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“Green IT Balanced Scorecard”

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Abstract:

This study focuses on the relevant topic of Green IT, and aims to provide a management framework in order to define and capture business value from a Green IT strategy. Green IT is currently a hot topic but, while awareness and established policies have increased in the last few years, studies show that there is still a lack of measuring tools, goals and embedded initiatives to be followed, and, mostly, there is a lack of a holistic approach, the only way to capture internal benefits and competitive advantages from a Green IT strategy. So, this document aims to contribute to the development of this area. Then, through a careful review of the literature have been identified all of the initiatives towards "being green". The field has been divided in two macro areas: "Greening OF IT" and "Greening BY IT". So, within these initiatives have been analysed all benefits and how they contribute to reduce the overall carbon footprint. From this, following the concept of the Balanced Scorecard (BSC, Kaplan, Norton, 1991), was built a Green IT BSC in order to define a Green IT strategy and provide a management framework for it. Then consistently with the Design Science Research Methodology (Peffers, 2007), have been demonstrated what was stated through a Green IT survey, deployed to domain experts.

ITALIAN ABSTRACT

Le emissioni di gas serra sono in costante crescita. In uno studio condotto nel 2010 da parte dall'*Environmental Protection Agency (U.S.)*, sono state scomposte queste emissioni nelle sue fonti principali, e si è riscontrato un fatto molto curioso: la maggior quota parte è causata dal consumo di energia elettrica (circa il 29%), seguita dai trasporti (circa 25%), e quindi dalle industrie manifatturiere.
Soprattutto negli ultimi anni, una grande spinta al consumo di energia elettrica è data dalla sproporzionata crescita dell'uso delle tecnologie dell'informazione e della comunicazione (ICT). È stato infatti stimato (Gartner, 2007) che l'ICT contribuisce all'impatto ambientale totale per il 2%, circa la stessa quantità dell'industria aerea (civile e commerciale). L'impatto ambientale dell'ICT, però, non si limita alle sole emissioni. Infatti, una parte rilevante del problema si riscontra anche nell'inquinamento del suolo e delle acque, con materiali tossici da dismettere alla fine del ciclo di vita. Si può quindi definitivamente affermare che l'ICT è una parte importante e non trascurabile del problema ambientale. D'altra parte, per quanto riguarda le emissioni, la buona notizia risiede nel fatto che l'ICT può assumere un ruolo rilevante nella riduzione del rimanente 98%. McKinsey, nel suo "Smart Report 2020", ha stimato che l'ICT può fornire soluzioni di business (a livello di processo, prodotto e attività) che possono alleviare almeno cinque volte l'impatto ambientale dell'ICT stesso. Si può quindi affermare con altrettanta certezza che l'ICT può essere allo stesso tempo considerato come una potenziale parte significativa della soluzione.
In conseguenza a ciò i governi stanno dando una forte spinta con nuove norme, regole e decreti legge, all'adozione, da parte delle imprese, di un approccio sostenibile. Anche investitori e clienti iniziano a muoversi verso "imprese sostenibili", e i mercati rispondono scontando i prezzi delle azioni di quelle compagnie con poco riguardo verso l'impronta ecologica che si lasciano dietro.
Ora il problema è definito e motivato ed è stata dimostrata la sua rilevanza.
Quindi, a partire da queste basi, si sono costruiti gli obiettivi per una proposta di soluzione a questo problema. In particolare, ciò che si vuole proporre, è una strategia sostenibile in questo senso, che consenta di catturare valore di business minimizzando (o eliminando dove possibile) l'impatto ambientale. Questa strategia è detta di "*Green IT*". È necessario sottolineare come dietro ad una strategia volta alla sostenibilità si nascondano dei benefici e, nel lungo periodo, la possibilità di catturare valore di business e vantaggi competitivi nei confronti dei "*competitors*".
Per implementare questo tipo di strategia è necessario seguire due passi fondamentali, coerentemente con i problemi presentati sopra. In primo luogo va minimizzato l'impatto ambientale dell'IT. A questo processo si è dato il nome di "*Greening OF IT*". Successivamente, ossia una volta che l'infrastruttura tecnologica è diventata "*Green*", si prende in considerazione il suo utilizzo nei diversi processi di business per promuovere e implementare un approccio sostenibile all'interno dell'impresa. Così facendo, si definisce il secondo step fondamentale di una strategia di *Green IT* come "*Greening BY IT*". Per definire gli obiettivi bisogna però spingersi di più nel particolare. In questo step infatti risiede un'attenta analisi della letteratura. Va sottolineato che vi è una sostanziale mancanza di testi e casi reali sul *Green IT* in termini di strategia integrata. Ciò che si è individuato sono varie iniziative in questo senso, ma che sono presentate singolarmente, piuttosto che in un contesto generale basato su una strategia allineata al *core business*. Queste iniziative sono state divise fra le due parti fondamentali della strategia di *Green IT*: "*Greening OF IT*" e "*Greening BY IT*" (in letteratura sono chiamati rispettivamente *Green IT 1.0* e *Green IT 2.0*). Sono state in particolare considerate solo quelle che prevedono contemporaneamente il raggiungimento di benefici di lungo periodo per l'impresa, e che contribuiscono a minimizzare l'impatto ambientale. Questi ultimi sono considerati i due pilastri del *Green IT* (San Murugesan, 2008). Per fornire qualche esempio di iniziativa per il "*Greening OF IT*" sono inclusi aspetti di design (con particolare

