board commitment, and customer demand.

Efficiency is where organisations can test their ground. Typically, a tangible ROI can be achieved, and the benefits are more tangible, i.e. cost savings, top-line growth, shareholder demand, and access to capital. It is recognised that IT consumes significant amounts of energy. Specifically, data centers account for a large part of an organisation's expenditures and energy consumption. For instance for air-conditioning, the technology currently used by a large number of data centers, is based on room cooling. This is like cooling the whole kitchen in order to have a cool banana on your kitchen top. There is a lot of efficiency potential in cooling needs to target the component requiring cooling, and in the end, this is the processor and power supply. In the kitchen example, you would put the banana into the fridge; the next step would be to cool the banana directly with liquid pipes. It is analogous for the data center: Room cooling, row-based cooling, rack-based cooling, server-based cooling, and processor liquid pipe cooling are the most efficient ways of applying cooling technology.

Offsetting is a service: The buyer pays another organisation to reduce its greenhouse gas emissions in the buyer's place. Buying credits from carbon offsets means investing in a project that reduces greenhouse gas emissions. The underlying idea of carbon offsetting is that greenhouse gases are distributed globally and the impact of their emissions on global warming is therefore independent of the source. Some rather absurd practices have sprung from the companies creating these credits, for instance, with tree plantations in developing countries. Some of the problems are monocultures of trees, reducing biodiversity and environmental stability, or the planting of non-native trees, resulting in "green deserts." Offsetting is a valid instrument for inducing behavioural change, since organisations react mostly on pecuniary stimuli. From an environmental perspective, this is the least preferred choice. Eventually, CO_2 emissions may become a tangible company asset, like desks and computers.

The real challenge in defining a business case lies in justifying the investment. You have to win the support of the people who have the authority to give your project the thumbs up (executive management). Building a compelling business case behind the proposed technology investment is essential. Structuring a strong business case may be time consuming, and sometimes tedious, but it is a necessary step that prevents misalignments and frustration down the road.

How do you build a compelling business case for a new investment? The principal objective should be to clearly define the business benefits and goals associated with the case. Most projects already fail with this; they fall short based on a misaligned and unfinished business case, neglecting to provide a comprehensive analysis of costs and benefits as measured against the goal. While the overall objective of building the business case is to justify the investment, it also serves the important purpose of setting a cooperative tone for the project and getting all parties on the same page and working towards a mutual goal.

A strong business case for an investment puts the investment decision into a relevant and specific (strategic) context. On the basis of the business case, senior management needs to be able to comfortably make an informed decision. Without this tactic, it is unlikely that the executive management will agree to invest in the project.

When looking at the specific business case, some key factors should be taken into consideration:

- Corporate social responsibility
  - Economic value
  - Social impact
  - Environmental practice

- Regulatory, compliance, and policy-based aspects
- Direct impact of climate change

The success of the business case will depend on the degree to which every stakeholder is involved and aligned with the overall vision and business objectives laid out by management. With a sound business case in place, and by considering the principles discussed above, the myth that environmental responsibility diminishes profitability can be eliminated.

11.5 Green Return on Investment (GROI)

Green return on investment (GROI) is probably the most common term tossed around in any IT or business organisation today. Chief information officers (CIOs) can add value to their businesses by projecting potential GROI for new investments.

GROI refers to the relative benefits of an action and is normally calculated by dividing the return from an action by the cost of that action. GROI analysis involves the evaluation of the investment potential of a project by comparing the expected gains with the costs. In the last few years, a more holistic view on GROI with the inclusion of metrics relating to corporate social responsibility (CSR) - the triple bottom line, has been favoured. There are various opinions on the ways in which GROI should be measured and, consequently, different conclusions regarding projects' actual returns on investment.

Faced with shrinking budgets and the increasing role of information technology (IT) as both a source of energy consumption and a potential asset in the quest for sustainability, IT organisations are confronted with a dilemma: ignore potential green initiatives until the financial crisis eases or incorporate a more holistic view in terms of adding environmental friendliness and social responsibility to the decision circle. Even when a budget is limited, the incorporation of these efforts into a strong business plan that demonstrates a return on investment might result in a winning argument.

Regardless of where a business stands in its sustainability efforts - whether it is creating a baseline inventory or engaging in long-range programs - central and distributed Information Communication Technology (ICT) must have a seat at the planning table. As a consumer of energy and producer of greenhouse gasses, ICT plays a critical role in the move towards green IT. CIOs must work alongside chief executive officers (CEOs) to show that green IT can be truly green through the implementation of cost savings and GROI initiatives. These leaders can contribute to an infrastructure and organisational landscape that is both financially healthy and environmentally conscious.

In addition to Web conferencing and purchasing more energy-efficient products, ICT offers other ways to help organisations burn less fossil fuel, such as telecommuting, which reduces employee driving time and therefore cuts down on pollution.

Green technology investments positively affect companies' bottom lines. The very purpose of such projects is to reduce energy consumption and other costly waste within an organisation, resulting in such benefits as a smaller carbon footprint and more efficient energy use.

When a company discusses GROI, the questions are:

- What return can I expect in terms of both financial and green benefits from the money I'm being asked to spend?
- What is my investment really worth?

The GROI does not solely encompass returns exceeding the original investment plus the cost of capital; it should also include compensation for the risk of undertaking the project. For example, if a project returns 50% of the investment and cost of capital is 40%, the additional 10% may not be a sufficient justification of the project. Competition and changing market conditions combined with the rapid pace at which technology, business environments, trends, and IT-industry preferences change pose a significant risk to the realisation of future benefits. To minimize exposure to unexpected changes, it is highly desirable to recover the original investment as quickly as possible. Non-financial or indirect benefits are hard to calculate and are vulnerable to errors and variances. If non-financial or indirect benefits constitute a high percentage of the overall benefits, the potential for variance is high, and vice-versa.

Not all green initiatives are alike, and many projects require the "divide and conquer" approach. While an IT department can undertake some initiatives on its own, many projects require full organisational support and close collaboration with other areas of the business. It is advisable to determine which departments and individuals within a business execute that projects best. The division of projects is based on percentages of expected financial and non-financial benefits. If the percentage of financial benefits is high and a clear GROI can be defined, the project bears minimal risk and can be executed by the IT department or an individual within the organisation. Projects with a high percentage of non-financial benefits typically involve the greater organisation and carry higher risk.

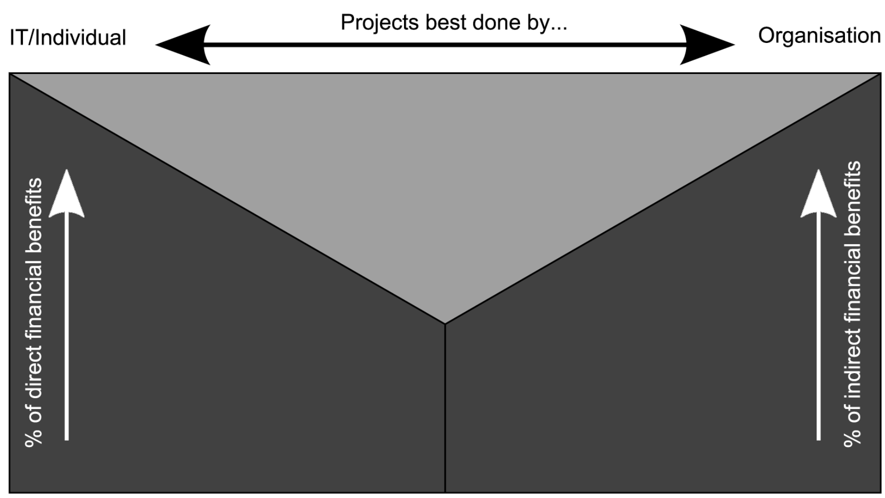


Table 11.8 details the delegation of specific projects using the "divide and conquer" approach.

Table 11.8: Divide and Conquer Approach

IT/Individual	Organisation
Data center optimisations (temperature, layout, HVAC, PDUs, generator, etc.)	Carbon neutrality, carbon offsetting and carbon trading programs
Data center redesign/rebuild (tiering)	Utility rebates; reduced electricity costs
Green procurement policy for IT	Comprehensive telecommuting policy; technology enablement
IT equipment metering	Full print output rationalisation, paperless office
Monitor replacement (CRT)	Reduction of greenhouse gas emissions
Life cycle management of ICT equipment	Emissions reduction (chemical pollutants, waste, water)
Company-wide PC power management and scheduling	Employee health programs
Operational savings	Initiatives for improved employee productivity
Combining heat and power systems for offices and data centers	Office energy management
Corporate social responsibility (CSR) regarding IT programs	Procurement of green programs
Virtualization; server consolidation	Green asset life cycle programs, equipment recycling
E-waste disposal guidelines	Green legislation compliance and efficiency incentives

11.6 Closing Remarks

Green IT is not about PR or racking up brownie points with a few quick and easy initiatives. It scores heavily on the corporate social responsibility (CSR) front. It needs to be an integral part of any corporation's climate sustainability agenda. Green IT (or, more accurately, "sustainable IT") can translate into substantial business opportunities and cost savings. Sustainable IT has emerged as a key factor affecting businesses today. Executives are under pressure to lead the adoption of sustainable business practices and need to understand what *sustainable* means for their business and what needs to be done about it.

Sustainable IT is about utilising your IT in an environmentally friendly manner. That's not just about using less paper, introducing equipment sleep modes, and virtualizing. It's also about handling e-waste responsibly and being diligent when purchasing; the whole product lifecycle needs to be in the focus. Not only hardware but also software can have sustainable characteristics. Poorly written software might call for more energy and processing time than is strictly required. Green software must be written with the objective of decreasing the processing time needed for a specific task, reducing the associated energy cost. The hardware aspect is far more straightforward. Several schemes are available for rating computers based on their energy efficiency and toxicity.

IT spending tends to be a business's second-largest outlay (after capital expenditure) - it is difficult to imagine businesses not engaging suitably and simply fiddling with sustainable IT in a limited fashion around the fringes of their organisation. Regulatory requirements and compliance considerations based on the introduction of governmental CO_2 schemes will bring the topic of sustainability quickly back to the corporate agenda, although from a risk-based perspective, initially. A few well-placed subsidies or pieces of legislation may hurry things along.

With rising energy costs and a strong global focus on climate change, businesses should consider actions to improve their corporate social standing. These cost pressures will drive energy-saving initiatives, reduce energy waste, reduce consumption, and help preserve the environment with the additional benefit of a reduction in environmental impact.

Management should be aware of alternatives and decide whether to embrace leading-edge technologies, potentially generating cost efficiencies and competitive advantages for their business and clients. Simply waiting for sustainable IT to become a business-as-usual or mainstream activity is not executing leadership. There is an opportunity for business and IT leaders to collaborate to deliver on sustainability objectives.