attenzione ai *data centres*), aspetti di ottimizzazione dell'uso dell'energia (non minimizzazione perché non vanno dimenticati i cosiddetti *rebound effects*), conformità con le leggi, utilizzo di fonti rinnovabili di energia e, ad esempio programmi di prevenzione dell'impatto delle tecnologie alla fine del loro ciclo di vita. Per quanto riguarda invece il "*Greening BY IT*" si riscontrano iniziative in senso di coordinamento, reingegnerizzazione, ottimizzazione, e ancora, di utilizzo della tecnologia per promuovere meccanismi di cambiamento culturale offrendo *environmental knowledge management systems* oppure *environmental decision support systems,* e molti altri.
A questo punto si ha un'idea pratica e concreta di che cosa prevede una strategia di *Green IT*. Si passa quindi al cuore di questo documento: la *Green IT Balanced Scorecard.*
Prima di iniziare a presentare il contenuto del *framework* è necessario fare qualche precisazione. In particolare si è scelto di utilizzare il modello della B*alanced Scorecard* (BSC, introdotto nei primi anni '90 da Kaplan e Norton) per tre ragioni principali. In primo luogo, questo è lo strumento più utilizzato dalle imprese, negli ultimi due decenni, per la gestione e la valutazione di diversi tipi di strategie, e i numeri in diversi studi ne dimostrano un elevata efficacia. Infatti, oltre alla classica BSC (volta alla valutazione e gestione della strategia d'impresa), si riscontrano differenti ambiti di applicazione, e ne sono un esempio la *IT BSC* (Wim Van Grembergen, 2005), *Public Sector BSC* (*City Managers of Charlotte, NC, 2005),* fino ad arrivare ad ambiti come la strategia di vita di un individuo con la *Personal BSC* (Lauchlan, 2006). La seconda ragione per cui è stato scelto questo modello, sta nella sua natura. Infatti, essa rappresenta un approccio olistico alla valutazione di una strategia, svincolandosi dall'idea generale di valutare solamente indicatori di natura economico – finanziaria. Vengono considerate infatti diverse prospettive (nell'originale erano quattro, ma non deve essere un vincolo assoluto) che contengono obiettivi quantificabili da raggiungere, ciascuno dei quali è a sua volta valutato da un set opportuno di indicatori. Ma questo non è sufficiente, e da qua viene fuori la terza ragione principale per cui è stato scelto il modello della BSC. Il modello che ne risulta, secondo quanto detto finora, è chiamato semplicemente "*KPI Scorecard"* (Kaplan, Norton, 1991). Infatti, va aggiunto che ogni prospettiva ed ogni obiettivo devono assumere un significato e un ruolo particolare nel percorso definito all'interno di una strategia. A supporto di questo aspetto vi è la mappa delle relazioni causa-effetto.
Quindi, si può passare alla definizione vera e propria della *Green IT BSC.* Innanzitutto è stato necessario definire le prospettive adeguate. Per fare ciò si sono imposti due vincoli. In primo luogo, queste dovevano avere un carattere di omogeneità e dovevano contenere tutte le iniziative individuate nella revisione della letteratura, e tutti gli obiettivi principali (rappresentati dai due pilastri del *Green IT).* In secondo luogo, queste dovevano individuare un percorso coerente che portasse alla *mission* della strategia. In pratica, quello che è stato fatto è un raggruppamento in categorie omogenee fino a quando queste non assumevano un ruolo ben preciso. Dopo numerosi tentativi si sono definite le quattro prospettive che, partendo dal basso, sono: "*Infrastructure Pesrpective", "Stakeholders and Culture Perspective", "Sustainability Perspective", "Business Value Perspective"*. In prima approssimazione si può spiegare il percorso con una semplice frase: con la struttura tecnologica adeguata e sostenibile si possono attivare meccanismi di cambiamento culturale (lungo tutta la catena del valore) che attraverso i processi possono portare alla creazione di valore di business. Ciò sarà più chiaro una volta data una definizione a ciascuna prospettiva.
Facendo il punto della situazione, si hanno ora dei gruppi omogenei di aspetti/iniziative con un significato strategico generale. Ora l'intento si sposta a un maggior livello di dettaglio, e consiste nel tradurre queste iniziative in obiettivi che devono essere specifici, misurabili, raggiungibili, realistici e con un significato temporale ("*smart*"). Il passo successivo consiste nel definire un set di indicatori per ciascun obiettivo che ne valuti il livello di raggiungimento. Prima di procedere va sottolineato un aspetto importante. Essendo il modello di carattere non specifico, ossia a prescindere dal settore di business, dalla dimensione dell'impresa, dall'andamento economico, e da altre variabili esogene, non tutti gli obiettivi/indicatori sono coerenti con tutte le realtà aziendali. Per esempio valutare opportunità di *tele-working* all'interno di un industria manifatturiera è di scarsa utilità,

mentre per, ad esempio, una società di consulenza può essere un buon *target.* Allo stesso modo, valutare l'efficienza di un *supercomputer* per una piccola-media impresa risulta essere di scarso significato. Si deve quindi affermare che il modello va usato dopo un'appropriata contestualizzazione, e alcuni indicatori e, a volte, interi obiettivi, possono essere scartati.
Si passa quindi alla definizione del contenuto di ciascuna prospettiva. Con un approccio *bottom-up* s'incontra per prima la prospettiva infrastrutturale. Questa è posto al livello più basso della catena causa-effetto per due ragioni. Primo, nessuna della altre prospettive comporta conseguenze dirette su questa, e in secondo luogo l'impatto dell'infrastruttura è connesso con tutti gli obiettivi dei livelli superiori in una strategia di *Green IT.* In generale si può affermare che attraverso gli obiettivi di quest'area si vogliono raggiungere due situazioni fondamentali. Da un lato, coerentemente con la definizione fornita per "*Greening OF IT*", è necessario definire obiettivi volti a minimizzare l'impatto ambientale della tecnologia stessa ("*performance and efficiency requirements*"). Dall'altra parte, una seconda classe di obiettivi deve essere definita a questo livello per assicurarsi che siano fornite le tecnologie adeguate per raggiungere gli intenti dei livelli superiori in termini di "*Greening BY IT"* ("*capability requirements*"). Quindi, in termini pratici, sono stati definiti nove obiettivi e trentotto indicatori. In particolare, fanno parte della prima classe obiettivi di riduzione di energia consumata dall'IT, di prevenzione dell'ammontare di rifiuti tossici, di riduzione dell'impatto ambientale dei *data centres* (argomento sull'agenda di tutti i grandi *CIOs* soprattutto per quanto riguarda i sistemi di raffreddamento) e una valutazione integrata sull'uso di fonti rinnovabili di energia (*green power*). Qui sono proposti calcoli standard e non, di efficacia e efficienza dell'infrastruttura. Parallelamente, coerentemente con quanto affermato sopra, vi sono obiettivi volti ad assicurare la presenza, nonché i requisiti prestazionali, di: tecnologie per fornire piattaforme di *knowledge management,* sistemi di supporto alle decisioni, per assicurarsi la possibilità di una rete integrata di sensori per il monitoraggio e, infine, per permettere l'implementazione di un percorso verso la virtualizzazione (cosiddetta *cloud computing*).
Salendo lungo la catena causa-effetto, al livello successivo si trova la *"Stakeholders and Culture Perspective".* Prima di presentarne il contenuto bisogna fare qualche precisazione. In particolare, prima di analizzare questa prospettiva è necessaria una valutazione delle parti interessate. Con ciò si intende un'analisi per valutare e classificare chi sono i *key stakeholders* e, in secondo luogo, quali sono i loro interessi e bisogni. Questo tipo di indagine è assolutamente indispensabile per focalizzare la valutazione, e quindi dare un significato preciso agli indicatori e a chi questi sono riferiti. Una volta condotta questa ricerca si possono fissare gli obiettivi. In linea generale il raggiungimento di questi deve portare a: soddisfazione delle parti interessate e gestione delle loro volontà/bisogni, una catena del valore che sia "*green*" con una sensibilizzazione di tutta la *supply chain.* Inoltre, pietra miliare di una strategia di *Green IT,* bisogna promuovere un cambiamento culturale interno definendo un "linguaggio sostenibile" per favorire una comprensione generale. Infine, altro aspetto fondamentale per cogliere valore di business da questa strategia, riguarda la comunicazione. Infatti, è proposto un *assessment* volto a valutare il livello di maturità della "*environmental communication".* Quindi, sono proposti per sei obiettivi, ventidue indicatori, che però, rispetto all'area precedente, hanno qualche particolarità. Infatti, data la natura delle misure, sono proposti alcuni metodi più qualitativi che quantitativi che, con un corretto sistema d'interpretazione dei risultati, non intaccano la qualità della valutazione.
Salendo ancora, si incontra la "*Sustainability Perspective".* A questo livello, l'oggetto dell'analisi diviene l'organizzazione e i suoi processi. In particolare, questa prospettiva copre quattro aree fondamentali. Infatti, include aspetti di *risk management,* miglioramento dei processi, obiettivi strategici e impone un orientamento verso il futuro con una visione di lungo periodo (qui è valutato la parte relativa alla ricerca e sviluppo). La prospettiva include otto obiettivi valutati su un totale di trentadue indicatori. Il ruolo giocato da questo terzo livello è fondamentale. Infatti, nel cammino strategico, una volta resa sostenibile l'infrastruttura, e aver raggiunto una cultura interna sensibilizzata e orientata verso il *Green IT,* è a questo livello che viene maggiormente implementata