The challenge for executives is to consider the economic, social, and environmental implications to achieve a balanced outcome for their organisation. I hope these chapters have provided insight and provoked thought on the topic of Green IT.

Experience factor: While working on large international assignments involving different stakeholders and cultures, I have often been

Enablers	• Sustainability initiatives embedded within corporate strategy • Executive champions • Engaged and involved employees • Dedicated resources • Information and communication technology • Sustainability initiatives fit within the overall strategy and program • An engaged and involved community • Celebration of successes • Quantifiable targets and performance reporting
Eliminate barriers	• Insufficient resources/budget • Corporate commitment • Insufficient priority/importance • Unclear targets • Culture • Legacy technology infrastructure • Requirement for short-term ROI • Inability to monitor/measure progress • Knowledge/understanding
Strong backup support	• Recognised standards • Relevant research • Independent advice • Training • Peer support group

Table 11.9: Key Success Factors

asked: How do I make the right decisions? Do I decide in favour of socioeconomic means or the short-term view of KPIs relevant to promotion and career advancement? This depends on your personal and professional work ethic. The topic of what *ethics* means is monumental. Often you are forced to make quick and rational decisions in an area you are just starting to learn about. Personally, I then call for "The Three." This means I reflect on three questions I ask myself. This is in no way scientific, but it extends the frame of reference and helps to consider more than one point of view.

The bubble and me.	Put yourself in the following position: Think of your unborn son or daughter and imagine that your ethical decision will make front-page news and be posted on every billboard in town, even making it to the local TV news and late-night shows. Would you be happy for your son or daughter to hear, see, and experience this?
The future and me.	Picture yourself sitting back, enjoying the fruits of your labour and achievements. Now think about the best decisions you have made in the past. Does your current decision stack up with those? Is it in line?
The social and me.	Think of your mentor, an inspiring leader, or someone less fortunate than yourself. If you have to explain your decision to this person, will it be understandable or reasonable in his or her context?

Table 11.10: Quick Ethics Check - Ask Yourself "The Three"

During my professional life, I have seen a lot - the good and excellent and the bad and ugly. Exceptional leaders and organisations have one thing in common - individuals make the difference. Green IT and other environmental considerations are topics requiring true leadership and vision. Set a new standard; be bold and innovative. Become the new sustainability ambassador of your organisation.

Dominique C. Brack
Bern, Switzerland - February 2010

Dominique has been working in the field of security and risk management for over 15 years. His areas of specialisation include IT risk management, security and controls optimisation, IT governance, and compliance management. He is also a long standing member of Information Systems Audit and Control Association (ISACA) and the International Information Systems Security Certifications Consortium, Inc. He worked on large scale Data center projects (Tier-4) in Malaysia, Vietnam and Australia. He has applied knowledge of the Green Grid principles, TIA-942 and including other relevant standards (i.e. ISO). He was working for Big 4 firms, providing information systems audit and sustainability services to large international organisations and public entities, specialising in developing controls and frameworks to deal with sustainability and risk management efforts. Mr. Brack was part of the team counselling News Corp Australia around its "One Degree" initiative. Mr. Brack is a frequent speaker at public and private sector venues including federal agencies, state and local governments, and Fortune 500 companies. He is passionate about sustainability as a discipline and the work involved with promoting the principles and spreading the word.

CHAPTER 12

Computing Energy Efficiency - An Introduction

Buzzzzzzz. Buzzzzzzz. Buzzzzzzz. Buzzzzzzz. Buzzzzzzz. Buzzzzzzz. Buzzzzzzz.

Can you hear it?

Probably not.

It's silent to the human ear but it's the cocaine of computing. It's what we could imagine the hum of electricity twisting its way through computer components might sound like, if we were able to hear it.

And it's constant. Day in, day out, there are hundreds of thousands of computers shooting up Buzzzzzzz even when they are not being 'gamed', 'spreadsheeted', 'worded' or 'emailed' on.

Quite frankly, our computers are addicted and until relatively recently we didn't even realise they had developed a habit. The energy use habit.

12.1 Computers and Energy Use Overview

Why is computer energy use a problem - and why is it specifically an environmental problem? Well, in reality energy use itself isn't an environmental problem. It's how energy is generated that is the core problem.

Across the world the major source for producing energy is through fossil fuelled power plants, such as coal. The combustion of coal to generate electricity produces carbon dioxide (CO_2) emissions. In turn, CO_2 emissions contribute to global warming, which in turn contributes to global climate change and the subsequent effects of rising sea waters (goodbye low lying islands) and change in local climates (goodbye local flora and fauna species).

There are also other associated issues with using fossil fuels to generate power, including:

- biodiversity loss, from mining and extraction;
- the fact that fossil fuels are non-renewable - which means when they are gone, they are gone;
- fossil fuels need to be imported/exported worldwide creating additional transport-related emissions;
- the creation of pollution from fossil fuel combustion, which in turn creates a host of pollution-related issues, such as health risks to humans, flora and fauna;
- dependence on fossil fuel prices and its fluctuations and the resulting impact to many business operations.

Let us concentrate, though, on the problem source - fossil fuel powered electricity generation. Anyone who has history as a computer engineer knows that when you have a problem you have three options:

1. Fixing the cause
2. Solving the resulting problem
3. Reducing the impact of the issue

12.2 Fixing the Cause

In this scenario we find alternative power sources for computing. Ones that aren't fossil fuel based and ones that produce as few greenhouse gas emissions as possible.

Fixing the cause of a problem is always the ultimate goal because then the core issue goes away, however it is easier said than done in most cases. A lot of the current power alternatives, such as wind and sun, require optimal conditions to operate under. And if they were to support all the data centers in the world as they stand now, plus their projected growth, they also require more advanced technology than may be financially or technically available right now.

This certainly doesn't mean that the problem can't start to be solved, it just means there needs to be investment in solving the cause. And IT departments can push the fix by voting with their feet.

The first step is developing an energy use policy to define a minimum requirement for alternative energy sources. At the moment in a number of countries, such as Australia, energy companies provide the option to produce a guaranteed percentage of the power and distribute it back to the grid from alternative sources, if a company or individual opts into the alternative or renewable energy program. It costs more than standard energy at the moment, however when alternative energy sources reach commodity point the price will drop - much like the first IBM Desktop computers costing US$20,000 in 1975, whereas thirty-five years of investment in the technology have dropped the price of an average desktop computer to less than $1000. Like the desktop computer, energy companies need to invest in the technology and infrastructure required to replace the old system before they can both lower their costs and make a profit. However to do so, they need to have buyers of alternative energy.

By defining an energy use policy specifying a minimum percentage of alternative energy sources, the business contributes to the ongoing investment in converting power sources from fossil fuel based to renewable based, without losing the reliability of fossil-fuel based energy sources until the clean technology overcomes these hurdles. Outside alternative energy use, another option is for a business to generate alternative power for a data center themselves. There are many data centers now supplementing their existing coal-based power generation with renewable energy sources.

One example is a data center company in California, United States, called AISO that is the only data center globally currently powered entirely by photovoltaic (PV) solar panels, in their 1500 square foot facility. Other, more common examples have data center operators supplementing existing sources - for example i/o Data Centers installed solar panels across their 11 acre roof, which can generate up to 4.5 megawatts of power (of the total 120 megawatts required). The benefit to supplementing can mean financial savings in the form of shifting purchased power use from peak to off peak hours, and alleviating the future prediction that power costs will surge over the next few years.

12.3 Solving the Resulting Problem

In this scenario the resulting problem is energy use. 'Solving' energy use for computing is impossible in most scenarios so 'solving' the resulting problem is by energy aversion.

Virtualization is an example of energy aversion. Virtualization doesn't "save" you energy per se, because although virtualization enables consolidation of existing infrastructure, it doesn't technically make it more energy efficient - so it helps you avert the use of more energy than you need.

To encourage energy aversion measures, countries such as Canada and United States (US), are providing incentives for data centers to use renewable energy sources and implement energy efficiency measures. For example Austin Energy (Texas, US) is providing up to $200,000 per site for measures, such as massive array of idle disk (MAID) storage systems, virtualised servers and server consolidation. While other energy companies such as BC Hydro (British Columbia, Canada) are offering up to 60% rebate on the total project costs for server consolidation projects that save up to 100,000 kWh per year. Other energy companies offer rebates on computer monitoring software ranging from $6-15 per computer.

Other methods of energy aversion come in forms such as building a data center in a cold climate or painting a data center roof white so you don't use as much power for cooling. Again, it doesn't fix the ultimate cause but it does result in less power used, and subsequently less greenhouse gas emissions from that particular data center.

Another form of energy aversion is turning off computing infrastructure. At the very basic non-technical level, employees are retrained to change their behaviour by turning off their computers at night. However taking advantage of technology, there are numerous software programs that can control turning off desktop computers across an enterprise at night.

In the data center turning off servers is a more challenging prospect however software management tools are catching up. It is now possible to have virtualised servers in data centers automatically migrate to a different server, which has more capacity, and have the original server shut down automatically, then wake back up when it is needed again. Over the next few years this technology will be mature enough to have widespread adoption.

12.4 Reducing the Impact of the Issue

In this scenario, reducing the impact of energy use is through energy efficiency measures.

Energy efficiency measures start at the manufacturer and are promoted through standards, such as Energy Star. Standards such as Energy Star provide a baseline by which companies can set purchasing policies, subsequently ensuring every computer purchased for the organisation meet the best practice in energy efficiency.

Another method of reducing the impact of the issue is through reconfiguration of existing computer infrastructure. Simple measures such as configuring standby power can save significant amounts of energy across an organisation in a year.

12.4.1 Inside the Box

Moving on from root causes, issues and solutions, let's delve into the computer itself to better understand its use of energy. Computer energy use depends on a number of factors, including:

- **The Computer Form Factor** - The computer form factor has a deciding influence on the types of components that are installed within a computer. Laptops differ significantly from desktop computers in terms of power use, as PDAs do from laptops. Laptops and PDAs, being mobile devices mainly run from batteries, are designed to be the most energy efficient through their use of energy efficient components.
- **What processing the computer does** - Energy consumption increases exponentially with clock speed on a computer, so CPU intensive activities such as gaming, increase the energy use of a computer.
- **What components are installed** - The motherboard, RAM, hard drive, graphic cards and processor design and architecture all contribute to energy efficiency. For example a 2.5" hard drive will use less power than a standard 3.5" hard drive.
- **The power supply** - When a computer converts energy from the socket (110 or 220 volts) to the internal components (3.3, 5 or 12 volts) there is a loss of energy through the conversion process - how much loss depends on the power supply energy efficiency and at what point the efficiency commences. For example, a power supply may have an efficiency rating of 70% however it only reaches that efficiency at 50% load. Energy Star products re-

quire power supplies to have a minimum 80% efficiency rating across all levels of load, from 1-100%.