la seconda parte della strategia ("*Greening BY IT*"). Inoltre, questo livello funge da ponte fra le iniziative e il valore di business. Infatti vi sono obiettivi come ad esempio "*improve public image"* o "*investors and customer loyalty"* che sono direttamente collegati ad obiettivi di natura economico-finanziaria.
Infine, al livello più alto della catena causa-effetto, si trova la "*Business Value Perspective".* Qui è incluso l'obiettivo finale della strategia: creare valore di business. Prima di presentarne il contenuto è necessario fare una precisazione. Infatti, va giustificato il fatto di avere scartato l'ipotesi di una prospettiva puramente finanziaria. Ciò è stato ritenuto più adeguato al contesto per la presenza e la forte incidenza di quelli che sono i benefici intangibili in una strategia di *Green IT.*
La parte più complicata all'interno di quest'area risiede nel generare un quadro generale di quelli che sono i costi e i benefici (tangibili e intangibili) monetizzati di tutta la strategia. È infatti proposta una linea guida per la formazione di questo quadro, ma, secondo la mia personale opinione, risulta molto difficile la stima soprattutto per quelli che si manifestano nel lungo periodo. Molto interessanti sono alcune misure innovative della sostenibilità. Si cita in particolare il "*Sustainable Value"* (approccio basato sul valore introdotto da degli studenti dell'Università di Marsiglia), e l' "*Energy Pay Back Time".* Sono infine brevemente riproposte le classiche tecniche di valutazione degli investimenti (*Discounting Cash Flow* e non), e una valutazione a carattere finanziario.
Così si conclude la parte relativa alle prospettive, ma non è abbastanza per dire di aver sviluppato una corretta BSC. Infatti, tutti gli obiettivi definiti sono stati collegati nella cosiddetta mappa causa-effetto, che è la chiave del modello, in quanto gli fornisce un significato a livello di cammino strategico, anche a un livello di dettaglio maggiore, ossia a livello di singoli obiettivi. Attraverso la creazione di questo strumento, si va a sviluppare un *easy to read format* volto a comunicare la strategia alle persone che ne fanno parte. Infatti, perché una strategia sia correttamente implementata, essa va propriamente descritta e comunicata. Ciò avviene tramite la mappa causa-effetto. Ma non è finita. Questo strumento infatti facilita anche la gestione della strategia nel lungo termine. Ciò avviene attraverso i collegamenti tra gli obiettivi, che permettono un'analisi delle problematiche (e delle anomalie derivanti dagli indicatori) focalizzata alle aree che impattano su quella parte dove risiede il problema. Inoltre, questa mappa, se correttamente utilizzata, può divenire uno strumento per raccogliere esperienze e affrontare il futuro con più certezza.
Così si conclude la *Green IT BSC,* e ciò che è necessario ora è fornire qualche prova empirica della sua efficacia e coerenza all'interno di una strategia di *Green IT.* Per fare ciò il metodo più adatto sarebbe la sua completa implementazione in un contesto d'impresa reale. Tuttavia, vista la vastità organizzativa del modello, un caso di studio avrebbe richiesto, in mia opinione, almeno un anno. Quindi, è stato sviluppato un sondaggio online da distribuire agli esperti del campo. In particolare, questo è stato compilato da persone provenienti dal mondo delle imprese e dal contesto accademico (ricercatori e studenti di PhD). Attraverso questo sondaggio si è provata la coerenza delle iniziative proposte all'interno della strategia di G*reen IT,* e si sono comprovati i potenziali benefici raggiungibili, sia in termini di vantaggi competitivi che in termini di benefici interni all'organizzazione.
Seguendo la *Design Science Research Methodology* (Peffers, 2007)*,* linea guida per questo lavoro, si giunge allo step finale, quello riguardante la comunicazione. Qui sono in programma, insieme con l' IVI (*Innovation Value Institute),* la pubblicazione di alcune pagine, e l'iscrizione ad alcune conferenze nell'arco del 2012 (in particolare a quelle di Vienna e Barcellona) per promuovere il lavoro svolto in questi mesi.

"It's better to burn out
than to fade away"
- Neil Young -

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Giovanni Maccani.