- **What software runs on the machine** - This correlates to both the operating system and the applications installed. At an operating system level the overall design and specific configurations of the operating system can affect power usage - Microsoft Windows, Mac OS and Linux operating systems all have different configurable options and have unique architectures that handle processing and applications in different ways.

12.4.2 How Much?

So how much energy do computers really use? As outlined above, there are various configurations and hardware design that will affect the numbers. However to give you a general guide, the following tables outline the power use in tests conducted by Choice (a not-for-profit organisation in Australia) in 2008:

Table 12.1: Desktop and Laptop Computers (all prices in AUD)

		Desktop PC: 2.13 Ghz Intel Core Dual 1GB RAM		**Desktop PC:** iMac 2Ghz Intel Core Duo 1GB RAM		**Laptop:** Macbook Pro 2.5Ghz Intel Core Duo 2GB RAM	
		Off	On	Off	On	Off	On
Weekly	Energy (kWh)	1.22	16.65	0.95	10.24	0.15	3.66
	Cost @ 15c/kWh	$0.18	$2.50	$0.14	$1.54	$0.02	$0.55
Monthly	Energy (kWh)	5.32	72.35	4.12	44.47	0.67	15.90
	Cost @ 15c/kWh	$0.80	$10.85	$0.62	$6.67	$0.10	$2.39
Yearly	Energy (kWh)	63.79	868.18	49.46	533.68	8.02	190.84
	Cost @ 15c/kWh	$9.57	$130.23	$7.42	$80.05	$1.20	$28.63

The desktop computer figures actually exclude other external components like the monitor and speakers. The additional figures for these components are:

Table 12.2: Other External Components (all prices in AUD)

		LCD Monitor		**CRT Monitor**		**PC Speakers**	
		Off	On	Off	On	Off	On
Weekly	Energy (kWh)	0.27	5.51	0.49	12.24	0.59	2.66
	Cost @ 15c/kWh	$0.04	$0.83	$0.07	$1.84	$0.09	$0.40
Monthly	Energy (kWh)	1.19	23.96	2.11	53.20	2.54	11.54
	Cost @ 15c/kWh	$0.18	$3.59	$0.32	$7.98	$0.38	$1.73
Yearly	Energy (kWh)	14.25	287.56	25.38	638.34	30.51	138.50
	Cost @ 15c/kWh	$2.14	$43.13	$3.81	$95.75	$4.58	$20.78

When calculating the complete energy use and energy cost of a desktop, a desktop computer with an LCD monitor and a set of speakers cost a total of AU$194.14 per annum, which is equivalent to 0.93 metric tonnes of CO_2 emissions.

In comparison a laptop (without an external monitor or speakers) costs a total of AU$28.63 per annum in energy costs, which is equivalent to 0.14 metric tonnes of CO_2 emissions.

From an environmental perspective, a single organisation of 5000 desktop computers is generating 4,647 metric tons of CO_2 per year from their energy use. This is equivalent to:

- Annual greenhouse gas emissions from 889 passenger vehicles
- CO_2 emissions from the electricity use of 604 homes for one year
- Carbon sequestered annually by 991 acres of pine or fir forests

From an IT management perspective, an organisation of 5000 desktop computers could save AU$827,550.00 in energy costs per year by switching from desktops to laptops. However, there are further considerations such as:

- Increased potential for laptop loss versus desktop computers
- Laptops sitting on desks usually have a keyboard, mouse and monitor for working extended periods to alleviate occupational health and safety (OHS) issues

- The cost of computer replacement to both the business and the environment (i.e. electronic waste output)

Additionally these figures are based on computers being on all the time - if a company with 5000 desktops turned off computers when they are not in use, they would gain a saving of AU$647,133.33 (based on 8 hour work day) in energy costs per annum.

12.4.3 Implementing a Computing Energy Efficiency Program

There are any number of ways to structure and setup a computing energy efficiency project in an organisation however most of them encompass these key steps:

1. Audit & analyse your existing environment
2. Develop a partnering strategy internally and externally
3. Review purchasing policies
4. Implement operational changes
5. Develop a monitoring, reporting and feedback program

12.5 Audit and Analyse Your Existing Environment

Before an organisation can implement new standards and policies, there needs to be understanding of what is already available, what is already running in the environment and how the environment is currently configured.

The audit will help you understand how much carbon you generate and how much money you spend on energy use across your IT infrastructure.

To assist with the audit, there are a number of standards available to help organisations baseline IT energy use including the Green Grid - this consortium developed two useful data center metrics called Power Usage Effectiveness (PUE) and Data Center Infrastructure Efficiency

(DCiE); and SPEC Power, which provides baselines for power usage of servers.

However, before conducting an audit, the IT department will need to define what information is going to be collected and where it will be collected from. At the same time, IT will need to define standard measurements and metrics for third parties, like utilities. For example all energy use should be calculated and displayed in the same format such as kWh.

Following the audit, the development of a business case will help define the overall requirements, and the costs associated with implementing an energy efficiency program. Sometimes one of the hardest things to define for Green IT initiatives is documenting why you need money to implement the changes. Consider including the following reasons in your business case and supporting them with statistics and research:

- **Achieving cost savings** - through more environmentally-efficient technologies and processes, and reducing general consumption
- **Improving overall business perception** - from employees, stakeholders, government, NGOs
- **Employee satisfaction** - 'we feel good about working here'
- **Complying with legislation** - in the case you have legal environmental commitments to achieve
- **Increasing shareholders** - for example FTSE4GOOD[1] analyse businesses on environmental metrics
- **Supply chain compliance** - increasing all the time is the requirement for suppliers to prove their environmental credentials
- **Sourcing additional income** - such as research grants for schools and universities, or meeting bank loan and insurance sustainability requirements.

Finally, in addition to analysing energy efficiency, it is a good idea to convert the energy use analysis into carbon equivalences, to show environmental impact and bring real-life relevance to figures. There are thousands of carbon calculators available on the web and choosing one depends on what you want to measure. The key tip here is to choose one that is specific to your country or that allows customisation based on your country. Carbon accounting is typically measured differently country-to-country.

The key outcome for this step of the program is the sign-off of a business case to implement an energy efficiency program in the organisation.

12.6 Develop a Partnering Strategy Internally and Externally

Many case studies show that management, employee and partner engagement are key building blocks for implementing any Green IT program.

Internally, engagement with both management and employees is crucial to the program's success. Once management accepts the business case and you know what your baseline looks like you need to make the commitment public - at least to your employees initially. Have executive management announce the high level targets e.g. 25% reduction in carbon emissions and saving of $xyz annually. Then implement an IT marketing program to both remind staff of the program you are undertaking and to show them how they can help.

The next step is setting up a working group composed of management, employees and IT. Implementing green IT changes are as equally related to organisational change as they are to technical change. As such you need to setup an influential working group that will support your activities.

Finally you need to assess and select the appropriate technologies and solutions. Many independent software vendors (ISVs) and hardware manufacturers offer their support to organisations through solutions designed to increase energy efficiency and also through their extensive partner networks and training. Taking advantage of all they have to offer including generating public case studies and any seed funding they have available will assist your program fulfil it's metrics.

In addition to traditional vendor & services partners, there are a number of not-for-profit and industry specific organisations such as ComputersOff.ORG, Climate Savers Computing and WWF, who can provide advice, guidance and partnering on computing energy efficiency initiatives.

The key outcome for this step of the program is engagement of management, training and encouraging cultural change for employees, and selecting appropriate partners, technologies and solutions to help support the program.

12.7 Review Purchasing Policies

To support the future implementation of a standard energy efficient baseline, existing purchasing policies should be refined. These policies could be very granular - for example they could define the specific efficiency level required for computer power supplies; or they could be broad - for example they could simply define Energy Star servers and desktops as the standard for the organisation.

Purchasing policies should also incorporate a set of standard IT equipment specifications. Classifying servers into workloads such as web, database and application, and then into performance workloads will help organisations 'right-size' their server infrastructure. This means servers aren't over-spec'd for the workload they are expected to host, resulting in reduced energy consumption and waste.

12.8 Implement Operational Changes

As the previous energy use figures indicate, a significant cost saving can be made with turning off computers at night or even by implementing sleep mode while the computer is inactive. However there are a number of other initiatives such as:

- Selecting low or optimised power servers and desktops

- Implementing virtualization, to reduce the total number of servers & increase the typically low utilisation of computing resources per server;
- Applying operating system power configuration using automated directory policies or power management software
- Streamlining standard operating environments (SOE) for minimal software
- Implementing thin clients
- Consider buying or implementing your own 'green' energy, which is sourced from renewable supplies or from certified suppliers
- Optimising the physical configuration of data centers

12.9 Develop a Monitoring, Reporting and Feedback Program

Finally, after setting up these environmentally friendly practices, you'll need a good reporting system to feedback progress to management, to ensure continued support and funding.

For energy use, you may only be able to report on overall energy utilisation; however the key is to make sure you take a baseline from the entire past year's reports to show any potential seasonal variability before implementing your improvements.

Finally, cultural change is an ongoing process and reporting back to employees and management will help support the continuous program for energy conservation. As such asking for staff advice, recommendations and ideas are crucial because often employees need to feel they own it - and that it is not pushed onto them from above.

12.10 Conclusion

Buzzzzzzz. Buzzzzzzz. Buzzzzzzz. Buzzzzzzz. Buzzzzzzz. Buzzzzzzz. Buzzzzzzz.

Can you hear it?

Now it's the sound of computers using alternative energy more efficiently.

Bianca Wirth
Sydney, Australia - December 2009

Bianca Wirth is the CEO of ComputersOff.ORG, a non-profit initiative dedicated to reducing technology's environmental impact; and founder of GreenITStrategy.com, the only Green IT information portal for Australians. Bianca has a degree in Environmental Science and is a certified provisional Environmental Auditor however since 1998 Bianca has held technology roles in major consulting companies and ISVs globally, including Microsoft. Bianca has led and managed teams of industry professionals; developed and implemented large technology strategies; and lead multi-million dollar projects. All the while, Bianca has earned her reputation as an advocate for green IT as she has put into practice the strategies she promotes. An accomplished speaker and writer, Bianca has written for magazines on technology and green IT issues, and presented to a wide range of audiences from industry, to academics, to school children on the importance of a greener IT future.

Notes

[1] FTSE4GOOD - http://www.ftse.com/Indices/FTSE4Good_Index_Series/index.jsp

CHAPTER 13

A Future View: Biomimicry + Technology

Stop. Stop thinking. Right now. Forget. Forget what you know. Forget what you believe. Relax. It won't hurt you. Clear your mind. Drift a little. Let go. Breathe in. Breathe out. Think about the air. In through your nose. Out through your mouth. Breathe in. Breathe out. Slowly. Close your eyes and breathe in and out. Nice and slow. Drop your tensed shoulders. Relax your hand muscles. Feeling relaxed. That's good...