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Chapter 1: Introduction

Life on Earth exists because of the constant electromagnetic irradiation from the sun. What is often called “the problem of global warming” (or “the greenhouse effect”), is actually a natural phenomenon that has always existed on this planet. In particular, from the greenhouse effect derives the Earth's temperature. Without this phenomenon, the temperature would be, on average, thirty degrees cooler (that would be around -18°). The problem is caused by the huge presence of some gases (greenhouse gases) in the atmosphere enough to cause the increase of global temperature. In general, these gases play two important roles: first, they filter radiation from the sun, avoiding to convey to the Earth surface the most harmful to life; then, the second main role, is hindering the release of infrared rays. In fact the sun's rays bounce off the Earth's soil, and are headed again upwards. The greenhouse gases in the atmosphere prevent somehow their complete loss in space, causing them to fall back down. What is created is a huge greenhouse. As a consequence, the steady accumulation of greenhouse gases (GHG) is changing the world's climate and weather patterns. There are also growing, due to this fact, the births of droughts in some countries and floods in others. Consequently global emission would have to stop growing.
The whole world is concerned. Many initiatives are being implemented worldwide to address this problem (see, for example, Kyoto Protocol, subscribed in 1997, involving more than 160 countries).
A major cause of this phenomenon is electricity because coal and oil that helps generate electricity also releases carbon dioxide, pollutants and sulphur into the atmosphere. These emissions can cause also respiratory disease, smog, acid rain, rather than only global climate change.
From a research conducted in 2009 by the U.S. Environmental Protection Agency (EPA) emission from electricity generation accounted for the largest portion of GHG emissions (about 29%). Transportation activities accounted for the second (27%) and the emissions from industry made up the third largest portion. The EPA report is summarized in the next figure:

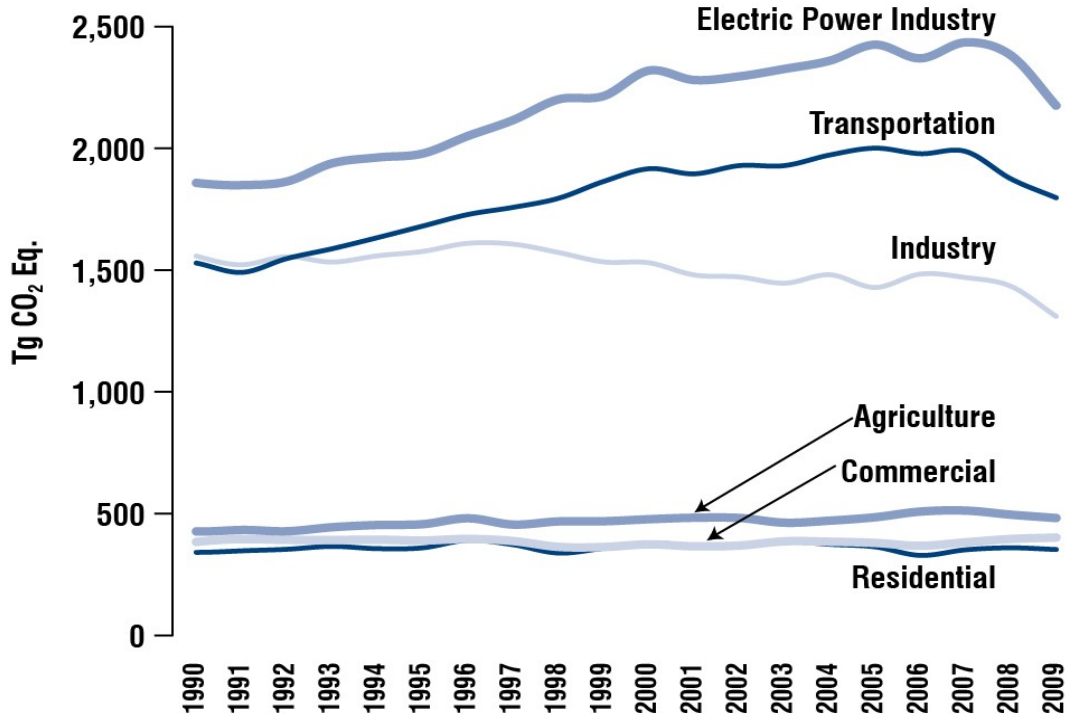


Figure 1. Source: *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2009, EPA.*
Tg CO_2 Eq: gigatonne of carbon dioxide equivalent;

What is more, is that the greenhouse issue is much more serious if is considered that the CO_2 in the atmosphere has an average permanence time of about one hundred years. Then, the constant growth of emissions requires an immediate action by governments, businesses, and individuals.
The disproportionate growth of the use of computers has led to an increase of energy consumption. The immediate consequence is its impact on emissions. It has been estimated that each PC in use generates a ton of carbon dioxide every year (Gartner, 2007). Therefore IT affects our environment in several different ways; moreover in each stage of its life from its production, throughout its use, to its disposal, IT is becoming a motive of major concern. Fabricating computers and their electronic and non-electronic components consumes electricity, raw materials, chemicals and water, and generates hazardous waste. All these impact the environment. Moreover, computer components contain toxic materials. Increasingly, consumers discard a large number of old computers, monitors and other electronic equipment two or three years after purchase, and most of this ends up in landfill, contributing to the soil and water contamination.
It has been estimated that "global carbon emissions attributable to ICT have been calculated at 2% to 2.5% of world totals - about the same as the airline industry - and as high as 5-6% of developed nation totals" (Gartner, 2007). McKinsey forecasts that the ICT sector's carbon footprint will triple during the period from 2008 to 2020. For office buildings, "ICT typically accounts for more than 20% of the energy used, and in some offices up to 70%" (USGBC, United States Green Building Council, 2008). So, for the businesses, the objective became in the last few years "minimize, or eliminate where possible, the environmental impact of IT to help create a more sustainable environment" (San Murugesan, 2008).
What is needed is a sustainable approach. Going deeper, the term sustainability has been defined in several ways, depending on the context. The word sustainability is derived from the Latin *sustinere,* which meaning is "maintain", "support", or "endure" (http://www.dictionary.com). Over the years, especially since the 1980s, the word sustainability was more linked to human sustainability and Earth sustainability. This has resulted in the most broad definition of sustainable development. In 1987 the United Nations Commission on Environment and Development defined sustainable developments as those that "meet present needs without compromising the ability of future generations to meet their needs". In recent years, "an area that has come to be called sustainability science has emerged" (Kates, R.W. "Readings in Sustainability Science and Technology", 2010). However, "sustainability science is not an autonomous field or discipline of its own, and has tended to be problem-driven and oriented towards guiding decision-making" (Clark, W; Dickson, N. "Sustainability Science: the Emerging Research Program", 2003). The goal must therefore be to include sustainability in the IT strategy. This issue will be defined in this document as Green IT strategy.
A further push towards a sustainable approach for the companies comes from the government legislations in this theme. In particular the most important are the European Union's directives 2002/95/EC (better known as RoHS directive), on the reduction of hazardous substances, and 2002/96/EC (WEEE directive) on the issue about "Waste Electrical and Electronic Equipment". So, the regulatory compliance could be seen as a additional reason to move towards the adoption of a Green IT strategy. Also industries in recent times joined their efforts forming new initiatives in the Green IT field. Some examples are Climate Savers Computing Initiative (CSCI), the EPEAT (Electronic Product Environmental Assessment Tool) initiative, and again the Green Grid, the Green 500, the Transaction Processing Performance Council (TPC), and further more. Hence, despite the literature is still weak, the real concentration and attention to the Green IT initiatives is remarkable, both by companies and governments.
This document will provide solutions and initiatives in order to capture business value from a Green IT strategy. Both short and long term aspects will be considered and analysed. So, moving from a moral obligation to new opportunities for generating business, sustainability has to become an integral part of regular business strategies in order to achieve competitive advantages.

The main goal of this master thesis will be provide a management tool to systematically align IT strategy with business strategy from an environmental sustainability perspective in order to achieve competitive advantages. This tool is the Green IT Balanced Scorecard.

The structure of this thesis will follow the Design Science Research Methodology (see, chapter 4) introduced by Peffers (2007). In particular, chapter 2 will be an overview of the literature on Green IT. Here will be defined what is meant for Green IT in this document, and all the initiatives with references to their contribution to a smaller impact on the environment and their potential benefits for the company. Then in chapter 3 will be introduced the Balanced Scorecard in order to provide an understandable explanation both on what will be the Green IT management tool, and on how to use it. Hence, in chapter 5, the core of this thesis, there will be the design and development of the Green IT Balanced Scorecard itself. Finally chapter 6 will focus on the collection of empirical data from domain experts by the distribution of a simple, but really significant in this context, Green IT survey. In this part these data will be also evaluated and interpreted in relation to the model previously defined.

Chapter 2: Green IT

2.1 HISTORY AND DEFINITIONS:

The term “Green IT” (or Green Computing) was probably coined shortly after the launch of the voluntary labelling program “Energy Star” by the U.S. Environmental Protection Agency (EPA) in 1992. Almost simultaneously was launched the “TCO Certification” by the Swedish Confederation of Professional Employees, born as a series of product certifications for office equipment and developed over the years to become a true standard for computers, keyboards, printers, mobile phones and office furniture.
Till recently, IT functions and activities were primarily focused on meeting their functional and performance requirements. Very little attention was paid to aspects like energy consumption, effective utilization of IT resources, IT's operational costs or IT's negative impact on the environment. So, the importance of green technology was made evident when computing attained critical mass in the early 1990s, which was followed, between late 1990s and early 2000s, by many regulatory milestones.
In more recent times (2008) San Murugesan has defined the field of Green IT as: "the study and practice of designing, manufacturing, using, and disposing of computers, servers, and associated subsystems, such as monitors, printers, storage devices, and networking and communications systems, efficiently and effectively with minimal or no impact on the environment". The idea is to make the whole process surrounding computers more friendly to the environment, economy, and society. This means that manufacturers must create computers in a way that reflects this triple bottom line positively. Once computers are sold, businesses or people have to use them in a green way by reducing power usage and disposing of them properly or recycling them. So, the idea is to make computers from beginning to end a “green product”.
It is generally understood that “going green” invariably leads to compromised productivity due to the adoption of unfeasible eco-friendly business practices that have been put by idealistic environmentalists. However, this perception is largely misplaced. Green IT is nothing more than “adopting a mindset that helps businesses in performing at least at the same level of productivity and profit margins, but in a more environment-friendly manner” (Bright Hub report, 2010).
So, some fields of this approach can be identified in improving energy efficiency, lowering greenhouse gases emissions, using less harmful materials, reuse and recycling. Further impetus to the Green IT initiatives are also given by rising cost of electricity and waste disposal, legislations, image and public perception of the company.
What has been said is not enough. A Green IT strategy does not just make IT green. A Gartner research (2007) affirms that “IT contributes for approximately 2% of global carbon dioxide emissions (about the same amount as the aviation industry), but the good news is that it can significantly concur to control and decrease the remaining 98% caused by other industries or business units”.
Moreover, a report released by McKinsey in 2007 (Figure 1) shows the important role that ICT can play in global emission of carbon dioxide reduction. This report estimates ICTs could deliver approximately 7.8 $GtCO_2e$ (gigatonne of carbon dioxide equivalent) of emissions savings in 2020, representing a 15% of emissions cut in 2020 and 600 billion € of cost savings. Hence, as said, ICT can provide business solutions that can alleviate at least five times the greenhouse gases footprint of ICT itself. In the following figure, the component “other abatements” refers to some actions such as for example avoided deforestation, wind power or biofuels usage, or other abatements that are not depending on the ICT. Finally the “2020 BAU” represents the 2020 Business-As-Usual

scenario, or if are not taken initiatives in this direction.

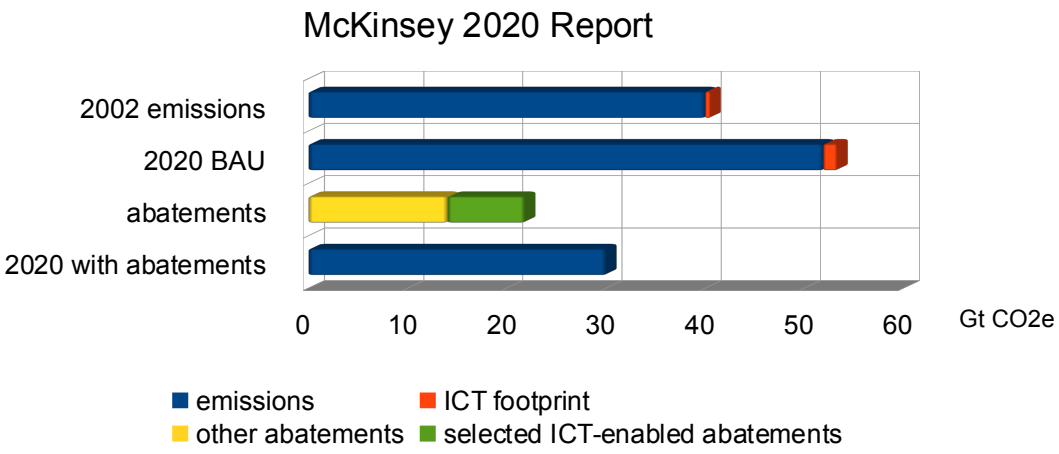


Figure 2: Smart 2020 report; Source: .