Now we are ready to go on a little journey. It's time to step out of now, step away from what you know and think beyond the box.

Beyond the computer box that is.

Are you relaxed yet?

Then let us begin...

Unlike the chapters preceding this one with facts and figures, standards and structure, history and humanity - this chapter is about futures. It's about dreaming. It's about thinking of the possibilities. If you don't want to know about the future or think about the possibilities, its best to stop now. This chapter may scare you.

If, on the other hand, you have courage, imagination and dedication you'll read this chapter. You may start a new business based on its contents. You may start a new career. But I just hope that, at the very least, it makes you think of the possibilities and inspires the mind.

13.1 Introduction

My background is in Information Technology and planning, primping and 'fixing' the here and the now. But if I am completely truthful with myself, and you my faithful readers, I live in the future and the perhaps-never-is. I think about what could be, and ask why not. I have to admit it's probably not one of the most useful practical skills to have. Businesses usually much prefer to hire people who think of here and now - unless of course it gives them competitive advantage and achieves the ever-lasting goal of 'increased profits'. And there is nothing necessarily wrong with increased profits. It's perceived as the way the human centric world spins on its axis currently. But why is it that anthropogenic success and environmentally sustainable futures be mutually exclusive? Why is it that millions of acres of forests are cut down every day for our needs? Why are flora and fauna populations going extinct before our very eyes? Why is it that the apes die while we mine their habitat for a mineral called coltan for technology manufacture?

Why, why, why?

But perhaps instead of asking the sometimes useless why, we should perhaps be asking "why...not a different way"?

13.2 What is Biomimicry?

Sounds like a latest DJ playing in Ibiza doesn't it? But don't worry - it isn't exclusively gen Y, or even exclusively any generation.

According to AskNature.org, Biomimicry is "a design discipline that seeks sustainable solutions by emulating nature's time-tested patterns and strategies, e.g., a solar cell inspired by a leaf. The core idea is that Nature, imaginative by necessity, has already solved many of the problems we are grappling with: energy, food production, climate control, non-toxic chemistry, transportation, packaging, and a whole lot more."

What this is essentially saying is that although as humans we expect that we must develop all the solutions - in reality there has already been over 3.8 billion years of research going on in the natural world. There has been mass evolution and mass extinctions based on the capability to survive and adapt to the immense challenges. For organisms that can't build a house, heat the home or adapt the environment to their needs, there has been a need to develop amazing evolutionary physical and social adaptations that have kept their species alive for thousands, millions or billions of years. In fact, we are not just talking about a few species that have stood the test of time. We are talking about between 10-30 million species that have beaten a path and scored the goal every time.

3.8 billion years of research. And 10-30 million other species who have perfected their form of evolution.

Commercially, wouldn't you like to get hold of some of that intellectual property?

Swiss Chemist, George De Mestral, did exactly that when he created Velcro in the 1940s. De Mestral based Velcro on the natural design of burdock burs (biennial thistles), which attached themselves to his dog's hair during a hunting trip in the early forties with tiny hooks. After examination he realised anything with a loop - such as hair or clothing - attached to the hook design. And the ever useful Velcro was born.

However, let's extend on the original field - biomimicry - and take it to the technological dimension. In the computing and technology field we also like to think that everything we are doing is new. Sometimes we think there is nothing as great as a computer or as advanced as a switching and routing network or as amazing as the World Wide Web in the natural world. Is there?

Could we potentially take advantage of 3.8 billion years of nature based research and trial and error, to inspire better technology and computing design or create better ways to manage technology?

Let's find out. Let us explore the emulation of nature through technology, and the application of nature-based concepts to technology and its associates.

Some of what we will go through is real. It's already out there in production and being used by the common man. Some is not 'quite there' yet in a commercial sense but in research development phase. And some concepts are future inspired - perhaps not even real or realised yet.

13.3 Here and Now

13.3.1 The Termite Data Center

When you walk into a data center today and walk deeper into the room, you'll eventually locate a massive dumb device. No - not those terminals that used to sit on desks and not the old mainframe that may now be out of commission.

It's the HVAC system.

The HVAC system, although it has gained a few brains over the years, is configured to bulk cool the data center. It's dumb in the sense that unless we tell it to operate in a particular way, it will keep on pumping out sweet, cold air to keep the computing mass cool and operable, while sucking in huge amounts of energy. In fact - probably half of the energy required for a typical data center operation today.

Because of this dumb operation and resource sucking, what has been happening recently is that data centers are being reconfigured into hot and cold aisles, their roofs painted white, or they are being re-built in remote ice-crusted countries to take advantage of ambient outside temperatures.

But what if it were to change the smarts of the data center itself? What if - the data center became 'termite-smart'?

I am not saying that termites are massively smart but what they do have is millions of years of practice in optimal heating and cooling architecture. In fact, termites have so perfected this architecture, that they are able to keep their 'buildings' at a constant 30 degrees Celsius. Without a HVAC and without electricity, they build the ultimate in passive cooling and heating design.

One example is the Australian Compass termites - so named because when they build their homes they build them in a chisel shape with the long axis pointing north and south. What this essentially does is exposes the least area of the mound to the heat of the day, keeping the mound cool in the day and warm in the mornings and evenings.

A cousin of the Compass termites are the Macrotermitine termites, some species of which are found in Africa. These termites keep their homes at a constant 30 degrees Celsius (87 degrees Fahrenheit), which is the optimum temperature for them to maintain fungi inside the mound. They achieve this by creating a structure which captures wind energy, which powers active ventilation of the nest through holes and funnels throughout the structure, acting like chimneys to filter the hot air out and the cool air in.

In the same way, an architect and a construction company adapted the concept to the Eastgate Shopping Center in Harare in Zimbabwe. With no air conditioning installed in the building, they saved $3.5 million in building costs during construction, and now only use 35% of the energy required for temperature regulation compared to similar buildings, which has also resulted in lower rent for the shopping center tenants.

13.3.2 The next generation of solar cells

Time to take a little journey back in time.

Think back a few (or a perhaps even a lot) of years to the days of high school. Sitting on the high chairs in the science lab you are vaguely listening to the teacher as they explain the process of photosynthesis...

Like the human body, other living organisms require energy to survive. Plants obtain this energy from sources such as the sun and convert the solar energy into chemical energy, which are then stored as sugars. In plants this process is known as photosynthesis and usually occurs within the plant leaves. When solar energy is converted to chemical energy, this reaction is known as a light reaction - that is the 'photo' in photosynthesis.

Stepping back to the present, the photosynthesis concept has been adapted to the use of solar energy. A company called Dyesol has developed a solar panel that emulates the process of natural photosynthesis with a sandwich of glass, an electrolyte, ruthenium dye and a layer of titania. In this artificial photosynthesis, light strikes the solar panel and excites the electrons. The electrons are absorbed by the titania creating an electrical current capable of operating more efficiently in low light conditions than traditional solar structures.

These panels have a lower cost and embodied energy during manufacture compared to traditional photovoltaic, and the manufacturing process doesn't create toxic output. However what makes this an even more commercially viable option is that existing glass panels in a building can be replaced with the Dyesol solar panels, essentially making the building itself a power generating machine.

Imagine an office building with the glass windows all drawing in power during the day, powering the computers and office infrastructure inside...

13.3.3 Here's looking at you...moth

You may be hard pressed not to find a moth flitting around your outdoor lights in summer, however, rather than thinking of them as potentially light-dumb, these tiny creatures have a practically unique eye structure: hexagonal shapes filled with thousands of pointed protrusions just 300 nanometres in length.

What this achieves for the moth is protection from predators. These protrusions reduce light reflection from their large eyes, helping them to evade predators in the moonlight and maximise the amount of light their eyes can absorb to help them see in the dark.

In the world of technology, the predator is sunlight and our PDAs and computers are the moths, with screens encased in anti reflective and anti glare films that emulate the moth's protrusion-style eyes with only 1% (or less) reflection properties.

13.3.4 The Flutterby

And while we are on the topic of flying creatures, have you ever watched a butterfly flutter by and wonder where its beautiful colours come from and how they are produced?

Actually it's all in the structure of their wings.

The butterfly's wings are constructed of scales composed of tiny, transparent chitin layers interspersed with air pockets. And instead of absorbing and reflecting light like pigment does, the butterfly's wings selectively cancel out some colours and reflect others using wavelength interference, dependent on the actual structure and spacing of the scales. Essentially they have colour produced by structure itself.

You may already see where this is going: if we are able to replicate the structural composition of a butterfly's wings, then we are able to produce a brilliant range of colours without dyes and pigments.

And this is exactly what a company called Mirasol has done. Mirasol currently provides reflective, low power screens to industry for mobile phones, eReaders and a range of other electronics that honour the butterfly's perfect wing structure and colour mechanisms.

13.3.5 The Flexible Sea Sponge

Wow - what a ride. So far we have traipsed an African desert, gotten up close and personal with plant leaves, flitted in the night-time moonlight and fluttered the garden flowers as a butterfly. But we aren't finished yet - now it's time to hit the beach.

Think about grainy sand squishing between your toes, waves lapping at your feet, sublime cool sea water in the heat of the day, your gaze moving out over the blue-green water to, what seems to be, an infinite waterscape beyond.

This beautiful environment is the playground of a massive number of oceanic fauna - many of which we haven't even discovered yet. However one we have discovered is a species that has been wise to fibre optics well before even we knew about them.

This fibre optic original, is a sea sponge called the Venus Flow Basket, or scientifically know as Euplectella. This sea sponge is a beautiful example of a silicate structure with delicate-looking weaves like an African basket, long and drawn out to create a sheath-like structure. Some of the materials within the Venus are exactly the same as current human-created fibre optic cable.

The difference though is the Venus is not only able to better conduct light than fibre optic cable, it is very flexible. In fact, you could tie a knot with the sponge's protuberances (called spicules) and not have it break - try to do the same to a traditional fibre optic cable and it would break before you could say 'light it up'.

13.4 What If

13.4.1 The three rules of nature

Janine Benyus is well respected in the Biomimicry world as an author and pioneer. In talking with a group of IT people in the mid 2000's she rightly pointed out one of the major areas where we go wrong: hardware carcinogens.

Benyus noted that life makes the most of every element - there is no waste - however with computing, electronics and technology hardware in general, we are not listening to the three rules of nature that Benyus believes are key:

The first is "how life makes things". We make things using the "heat, beat and treat" concept leaving us with over 90% waste from our processes. Nature has practically zero waste - everything has a use because it can't afford waste.

The second area is "how life makes the most of things" - and what nature does is adds information to matter to give it a structure. In complete contradiction, what humans do is build something up and then remove matter to make it suit our purpose.

The final area is "how life makes things disappear back into nature". In nature things biodegrade, break down, get absorbed, get eaten, soak in or get sucked up. We are creating billions of tonnes of electronics and computing waste each year, with millions of tonnes of precious metals, chemicals, toxins, greenhouse gases, plastics and metals being dumped or burned - which in turn creates atmospheric or physical waste that is not able to be reabsorbed back into the natural chain of life easily - or at all.

So our challenge becomes: how can we design computing hardware that follows these three rules of nature?

13.4.2 Natural Silicon

As we all know, the key difference between humans and computers is that humans are carbon based life forms and computers are silicon based forms.

Unlike its natural equivalent though, silicon created by humans are on drugs - that is - they are filled with chemicals and carcinogens. In addition, the manufacture of semiconductors has other effects such as the release of nitrous oxide (N2O), a major greenhouse gas. Carbon emissions too figure significantly in silicon production - it is estimated that for every 1 tonne of silicon produced, 1.5 tonnes of CO_2 is emitted.

So what about natural silicon life forms, minus the chemicals?

Diatoms are just one example of a silicon based life form. Diatoms are a type of algae that usually reside in water. They are most often used for measuring the health of water ways. However their natural silicon form is also of interest to scientists and universities such as UC Santa Barbara, who are investigating the creation and use of natural silicon as a replacement for synthetic silicon production, such as in computer manufacture.

13.4.3 Self assembling computer screens

Do you go on holidays to the beach? Perhaps as a child, perhaps as a teenager or perhaps now with your own children? Do you remember picking up a seashell from the shore... it may have had rough little knots covering the outside or maybe it was smooth and clothed in a fantastic array of colours and stripes. Do you remember running your hands over the surface? Did you ever think that seashell could be more than a home for a small crab or sea animal, or something to take home as decoration?

Next time you are at the beach, bend down and take a closer look.

The materials of that seashell are mainly calcium carbonate. This mineral develops in a layered affect interspersed with biopolymer - a naturally occurring polymer - that together becomes a strong, hard and tough material through protein and ion interaction from the seawater. In fact it is as tough as Kevlar in some cases.

The seashell layering concept has already been used to create optical lenses. Why not computer screens?

13.4.4 Biodegradable Hardware

In the same way calcium builds up over time to create a hardy shell, the ever-desirable pearl is created in the same vein.

A pearl is created in nature by dirt. Yes - dirt.

One day the mollusk - a living creature - is sitting in the bottom of the ocean and into its shell falls a small piece of dirt or foreign material. The mollusk takes affront at this intrusion! And to stop the foreign material from affecting its life, the mollusk builds calcium carbonate, layer upon layer, around the foreign object until it is encapsulated in what is one of the worlds most desirable jewellery pieces. An iridescent, gorgeous pearl.

What if the future of hardware construction were to take the same approach? Could we replicate the pearl process where an organic, strong layer crusts over a case structure that breaks down naturally after a period of time?

13.5 Conclusion

These are but a few ideas for the future of biomimetic computing. Some are new inventions, some may become new inventions and same may only ever be what my parents used to call "a twinkling in your eye" - an idea.
Now its time to stop again. Breathe in. Breathe out. Relax. This time don't forget everything. Just think differently. 30 million species differently.

Bianca Wirth
Sydney, Australia - December 2009

Bianca Wirth is the CEO of ComputersOff.ORG, a non-profit initiative dedicated to reducing technology's environmental impact; and founder of GreenITStrategy.com, the only Green IT information portal for Australians. Bianca has a degree in Environmental Science and is a certified provisional Environmental Auditor however since 1998 Bianca has held technology roles in major consulting companies and ISVs globally, including Microsoft. Bianca has led and managed teams of industry professionals; developed and implemented large technology strategies; and lead multi-million dollar projects. All the while, Bianca has earned her reputation as an advocate for green IT as she has put into practice the strategies she promotes. An accomplished speaker and writer, Bianca has written for magazines on technology and green IT issues, and presented *to a wide range of audiences from industry, to academics, to school children on the importance of a greener IT future.*

CHAPTER 14

Greening Supply Chains - The Role of Information Technologies

14.1 Introduction

In a world that is fast becoming "Hot, Flat and Crowded" (Friedman, 2008) our society and its systems have to become smarter than they currently are, and are in need of radical innovations. *"Instead of avoiding the unmanageable, we have to start managing the unavoidable"* - as Friedman formulates it. The flatness Friedman mentions refers not only to today's cheap communication, but especially to the worldwide supply chains that have been created over the past decade(s).

Supply chains are the sum of all activities to get from ore to a brand-new vehicle, and from the grass a cow eats to a carton of milk at your kitchen table, to name just two examples. As such, a supply chain transforms natural resources, raw materials and components into finished products for end customers. Herein, human consumption is the primary trigger driving these supply chains.

In this chapter we take a look at what supply chains are, how green these currently are, and how information technologies can be of help in greening them. We describe seven important trends that help to transform your supply chain making it both more cost efficient, more customer driven and while making it more sustainable by reducing its environmental impact.

14.2 What Supply Chains Are

A supply chain is a system of organisations, people, technology, activities, information and resources involved in moving a product or service from the supplier to a customer. As such, the term supply chain is wider than logistics alone (Kopczak and Johnson, 2003), which is well described by the definition of supply chain management given by the Council of SCM Professionals: *"Supply chain management (SCM) encompasses the planning and management of all activities involved in sourcing and procurement, conversion, and all logistics management activities. Importantly, it also includes coordination and collaboration with channel partners, which can be suppliers, intermediaries, third party service providers, and customers. In essence, supply chain management integrates supply and demand management within and across companies"*. Inter-company coordination has become essential in supply chains, as Lambert and Cooper (2000) state that *"SCM represents one of the most significant paradigm shifts of modern business management by recognizing that individual businesses no longer compete as solely autonomous entities, but rather as supply chains (consisting of individual businesses, working together)."*

Two important enablers have constituted the worldwide supply chains as we know them today. First is the Internet, making communication cost a non-issue, even with the other side of the world. This is in line with the transaction cost theory of Coase (1937), which says that when transaction costs decrease, the need for corporations to keep all business functions in-house reduces. Second is the standardisation of the shipping container. Containerised transport has made products from every corner of the world commonplace and accessible everywhere, by dramatically cutting the cost of transportation and thereby making outsourcing a significant issue (Levinson, 2006). Following Thomas Friedman's theory, first brought forward in his best-selling book "The World is Flat" (Friedman, 2005), supply chains even bring the world stability and peace, as no countries involved in global supply chains and trade lanes have manoeuvred themselves in situations of war with trading partners.

14.3 The Role Of Transport In Supply Chains

Transport is an essential element in any supply chain. Goods have to be moved between production stages, and eventually find their way towards consumers. Producers, brand-owners, and retailers often outsource transportation to specialised firms, referred to as Third Party Logistics (3PL) or Logistics Service Providers (LSP) (Christopher, 1999). Logistics service provision is an industry under great pressure; with small margins. LSPs are generally not seen as very strategic supply chain partners. One factor that illustrates this is the fact that the most important factor for selecting an LSP (still) is price, whereas the quality of its logistics services ranks only second (Stewart, 1995; Menon et al., 1998; Moore, 2006). Secondly, it is also illustrated by the fact that only as little as 25% of the shippers use electronic data integration with their LSP (Moore, 2006). Another 56% of firms use technology to correspond with their LSP, but in labour-intensive ways that require manual activities: through means such as e-mail and Internet portals. As a result, the LSP is poorly integrated with the up- and downstream supply chain, which makes it an intermediary with little space to decide on how it fulfils its tasks (Lai et al., 2004). Hence it has little opportunities to optimise streams, as parties too often attain local optima. Fourth Party Logistics (4PL) is a term coined in the late 1990s by Accenture. A 4PL is by definition, *"an integrator that assembles the resources, capabilities, and technology of its own organization and other organizations to design, build and run comprehensive supply chain solutions"*. Over the years, many 3PLs have tried to become 4PLs, but most of them failed in their ambitions. Reasons include (Hertz and Alfredsson, 2003): First, customers require neutrality from their supply chain manager. 4PL's with a background as a 3PL have a legacy of resources (e.g., warehouses and wheels). Second, 3PL's often lack the more advanced knowledge and capabilities needed for a 4PL. Third, up- and downstream supply chain partners are often not (yet) ready for a 4PL structure, which often includes a transfer of decision authorities (e.g. the 4PL deciding about shipment dates). Berglund et al. (1999) pointed to a future 4PL role for information-oriented outsiders, such as information technology or consultancy firms.

The result of these difficulties to harvest the fruits of collaboration is that margins are low, operations could be improved, and innovation lags behind (Chapman et al., 2003; Bold and Olsson, 2005). For instance, the percentage of empty-truck-kilometres is considerable. Estimates vary, but percentages of empty-truck-kilometres go as high as 58% (De Ridder, 2003) - which means that in fact more truck kilometres are driven empty than full. This is partly due to physical limitations of freight (heavy steel does not fill up an entire container, to name an example), but the most important factor is lacking coordination. Simply put: it takes too much effort to arrange for a return-freight.

14.4 How Green Are Supply Chains

Before we look at the potential impact that IT can have on greening supply chains let's discuss how green supply chains actually are. In fact, that is a hard and too generic question to answer. To start with, how green is it to let our goods be produced at the other side of the world? That is an easy question to ask, but a difficult one to answer. While specialisation results in very efficient forms of production in huge quantities, all logistical operations that come with the shipment of products from the factories to the end consumers have an enormous impact on energy consumption, emissions, and air quality. A similarly complicated question can be asked for the impact of potential solutions for traffic jams, a factor now playing a role in urban areas around the world. Will reducing traffic jams result in more traffic, or in less idling and fuel waste of trucks and passenger cars?

What we can say however is that supply chains have an enormous impact on the consumption of fossil fuels and greenhouse gas emissions around the globe. We have mentioned the amount of empty-truck-kilometres before. Furthermore, it is known that transport makes up 30% of the European Unions total energy consumption and 28% of Europe's CO_2 emissions. Emissions related to transport alone (including non-supply chain related passenger traffic) have been up in 2010 by 47% since 1985 (Logica, 2010).

The good news however, is that there is ample potential to do things better. Essential herein is to do things smarter.