There is therefore a second macro area of Green IT that aims to achieve positive environmental aspects starting from an IT that has already become green; so, it's represented by the use of IT in several ways to improve environmental sustainability in different areas of business activities, and by the use of IT in innovative ways to create awareness and promote sustainability among its employees, business partners, stakeholders and customers (among the extended enterprise). Some examples might be software tools for analysing, modelling and simulating environmental impact and its risk management, or platforms for eco-management, emission trading or ethical investing, and, as discuss below, many others.
Accordingly, Green IT is on the radar screen of CIOs; that's why leading IT enterprises joined forces (2007) to form a non-profit group, "Green Grid", that aims to propagate the best practices in this sense and delivering a consistent set of definitions and tools to make a Green IT solution easier for IT managers and to determine and compare their operational efficiency. Moreover, beside this, there have been many initiatives proposed by governments and organizations. In general, however, only about 20% of the initiatives have measurable targets and, being difficult manage what can't be measured, those assume a relative weight.

2.2 TWO PILLARS OF GREEN IT :

- ENVIRONMENTAL ASPECT OF TECHNOLOGY: as written before, it is necessary to include IT as one aspect of environmental sustainability; each stage of the IT life cycle, from design, trough its manufacturing and usage, to its disposal can pose environmental damages. But IT is not only a part of environmental problem, but it can also be a part of the solution. In fact IT can support, assist, and leverage other environmental initiatives by offering innovative modelling, simulation and decision supporting tools (of course besides IT itself being green).

- COMPETITIVE ADVANTAGES OF GREEN IT IMPLEMENTATION: there are several different forms of competitive advantages connected with the field of Green IT. Some might refer to the nature of hardware and software platforms, networks, and data architectures. Some others are connected to the usage of IT, and others might refers to the manners in which the companies use their IT capabilities to generate knowledge. Being impossible to

provide a list of all the potential advantages, for their variability depending on the organization, these will be highlighted during the description of the focus areas of the Green IT. Focus a Green IT project on the long-term benefits could also give the necessary impetus and motivation to turn IT green and use IT in innovative ways to green the rest of the corporate functions.

Will be now presented a description of the Green IT main focus areas. The purpose is to proceed separately for the two parts previously presented:

- Greening OF IT;
- Greening BY IT.

Summarizing, expecting that usage of ICT will increase substantially in the coming years (Climate Group report, 2008), paying attention to the direct energy consumption for ICT itself is certainly very important. However, beside the "Greening OF IT" activities, it is recognized that the smart application of IT can have a substantial impact on reducing energy consumption in other fields. This is here called "Greening BY IT".
Consistently with the two pillars, for each topic will be presented the main potentials competitive advantages.

2.3 GREENING OF IT:

For the analysis of this first phase of the strategy are discussed those that, in my personal opinion, are the most important areas for reducing environmental impacts and for attainable benefits , both tangible and intangible. General ideas presented here are the areas of intervention, and are included aspects of real investment, cultural and behavioural aspects. However, it is obvious that each area must be supported by an appropriate strategy and an evaluation of feasibility and affordability that is different depending on the business reality is being considered.
It is here provided a brief description for each of the 10 most important focus areas of a "Greening OF IT" strategy.

2.3.1 Design for environmental sustainability:

The goal is to create a systemic idea of the product in order to minimize the input of raw materials and energy, let alone the impact of all emissions and waste, both quantitatively and qualitatively, and calculating the harm of all effects. However, the scope of the "eco-friendly design" is not limited to products only.
A study (2000) by the Lawrence Berkeley National Laboratory (U.S.) indicates that "buildings with good overall environmental quality, can reduce the rate of respiratory disease, allergy, asthma, "sick building symptoms", and enhance work performance".
Defining a green building as a structure that is designed, built, renovated, operated, or reused in an ecological and resource-efficient manner, can be introduced a very important standard developed by the U.S. Green Building Council (USGBC): the LEED (Leadership in Energy and Environmental Design). The LEED rating recognises Green Building to meet certain objectives, such as: protecting occupant health, improving employee productivity, using energy, water and other resources more efficiently. According to this standard, companies could also achieve a lower overall impact on the environment and could also decrease the costs of the building owners. Hence Green Building leads to reduce costs and meet growing social demands.

Another study, this time from the Rocky Mountain Institute (U.S.), shows that “productivity gains of 6% to 16%, including decreased absenteeism, and improve quality of work, have been reported from energy-efficient design”.
It's also important to underline that operate/build/maintain a facility has a life span of about 40 years, and therefore the effects are not immediate but also in a long term view.
On the technology-procurement side, companies must create or see again their supply chain according to criteria that aim to a reduction of the amount waste electrical and electronic equipments, encouraging suppliers that sell ICT products with a long life span. It would be also required that suppliers publish reports about their GHG emissions. The best way to minimize the Computer's impact on environment is using non-toxic materials that consume less electrical power and are easily reassembled, encouraging its reuse. In fact computers components contain toxic materials like lead, chromium, cadmium and mercury that collaborate on the increasingly amount of “e-waste” going to landfills.
Finally deserves particular attention to the process of designing a data centre, which be specifically discussed later.

2.3.2 Power management:

“The most energy efficient PC is one that's off”; a recently released report concluded that US company alone waste $2.8 billion powering unused desktop PCs (“PC energy report, EPA 2009). That's why enabling power management features.
There are two basic modalities for power management: a running versus suspended (not running) aspect in which a component, or whole system, can be powered off when it is not being used, for example, once it has become idle, but turned on again when it is needed; then, is proposed a performance adjustment aspect (while running mode) in which the performance level of a component can be lowered or raised, based on either the observed level of its utilization or other needs of the workload.
An optimal system must be able to construct a power model that allows it to know how and where power is consumed, and how it can manipulate that power. From a more pragmatic point of view are available on the market some software that offer network-level control over PCs and monitors. The software places the PC into a lower-power consumption mode, such as shutdown, hibernation, or standby, and monitors into a sleep mode when they aren’t being used. It also measures and reports how much power each PC and monitor consumes.
A report from U.K. Parliamentary office of Science and Technology (2008) shows that 18% of office workers never switch off their computer at night or weekends and a further 13% leave it on some nights each week, producing about 700,000 tons of CO2 emissions, equivalent to the annual emission of a typical gas-fired power station; it shows also that “a centralized active power management software could save £175,000 a year for a business with 20,000 staff”.
Many people believe that the duration of a computer's life depends on how many times it is turned on and off, getting used to leave their computers on all the time. The reality is that the lifespan of an electronic equipment depends on his temperature and on his cumulative operational time, and turn a computer off reduces both of this factors.
Another common energy waste can be found in the use of screen-savers. The use of a multitude of colours and shapes represents a significant consumption and is significant in its size as well. It's therefore desirable the elimination of these screen-savers and the substitution with empty (black) displays.