14.5 Consumers Are In The Driver's Seat

As mentioned before, end consumers in fact drive supply chains. As such, supply chains have to produce what consumers want. For complex products as cars that is nowadays simple: a customer configures a car exactly as he or she wants it to be, orders it, and then the car is produced exactly as the customer wants it to be. Delivery generally takes a couple of weeks or even months. Many other products are made following a different paradigm, namely make-to-stock: manufacturers anticipate future demand, and produce what they expect the market will eventually require. Not an easy task, to give the example of fresh-cut pre-packed vegetables in supermarkets nowadays: next to the fresh lettuce, tomatoes, onions, radish etc., supermarkets now also sell pre-packed vegetables that are already pre-cut. Easy for the consumer, who is willing to pay a premium for that convenience. Practical problem however is that as soon as the lettuce is cut, its expiration date degrades enormously. Supermarkets therefore need to have good insight in customer behaviour. However, customer behaviour is related to many different factors: consumer buy different when they shop for a

BBQ evening, than when they shop for a normal meal. Outside temperature and weather circumstances are therefore factors playing a role. But also the day of the week, or whether it is a holiday, or not. Supermarkets try to get a grip on this, in order to not have to throw away or rebate too many items, and therefore advanced planning and forecasting systems that deal with all this information become important. Planning within supply chains is the process of anticipating and preparing for future events, generally customer demands, variations in supply, and other internal or external variations - see also Daganzo (2005).

Different production paradigms - that in fact range from engineer-to-order (ETO), through build-to-order (BTO), assemble-to-order (ATO), to make-to-stock (MTS) - require different types of supply chains. The car and lettuce examples are examples of ATO and MTS. Traditionally less valuable goods were produced MTS, whereas more expensive items lean more towards the engineer/build-to-order side - a house designed by an architect is as example of the latter. However, as consumers become more demanding, also less expensive goods are often constructed through the BTO or ATO paradigms - a trend often referred to as mass customisation - examples include personalised PC configurations as Dell and Apple offer them, or a custom made shirt one orders through a web shop over the Internet. The drawback is that these less standardised forms of production result in more complex handling of supply streams, as traditional static supply chains are no longer sufficient (Lee, 2004). Mass customisation also results in production environments that better make what customers want, and therefore fewer disposals of unsold goods are needed. Again, two sides of the same coin.

14.6 Why Information Is Key In Greening Supply Chains

Ample inefficiencies exist in supply chains. Inefficiencies that could be improved upon by better utilising information, resulting in either improvement of efficiency or effectiveness. Doing things better, or doing things different. Let us consider some examples of currently existing inefficiencies. Although the Port of Rotterdam tranships over twelve million sea containers every year, these containers still tend to be randomly stacked when they leave the ship. Information on destination, transport mode, and expected shipment date is not used in stacking the containers. Containers arriving at terminals get randomly stacked; as such it can happen that a container, which is intended to leave by barge in two weeks from now, is placed on top of a container, which has to leave the terminal in two hours by truck. Another example relates to the earlier identified high percentage of empty truck kilometres, which is largely due to the fact that it is often too difficult to arrange for a return freight. At the same time, the choice for shipment by truck is often made for time reasons. As things become time-critical, shipment by barge or rail is often not an option anymore, as it is more time consuming. Strangely enough, the planning of these activities often only takes place when the deadline approaches. At that moment, time does not allow for too much optimisation anymore. Multi-modality, often identified as an instrument to make supply chains more sustainable, till now turned out to be just too hard to organise. These three examples illustrate the need for a different use of information and information technology.

Let's take a look at a more theoretical perspective on the use of information in supply chain processes.

In his organisational information processing theory, Galbraith (1974) identified two strategies to reduce task uncertainty in business processes: the reduction of the need for information processing, and the increase of the capacity to process information. Raman (1995) showed that logistical information- and decision-support systems generally focused on reducing the need for information processing. Companies could increase the capacity to process information, for example by information coupling in their supply chains. Instead of predicting and anticipating what is likely to happen, companies could utilise real-time information from up- and/or downstream on the supply chain to monitor what really happens and react accordingly (Sheombar, 1997). Up-to-date supply chain information is becoming increasingly important (Sriram et al., 2000). The MIT Beergame illustrates the importance of information exchange in supply chains - see Lee et al. (1997). Collaborative planning with partners in the supply chain is often suggested as an instrument to cope with uncertainty and to improve the overall supply chain (Lambert and Cooper, 2000), and its robustness (Chen, 1999).

In fact, next to information exchange among partners, IT and information can be valuable also in other ways. Information can give insight in better knowing what customers really want (either by analysing their past, or by interacting with them), can prove useful to coordinate activities, and perhaps even to influence customer behaviour. Revenue management principles are quite known in the airline and hotel worlds, industries where each customer tends to pay a different price for the same service. However, such principles - often referred to as demand management - can prove useful in supply chains as well. See for example the work for Dutch e-retailer Albert.nl done by Agatz et al. (2009).

14.7 The Changing Scope Of IT Systems In Supply Chains

The pace of change in enterprise information systems application in industry and therewith supply chains is a paradoxical one. On the one hand, developments in hardware and software seem to progress at rocket speed - see for example Coltman et al. (2001) description of the pace of Internet adoption, reread Bill Gates' 1995 vision of the Internet and network services in light of the current situation (Gates, 1995), or read the history of information technology in The Netherlands (Van Den Bogaard, 2008) and see how fast technology has evolved. Technology matures and develops - computer power still doubles every eighteen months (Moore, 1965). What is state-of-the-art today seems to be ready for the museum tomorrow. As Jim Gray put it (Milojicic, 2004): *"What you have on your desk now, is more powerful than all power of the world's supercomputers together 30 years ago. Imagine what another 30 years of developments will bring us?"*

Nevertheless, looking at the underlying processes one could make the opposite observation. Fundamental change, also in information systems, takes a rather long time. Real-time systems for example were already reported on as early as 1970 (Zani, 1970). Also Enterprise Resource Planning (ERP) (Haigh, 2001) and Business Intelligence (BI) (Luhn, 1958) took a long time to get from idea to practice. An interesting example is the LEO, which is recognised (Baskerville, 2003) as the first business software application ever, which was first booted in 1951. Although technology might have accelerated at rocket speed ever since, many of today's system implementations still aim at achieving objectives similar to the ones LEO delivered in the early 1950s.

Of course things have changed. The first computing applications in business in the 1950s and 1960s were mainly used for simple calculations and data storage. When hard- and software capabilities evolved, Material Requirements Planning (MRP) and Manufacturing Resource Planning (MRP-II) applications became available throughout the 1970s (Van Busschbach et al., 2002), mainly to support the business need for better-coordinated material flows. In the late 1980s, the first Enterprise Resource Planning (ERP) applications were introduced. ERP's initial focus was to execute and integrate functionality to support finance, accounting, manufacturing, order entry, and human resources (Davenport and Brooks, 2004) - and as such it brought operational improvements. ERPs are generic systems, designed with "best practices" in mind. Customising an ERP - which means changing, or extending internal code, or interfacing with legacy systems - adds complexity, costs, and complicates upgrades and integration with business partners (Ragowsky and Somers, 2002). Only in the 1990s companies started looking for enterprise software that could reach beyond enterprise's borders (Van Busschbach et al., 2002) and could serve a supply chain function. Electronic Data Interchange (EDI) technologies were later followed by more flexible XML (eXtended Markup Language) technologies that could leverage the standard Internet infrastructure (Davenport and Brooks, 2004).

ERPs, in fact, are not designed for inter-organisational usage (Wortmann and Szirbik, 2001; Sharman, 2003; Davenport and Brooks, 2004). An entire category of "supply chain management" software is sold as an extension to ERP. Surprisingly, this category mainly covers software with an intra-enterprise focus (Davenport and Brooks, 2004). Despite its name, SCM software hardly supports SCM activities or processes throughout the wider supply chain, and mainly concentrates on planning and scheduling within the four walls of the enterprise.

Triggered by a changing world enterprise software needs to become (more) inter-organisational (Anussornnitisarn and Nof, 2003). Hagel and Brown (2001) state that *"that is where the limitations of existing IT architectures are most apparent and onerous; applications on the edge of one's enterprise can benefit by definition from sharing"*. Traditional enterprise information systems do not sufficiently cover inter-organisational coordination processes (Sharman, 2003; Van Hillegersberg, 2006).

Next to the factor "scope" - intra-organisational, becoming inter-organisational, discussed above - the factor "time" is another important dimension that is changing. We observe the need for real-time systems. ERP systems are designed around an optimisation engine that typically runs once a day (or night). Nowadays, information is available everywhere and at any time, which shapes possibilities for real-time utilisation of this information (Klapwijk, 2004). Examples of sensor systems include RFID (Radio Frequency Identification) technology and GPS (Global Positioning System) positioning (McFarlane and Sheffi, 2003). Future generations of RFIDs can be equipped with processors to execute software code. These smart sensors will be connected with the cloud, and continuously share information with and will be informed back from the cloud. The European FP7 projects INTEGRITY and especially EURIDICE are examples of projects in which such concepts are pioneered. In the last project a foundation is currently being established for future adaptive self-organising cargo networks.

14.8 Old Versus New School Supply Chains

Having gone over all this we perceive the big supply chain challenge of today to reduce the supply chain's environmental impact and at the same time become more agile, more cost efficient, more responsive to customer demands, and reduce time-to-market. IT as such has great potential to support inter-organisational processes, through integration, coordination & cooperation with chain partners. However, something to beware of is that firms would like to leverage their existing investments in systems and technologies, systems often with serious drawbacks in their architecture.

Further complicating factors are

1. Information is partly available in systems, but not unleashed, ineffectively used, and is spread over multiple parties & systems
2. More intelligence & a redesign of processes is required to effectively use the right information
3. Firms have a complex landscape of (IT) systems and processes, and a helicopter-view often lacks
4. Resistance towards chain integration with partners exists.

We recognise seven important trends that together assemble the new school supply chain paradigm, versus more traditional (old school) supply chains. These seven trends are listed in Table 14.1, and discussed one-by-one below.

Table 14.1: Seven Important Trends To Improve and Green Supply Chains

Old School	New School
Reactive	Proactive
Isolated optimisation	Optimisation is the result of multi-level coordination and cooperation
Plan and never look back	Plan, replan, real-time replanning and control, continuous learning
Static flow design solely at strategic level	Network design at strategic level and continuous dynamic rerouting of flows
Sole cost focus	Balanced trade-off between low costs / high customer service / sustainability
Traditional inflexible systems	Flexible distributed service-based solutions and flexible integrated centralised solutions
Isolated use of information	Intensive utilisation and enrichment of information

14.8.1 ONE - Proactive is the new strategy

Being reactive in one's processes is no longer sufficient; proactive should be the new strategy. Why wait till something breaks down, inventory finished earlier than expected, or market prices have negatively changed without noticing? Smart sensoring technology to capture real-time statuses, analysis of historical patterns, and intelligent predictions all help in better handling today's and tomorrow's reality. Proactiveness in one's operations help to save costs and reduce emissions, react quicker to changes, and better fulfil customers demands.

14.8.2 TWO - Optimisation is the fruit of collaboration

Optimisation has been, still is, and will remain important in logistics. However, optimisation taking place in isolation should no longer be one's strategy. Of course it is easier to define your own optimal milk-run, however, if you have to deal with customers' operations - for example in delivering goods - why not involve these customers in the optimisation process? It might be "optimal" to arrive at a customer at 10 O'clock sharp, but if the customer only has time after 10:30 what would then be optimal? The same holds for large enterprises that optimise only part of their internal operations. We have been personally involved in the case of a Dutch fashion-house where the procurement and logistical departments did not discuss delivery windows. As a result the buyer got a small rebate, by allowing the Chinese manufacturer to take two days longer to fulfil the order, which resulted in extra supply chain cost as the goods could not make it in time to Europe by ship anymore, but had to take a flight. Resulting in extra costs and emissions. Therefore, optimisation should become the result of multi-level coordination & cooperation.

14.8.3 THREE - Dynamic planning can play a vital role in decision making

Planning as such used to be an activity a company did generally well in advance of actual execution. New generations of technologies make it possible to perform (near) real-time replanning and control. Next to that, technologies have appeared that make it possible to learn from the past and the current, to improve the planning of future processes - this is quite a change from the past. Consider for example all the fixed parameters that have been implemented in your ERP system, ten years ago at first implementation. Do these still hold, are these still valid, or have your processes changed in the years that passed? Planning therefore is likely to evolve towards a process of: real-time replanning & control and continuous analysis & learning (for future plan cycles).

14.8.4 FOUR - Redefine supply chain network design for smart operations

The physical design of flows through supply chains tended to be a one-off activity. Once a supply chain was designed, its flows and operations became standardised and static. Until a major redesign, typically only after several years, the chain was fixed - leaving little space for on-the-fly adjustments. As delays, capacities, or other unforeseen situations occur, rerouting flows is a smart(er) strategy. It is better to change the (strategic) process of supply chain flow design into the (strategic) design process of a supply chain network environment, and a (tactical/operational) smart and dynamic (re)routing of flows through this network. Li&Fung, a Hong-Kong based supplier of high-volume, time-sensitive consumer goods operates as a supply chain manager in its network of thousands of producers across a series of countries: production orders that are planned today are scheduled differently than orders that arrive tomorrow. This way optimally balancing capacities, capabilities and costs.

14.8.5 FIVE - Make a balanced trade-off between low costs & high customer service while being sustainable

As mentioned before, logistics and supply chain management does not only deal with a sole focus on cost anymore. Rather one could state that today, logistics have to make a balanced trade-off between low costs (which are still very important), a high customer service (fast delivery, high customisation, short lifecycles), and at the same time perform this in a sustainable manner. One aspect of this is that orders are not all equal anymore - as customer preferences and markets differ. This trend is further strengthened by mass customisation, as discussed before.

14.8.6 SIX - Empower decision making with flexible distributed service-based solutions

Traditional information systems and technologies have resulted in a serious amount of inflexibility in enterprises, and therewith supply chains. Implementations have been long and painful processes, and adding new functionality, or changing workflows are major struggles. As such, new technologies and designs are needed. Moore's law is still going strong as we mentioned: computers and devices keep on getting faster, with more capabilities to process information. Novel hybrid system architectures that incorporate a combination of distributed decision making on the one hand (for example in the form of smart devices), and integrated centralised functionality in the cloud, are therefore a logical development. Let's for example take a smart monitoring device on a container. The smart device measures temperatures, movement, door opening, location, and senses its environment. It communicates with a cloud infrastructure that briefs the container about market prices, possible travel trajectories, modes of transport, and so on. The container, the infrastructure and the owners this way get informed decision power. Sounds like science fiction? This might be out of the labs sooner than you think ...

14.8.7 SEVEN - Create value through intensive utilisation and enrichment of information

The last factor to mention is the use of information. This used to be isolated and is likely to become much more intensively utilised throughout the wider supply chain. Also, enrichment of information is an important aspect. Like the mobile phone changed the way people coordinate in daily life, new technologies that utilise chain-wide information have the potential to fundamentally change coordination in supply chains.

14.9 Closing Words

In this chapter we have discussed the current state-of-art in supply chains. In fact we choose to concentrate in essence on all supply chain activities, except manufacturing, as that is in essence a different playing field. Supply chains are important in today's world, and give ample opportunity for improvements, that will help making the world a greener place. It is important to realise that until recently, cost (Alt and Klein, 1998) has been the sole motivator that drove supply chains. Cost savings have been the most important motivator to outsource production abroad, and to establish the global trade lanes as we know them today.

Recently, sustainability and more specifically the reduction of greenhouse gas emissions have become a theme in supply chains. TNT, one of the world's largest mail, parcel and express firms has made sustainability its key selling point and integral part of its internal strategy.

This seems to pay off for them, and is now followed by others in logistics. Green labels are appearing everywhere, and carbon reporting has become an important theme for many companies.

For managers who used to have a sole focus on low cost, sustainability is not necessarily bad news. In fact, reducing waste and streamlining operations pays off both on reduced emissions and cost! As such, the seven trends discussed in this chapter, that help to move supply chains from traditional "old school" supply chains, to "new school" supply chains are very valuable instruments in greening supply chains.

Established supply chain integration with partners is an important strategic weapon (Rai et al., 2006), and not in the least because it is so difficult to copy. Collaboration within the supply chain can, for example, reduce chain-wide inventories (Chen et al., 2005; Van Der Vlist, 2007). Furthermore, we should be aware that SCM systems do not solely concern the technical aspects of information systems. SCM is, foremost, a human activity system that is *"subject to all risks and foibles of joint human endeavour"* (Kumar and Van Dissel, 1996). In fact, following the vision sketched up by Sharman (2003), chain-wide collaboration can achieve cost reductions in supply chains that go hand-in-hand with greening, going beyond the first attempts to electronically enable supply chains, which *"in principal all came down to instruments that helped to reduce transaction costs"*. Real collaboration will result in much larger savings and contributions.

Mobile phones changed the way we coordinate our daily lives. Mobile phones have introduced more flexibility, and have led to less unnecessary waiting, and fewer frustrations in daily life, and as such, have increased quality of life. This new technology created a different way of coordination. Now the parallel to supply chains: more information than ever before exists in supply chains, and computing and communication devices are literally everywhere (Wooldridge, 2005). Can these new information technologies enable a similar change in supply chains? Can this technology help greening supply chains? Can we turn supply chains around, and put the consumer really in the driver's seat, but influencing his/her behaviour by smart technologies? Indeed, we believe it can, and will. Let's team up, and make this world a better place. A greener place!

Dr.ir. Hans Moonen
Utrecht, The Netherlands - April 2010

In the past ten years, Hans operated on the interplay between supply chain management, process change and innovative software. Currently, he splits his time between consulting and academia. At Logica he is employed as an innovation consultant, whereas he spends one day/week at the University of Twente as an assistant professor. In both professions Hans' core focus is on "smart & sustainable logistics"; in other words: how to organize supply chains in smarter and better manners utilising IT.

Before his current professions, Hans earned an MSc degree in Industrial Engineering & Management Science from Eindhoven University of Technology, worked at enterprise software vendor Baan (in both Canada and The Netherlands), which was followed by a position at Erasmus University Rotterdam, where he obtained his PhD degree. Hans perceives it a challenge to approach problems critical and out-of-the-box, and he has been a frequent participant and speaker at national and international conferences and symposia. He is driven by a desire for sustainable improvement, and a passion to really make things happen, and make the world a better place.

CHAPTER 15

Epilogue

As clearly illustrated throughout this book, Information Technology holds a great potential in making society greener. Information Technology will, if we use it wisely, lead the way to resource efficiency, energy savings and greenhouse gas emission reductions in the Low-Carbon Society.

There is no single perfect solution; Green IT is not a silver bullet. But already today, we have a number of solutions that are ready to do their part of the work in cleaning and greening society. And enough proven solutions and implementations for us to argue not only that IT has gone green, but also that IT is a major greening enabler.

No doubt that we put a lot of faith into technologies, believing that they will be part of saving us - also this time. Yet, technologies will not stand alone in this immense task that lies before us. Technology will take us only so far. Changing human behaviour and consumption patterns is the only real solution in the longer-term perspective. IT may help us in doing so, by confronting us with our real-time consumption - for instance through Smart Grid and Smart Meters - thereby forcing some of us to realise our impact. This way technology would help turn humanity into more resource-aware creatures.

But technologies, such as Green Information Technologies, are not going to disperse themselves. Before betting on new technologies, we need to establish long-term security of investments.

And the only way to do this is to have an agreed long-term set of policy decisions that create the right incentives to promote the development we want.

A new global climate change agreement is vital to create incentives for government and business to undertake Greening IT investments.

Now is the time for action! Why would we wait any longer?

The world's countries worked for years towards the deadline in Copenhagen for reaching a new deal on climate change and emission reductions. Progress was made, but there is still much work to be done. We urge that a deal will be made and ratified to be ready to go into force by January 2013 taking over where the Kyoto Protocol expires.

References

Agatz, N. et al. (**2009**). "Demand Management in E-Fulfillment."

Alt, R. and Klein, S. (**1998**). "Learning from Failure: The Myths and Magic of Electronic Transportation Exchanges." In "IEEE, Proceedings of the 31st Hawaii International Conference on Systems Sciences," pages 102–110.

Amos, S., Amos, R., and Dummer, G. (**1999**). *Newnes dictionary of electronics*. Butterworth-Heinemann.

Andrzejak, A., Arlitt, M., and Rolia, J. (**2002**). "Bounding the resource savings of utility computing models." *Hewlet Packard Laboratories*.

Anussornnitisarn, P. and Nof, S. (**2003**). "e-Work: the challenge of the next generation ERP systems." *Production Planning & Control*, 14(8): 753–765.

Baskerville, R. (**2003**). "The LEO principle: perspectives on 50 years of business computing." *The Journal of Strategic Information Systems*, 12(4): 255–263.

Belady, C., Rawson, A., Pfleuger, D., and Cader, S. (**2008**). "Green Grid data centre power efficiency metrics: PUE and DCIE." *Consortium Green Grid*.

Berglund, M., Van Laarhoven, P., Sharman, G., and Wandel, S. (**1999**). "Third-party logistics: is there a future?" *International Journal of Logistics Management*, 10: 59.

Berstis, V. (**2002**). "Fundamentals of grid computing." *IBM Redbooks paper*.

Bold, A. and Olsson, J. (**2005**). "What it costs to Manage Collaborative Logistics."