2.3.3 Energy efficient computing:

Traditionally, systems have been designed to achieve maximum performance for the workload. On energy-efficient systems, maximum performance for some tasks, or the whole workload, will still be desired in some cases, but the system must now also minimize energy usage. It is important to understand that performance and energy efficiency are not mutually exclusive. For example, even when achieving maximum performance, any resources that can be deactivated, or whose individual performance can be reduced without affecting the workload's best possible completion time or throughput, constitute energy optimization. So, energy-efficient computing differs from power management because is an optimization problem. This system must adapt the system's hardware resources so that only what is needed to perform the required functions is made available, and the total energy used is minimized as a result.
For moving toward energy efficient computing major IT vendors are addressing these problems by assisting their customers in migrating applications from mainframes to servers; "old mainframe computers are bulky power systems that demand a lot of cooling" (San Murugesan, 2008).
The recent move from Dual-core system to Quad-core one, demonstrates that it is possible saving power while increasing processing performance. In fact a 15% reduction in frequency of chip's operation (from dual-core to quad-core) could save up to 50% power consumption.
Another energy-efficient component should refers to monitors. In particular it's not necessary to buy a larger one if it is not needed. For example a 17-inch monitor uses 40% more energy than a 14-inch monitor (San Murugesan, 2008). Also, to the growth of the resolution, corresponds a more energy consumed.
Furthermore there are some common and simple best practices, as: "try to plan your computer-related activities so you can do them all at once, keeping the computer off at other times", or "do not turn on the printers until you are ready to print. Printers consume energy even while they are idling", and "do not print out copies of email unless necessary", "buy a monitor only as large as you really need", and many others.

2.3.4 Server virtualization:

Server consolidation using virtualization is not only a good idea for disaster recovery and for development servers, but also it's a key strategy to reduce power consumption. The basic idea is that one physical server hosts multiple virtual servers. This process is also known as Physical to Virtual (P2V) transformation. Hence it might be seen as a translator between two different environments. According to various studies, "the average usage on a dedicated, stand alone, functional server is less than 10% of its capability" (Miller, A. "Virtualization: A Green Thinker's Primer", 2007). The common approach to virtualization refers to segment the device into multiple operating systems and to allow these environments to operate independently and simultaneously on one device.
Currently vendors, like Intel, are selling processors with native functionally to support virtualization. Some good things from an environmental perspective that come from this strategy are less waste, less energy consumption and less "real estate", even if maybe the most important effect is reflected in the data centres cooling systems. In fact, give the heat generation of a processor, the ability to minimize the number of required processors is highly desirable from an environmental point of view.

2.3.5 Responsible disposal and recycling:

The IT disposal is cause of a major concern because through landfills it's polluting the earth and contaminating the water. Is of fundamental importance to dwell on the environmental impact of the IT disposal. Has already been said a lot about how the e-waste disposal affects the environment. Is rather interesting that from another point of view we can see an advantage to do so. In recent years has established a proven approach to prevent the environmental impact of IT disposal: "the three Rs way: Reduce, Reuse, Recycling". However, I think that should be added another important "R" to the model: Refurbish. Particularly we should consider the third stage (recycling) even after considering the prospect of refurbishing. So it become "The four Rs approach" (and it is clear how each component helps to decrease the quantity of material discarded):

- Reduce: there are several different ways to reduce the amount of IT components and equipments. The main road may be, as previously described, the virtualization.

- Reuse: most of companies buy new computers for each or every project or once every two years. Usually this process is automatic planned and carried out without an effective control of correspondence with the required performance. Moreover, if the performance prerequisites are not met, an "old" computer should be given to someone who needs it or use functional components from a retired product. So, by using the hardware for a longer period of time, it can be reduced the environmental footprint caused by computer manufacturing and disposal.

- Refurbish: old computers and servers can be refurbished and upgraded to meet new requirements. Old computers and other IT hardware could be made almost new again by reconditioning a replacing their parts. The market of refurbished IT equipment is growing, and more enterprises are open to purchasing refurbished goods. From a green point of view, "reusing what we have is a better long-term way of managing resources" (San Murugesan, 2008). In other words, companies could potentially save their cash flow and capital expenditures. Finally if these options are unsuitable, before the disposal, it should be considered the possibility of charity (for example to schools).

- Recycle: this stage should become exclusively only in the prospective that the good cannot be reused or refurbished. The word recycle, if referred to a good, can be also viewed in the way that it must be disposed in a properly environmental friendly manner. The problem of e-wastes that end up in landfill is global and growing fast. The U.N.E.P (United Nations Environment Program) estimated in 2004 that up to 50 millions tons of e-waste are generated worldwide each year and this is increasing. If computer's components are buried in landfills they affect the soil, if burned, they release toxic gases into the air; so if these wastes are not discarded properly, they can harm the environment and people. A partial solution to this issue can be found in the fact that e-waste could be a valuable source for a secondary raw materials. Hence components can be reused in manufacturing processes or be broken down into constituent material for reuse.

After all we must add that consider e-waste can provide both revenue and savings. Indeed handling large amount of waste is costly; keeping people on staff with the expertise to ensure that waste is handled in accordance with regulations, and to process the paperwork is also costly. Consequently there can be significant liabilities associated with employees' handling of this type of waste. Finally can be said that reusing, reducing, or source

prevention of waste cuts down raw materials costs and reduce disposal costs.