Brown, W., McCormick, H., Mowbray, T., and Malveau, R. (**1998**). *AntiPatterns: refactoring software, architectures, and projects in crisis*. Wiley Chichester.

Campbell-Kelly, M. and Aspray, W. (**2004**). *Computer: a history of the information machine*. Westview Pr.

Chapman, R., Soosay, C., and Kandampully, J. (**2003**). "Innovation in logistic services and the new business model." *International Journal of Physical Distribution and Logistics Management*, 33(7): 630–650.

Chen, F. (**1999**). "Decentralized supply chains subject to information delays." *Management Science*, 45(8): 1076–1090.

Chen, H., Frank, M., and Wu, O. (**2005**). "What actually happened to the inventories of American companies between 1981 and 2000?" *Management Science*, 51(7): 1015–1031.

Christopher, M. (**1999**). "Logistics and supply chain management: strategies for reducing cost and improving service." *International Journal of Logistics Research and Applications*, 2(1): 103–104.

Coase, R. (**1937**). "The nature of the firm." *Economica*, 4(16): 386–405.

Coase, R. (**1992**). *The firm, the market, and the law*. Univ. of Chicago Press.

Coltman, T., Devinney, T., Latukefu, A., and Midgley, D. (**2001**). "E-business: revolution, evolution or hype?" *California Management Review*, 44(1): 57–86.

Daganzo, C. (**2005**). *Logistics systems analysis*. Springer Verlag.

Davenport, T. and Brooks, J. (**2004**). "Enterprise systems and the supply chain." *Journal of Enterprise Information Management*, 17: 8–19.

De Ridder, E. (**2003**). *Op weg naar een succesvolle introductie van een revolutionair logistiek planningsplatform*. Rijswijk, Technische Hogeschool: 61.

DOE, U. (**2006**). "National Electric Transmission Congestion Study."

Freiberger, P. and Swaine, M. (**1984**). *Fire in the valley: the making of the personal computer*. Osborne/McGraw-Hill.

Friedman, T. (**2005**). *The world is flat*. Farrar, Straus and Giroux New York.

Friedman, T. (**2008**). *Hot, flat, and crowded*. London, Allen Lane.

Galbraith, J. (**1974**). "Organization design: An information processing view." *Interfaces*, 4(3): 28–36.

Gates, B. (**1995**). *The road ahead*. New York, Viking.

Gravelle, H. and Rees, R. (**2004**). "Microeconomics." *Harlow: Prentice Hall*.

Hagel, J. and Brown, J. (**2001**). "Your next IT strategy." *Harvard Business Review*, 79(9): 105.

Haigh, T. (**2001**). "Inventing information systems: The systems men and the computer, 1950-1968." *The Business History Review*, 75(1): 15–61.

Hanley, N., Shogren, J., and White, B. (**2007**). "Environmental economics in theory and practice." *New York*.

Hertz, S. and Alfredsson, M. (**2003**). "Strategic development of third party logistics providers." *Industrial Marketing Management*, 32(2): 139–149.

Heuvelhof, E., Jong, M., Kuit, M., and Stout, H. (**2003**). "Infrastratego." *Strategisch gedrag in infrastructuurgebonden sectoren*.

Jaffe, A. and Stavins, R. (**1994**). "The energy-efficiency gap What does it mean?" *Energy Policy*, 22(10): 804–810.

Klapwijk, H. P. (**2004**). "Economics Reconfigured ... A Vision of tomorrow's Value Chains ..."

Koomey, J. (**2007**). "Estimating total power consumption by servers in the US and the world."

Kopczak, L. and Johnson, M. (**2003**). "The supply-chain management effect." *MIT Sloan Management Review*, 44(3): 27–34.

Kumar, K. and Van Dissel, H. (**1996**). "Sustainable collaboration: managing conflict and cooperation in interorganizational systems." *Mis Quarterly*, 20(3): 279–300.

Lai, K., Ngai, E., and Cheng, T. (**2004**). "An empirical study of supply chain performance in transport logistics." *International Journal of Production Economics*, 87(3): 321–331.

Lambert, D. and Cooper, M. (**2000**). "Issues in supply chain management." *Industrial marketing management*, 29(1): 65–83.

Lee, H. (**2004**). "The triple-A supply chain." *Harvard business review*, 82(10): 102–113.

Lee, H., Padmanabhan, V., and Whang, S. (**1997**). "Information distortion in a supply chain: the bullwhip effect." *Management science*, 43(4): 546.

Levinson, M. (**2006**). *The box: how the shipping container made the world smaller and the world economy bigger*. Princeton Univ Pr.

Logica (**2010**). "Intelligent Transport Systems - Your journey starts here. Empowering sustainable mobility." *Logica Whitepaper*.

Luhn, H. (**1958**). "A business intelligence system." *IBM Journal of Research and Development*, 2(4): 314–319.

McFarlane, D. and Sheffi, Y. (**2003**). "The impact of automatic identification on supply chain operations." *International Journal of Logistics Management*, 14(1): 1–18.

Menon, M., McGinnis, M., and Ackerman, K. (**1998**). "Selection Criteria for Providers of Third-Party Logistics Services: An Exploration Study." *Journal of Business Logistics*, 19: 121–138.

Milgrom, P. and Roberts, J. (**1992**). *Economics, organization and management*. Englewood Cliffs, EUA : Prentice-Hall.

Milojicic, D. (**2004**). "Microsoft's Jim Gray on computing's breakthroughs, lessons, and future." *IEEE Distributed Systems Online*, 5(1).

Moore, G. (**1965**). "Cramming more components onto integrated circuits, electronics." *April*, 19: 114–117.

Moore, G. (**1991**). "Crossing the chasm." *New York*.

Moore, K. M. e. a., P.D. (**2006**). "The Power of O3 - Optimized Strategy, Planning and Execution." *Report on Trends and Issues in Logistics and Transportation*.

Office, U. C. (**2001**). "Energy productivity to 2010 - Potential and Key Issues." World Wide Web electronic publication. URL `http://www.cabinetoffice.gov.uk/media/cabinetoffice/strategy/assets/piuh.pdf`.

Ostertag, K. (**1999**). "Transaction costs of raising energy efficiency." In "IEA International Workshop on Technologies to Reduce Greenhouse Gas Emissions: Engineering-Economic Analyses of Conserved Energy and Carbon. Washington, DC," .

Pamlin, D. and Pahlman, S. (**2008**). "Outline for the first global IT strategy for CO2 reductions." *WWF Sweden*.

Program, U. E. P. A. E. S. (**2007**). "Report to Congress on Server and Data Center Energy Efficiency Public Law 109-431."

Ragowsky, A. and Somers, T. (**2002**). "Enterprise resource planning." *Journal of Management Information Systems*, 19(1): 11–15.

Rai, A., Patnayakuni, R., and Patnayakuni, N. (**2006**). "Firm performance impacts of digitally enabled supply chain integration capabilities." *Management Information Systems Quarterly*, 30(2): 225–246.

Raman, A. (**1995**). "Coordination: An overview." *Harvard Business School teaching note (9-696-001)*.

Sathaye, J. and Murtishaw, S. (**2004**). "Market failures, consumer preferences, and transaction costs in energy efficiency purchase decisions."

Saunders, H. (**1992**). "The Khazzoom-Brookes postulate and neoclassical growth." *The Energy Journal*, 13(4): 130–148.

Schulz, G. (**2009**). *The green and virtual data center*. CRC Press.

Sharman, G. (**2003**). "e-Supply Chain Management - Venturing beyond e-Commerce." *Business Briefing: Global Purchasing and supply chain strategies*.

Sheombar, H. (**1997**). "Logistics coordination in dyads: some theoretical foundations for EDI-induced redesign." *Journal of organizational computing and electronic commerce*, 7(2): 153–184.

Simon, H. (**1997**). *Administrative behavior: A study of decision-making processes in administrative organizations*. Free Pr.

Sriram, R., Arunachalam, V., and Ivancevich, D. (**2000**). "EDI adoption and implementation: an examination of perceived operational and strategic benefits, and controls." *Journal of Information Systems*, 14(1): 37–52.

Stewart, G. (**1995**). "Supply chain performance benchmarking study reveals keys to supply chain excellence." *Logistics Information Management*, 8(2): 38–44.

Tesla, N. (**2007**). *My inventions: the autobiography of Nikola Tesla*. Wilder Publications.

Van Busschbach, E., Pieterse, B., and Zwegers, A. (**2002**). "Support of Virtual Enterprises by an Integration Infrastructure." In "Collaborative Business Ecosystems and Virtual Enterprises: IFIP TC5/WG5. 5 Third Working Conference on Infrastructures for Virtual Enterprises (PRO-VE'02) May 1-3, 2002, Sesimbra, Portugal," page 311. Kluwer Academic Pub.

Van Den Bogaard, H. L. e. a., A. (**2008**). *De eeuw van de computer*. Deventer, Kluwer BV.

Van Der Vlist, P. (**2007**). *Synchronizing the retail supply chain*. Erasmus Research Institute of Management.

Van Hillegersberg, J. (**2006**). *Information Systems for a Networked World*. Enschede.

Wooldridge, M. (**2005**). "Responding to Real-World Complexity: Introduction to Multi-Agent Technology."

Wortmann, H. and Szirbik, N. (**2001**). "ICT issues among collaborative enterprises: from rigid to adaptive agent-based technologies." *Production Planning & Control*, 12(5): 452–465.

Zani, W. (**1970**). "Real-time information systems: A comparative economic analysis." *Management Science*, 16(6): 350–355.

Index

Great potential for making society greener lies within the Information Technology (IT) sector. If we use IT wisely, it will lead us the way to sustainability, resource efficiency, energy savings and greenhouse gas emission reductions – taking us to the Low-Carbon Society. The IT industry itself, responsible for 2% of global greenhouse gas emissions, can become greener by focusing on energy efficiency and better technologies. Yet, more importantly, IT has the potential to reduce the remaining 98% of emissions from other sectors of the economy. We call this the process of Greening IT.

This book delves into this important issue and contains contributions from an international group of experts. The goal is to increase awareness of the potency of IT as an enabler of the transformation our societies must undertake.

" This timely book is the result of an international group of opinion leaders who have set out to communicate the importance of ICT in transforming today's societies into Low-Carbon Societies with many other surprising benefits as we are rethinking what we are doing.

Kim Østrup, Vice President, IBM Denmark

" Greening IT is a collaboratively produced book, by a team of globally dispersed experts on one of the most important themes of our time - a must read!

Tom Raftery, Lead Analyst, GreenMonk.net

" Greening IT is a book that helps its readers understand the many different facets of being Green along with how to enable more environmentally and economically efficient IT data centers.

Greg Schulz - Author "The Green and Virtual Data Center"

ISBN 978-87-91936-02-9
90000
9 788791 936029

http://greening.it