2.3.6 Regulatory compliance:

Many governments have continued implementing regulations that encourage Green IT. Adherence to legislations is a critical success factor for an IT infrastructure. In fact it can results in a competitive advantage, in the way of avoidance of financial penalties and also sometimes in financial bonus for superior performance. Some researches demonstrate that the financial penalties can reach a value of approximately 3%-7% of the total energy spend. Below the intent is to provide a brief overview on the most important laws in force:

- WEEE: the Waste Electrical and Electronic Equipment directive was adopted on February 3, 2011 by European Parliament (by 580 votes to 37). The intent of this EU legislation is to restricting the use of hazardous substances in electrical and electronic equipment and to promoting the collection and recycling of such equipment. With this adoption consumers return their used e-waste free of charge, for increase recycling and/or reuse. It also wants to struggle the illegal trade of electrical and electronic waste to non-EU countries. So, WEEE aim to increase the amount of e-waste appropriately treated and reduce the volume that goes to disposal, but also aim to decrease the administrative burdens. In particular, from the March 14, 2011 members states must annually collect 45% of the average weight of electrical and electronic equipment placed in the national market, and producers must achieve a minimum collection rate of 65%. Is so obvious a measure by the state against IT companies in this regard.
  It's my personal opinion that the proposal to encourage producers to finance all costs, including those resulting from collection facilities, is likely to emphasize the "extended producers responsibility" without the right for them to physically organize the collection. An optimal management of WEEE, in my opinion, should be consider the cooperation between all actors involved (not only producers, but also consumers, retailers and distributors).

- RoHS Directive: the Restriction of Hazardous Substances in electrical and electronic equipment directive was delivered by NMO (National Measurement Office) of the UK market surveillance authority. It aims to decrease the use of hazardous materials (as lead, hexavalent chromium, cadmium, and mercury). It bans new electrical and electronic equipment if it contains more than the agreed-upon levels of that substances.
  The consolidated text of ROHS is still subject to confirmation by the European Parliament to find publication in the OJEC (Official Journal of the European Community), but it will become soon an effective law.

Finally is important to underline that may also derive competitive advantages in terms of public image. Moreover companies could also leverage the regulatory compliance process into marketing policies (Prakash, A. "Green Marketing, Public Policy and Managerial Strategy", 2002). Again, as an effective communication should treat real numbers, and as it is hard to find benchmarks, companies can take advantages to compliance with legislations to convey their commitment to a sustainable way.

2.3.7 Environmental-related risk mitigation:

From a Gartner research can be learnt that “By 2014, combined with pressure from stakeholders and the supply chain, will affect the strategies of at least two-thirds of organizations, which will need to exploit or risk-mitigate environmental sustainability”.
There are several different causes. From a socio-political point of view the growing pressure from governments and stakeholders is a major concern. Also the world is expecting the long-announced energy crisis.
For a company, before developing a risk mitigation plan, is necessary to profile the sustainability risks in its organization through its value chain. Risks relating to the environment can be divided, by a first approximation, into two macro areas: environmental risks and social risks. The firsts refer to sustainable practices in production and procurement processes, and to the effective compliance of all stakeholders with sustainability norms. Instead, the social risks are identified on a sort of adherence to human rights in all business operations, and on the impact on stakeholder community. Only after evaluate its profile an enterprise should deliver its risk mitigation plan, compatibly with its situation. Some goals might be for example reduce social conflicts within communities, prevent, in the sense of arrive before, the long-term energy crisis, protect environment, and help reduce political risks.
It's needed to add that also investors and consumers are moving toward that companies with regard to their carbon footprint (Kinaxis report, 2009). Consequently markets are discounting share prices of companies that poorly address the environmental problems they create.
Finally deserves a special analysis the situation of small and medium enterprises. The companies at the top of the business supply chain in many sectors are making significant specific and targeted commitments to improved environmental performance, putting pressure down the supply chain to do the same. Is therefore forecasting a reselection of the most deserving companies.

2.3.8 Usage of green power:

The EPA defines green power as: “electricity generated from resources such as solar, wind, geothermal, biomass, and low-impact hydro facilities”.
Green power is available in some basic forms; the best choice depends upon the status of the electric utility restructuring in the country where the purchase is being made. Some exampl might be: block products, in which customers are allowed to choose green power from electric grid in standard units of energy at fixed price; green tags (or renewable energy certificates) is another form (mostly used in the U.S.), in which a customer can purchase the renewable attributes (tested and certified) of a specific quantity of a renewable energy; the third solution is represented by blended products, in which according to the renewable resources available to utilities (or marketers), customers are allowed to switch to electricity that contain a variable percentage of renewable energy. Finally the most advantageous solution is to generate renewable energy on-site. It not only can increase the power reliability, but also can provide stable electricity costs, help manage waste streams, and, in most of countries, excess green power generated on-site can be automatically purchased to the electric grid (beside agreements at the installation).
Choosing green power solutions lead to a lot of critical benefits in businesses and organizations, including:

- Environmental stewardship: it represents a simple, but fundamental, step towards creating a more sustainable organization.

- More secure energy supply: it's first of all because fossil fuels will not last forever. Moreover, in a shorter term view, supply is increasingly dependent on imports from countries that, for the recent events, do not give specific guarantees for the future.
- Public image: in this case the use of renewable energy sources help to demonstrate the environmental stewardship in the organization.
- Financial incentives by government; in some countries governments, through the Carbon Trust, also permits, at small or medium sized businesses, interest-free loans to invest in those technologies.
- Power portfolio management: with the avoidance of fuel costs, the use of renewable energies helps protect the power portfolio from volatile prices of fossil-fuel-generated electricity.
- Power reliability: if the generation is on-site, it can be a more reliable source of power than that one distributed though the electric grid.
- Opportunity to exploit synergies by relationships with businesses that have similar values. Joining the forces constructing a common project may lead to the mitigation of the risks that entails a small scale.
- Customer loyalty: by demonstrating the environmental stewardship, it resulted increased the company's investor and customer loyalty (Industry Canada report, 2011).

Is evident how it is a crucial step for “greening” an organization. However, before switching to renewable energy, IT managers must do all they can to reduce their need for energy in first place.
Once reduced the need, a company should consider an analysis on the current energy use and on the energy mix required. Hence it's necessary to carry out a study about the limitations of the different types of renewable energy. After all can be implemented a practical plan that includes feasibility studies, usually undertaken by a specialist consultant.
Finally it's also recommended to confront the opinions of businesses who use renewable energy, and to speak with the local authority planning department.

2.3.9 Eco-labelling of it products:

This process would be critical for an organization and it's used to assess the brand position and seriousness towards the environment. A reputational point of view is also included.
There are many standards of assessment. In my opinion the most important for completeness and possible future implications are two: EPEAT and ENERGY 4.0 STANDARD.

- EPEAT: the Electronic Product Environmental Assessment Tool aims to assist buyers to evaluate, compare, and select desktop computers, notebooks, and monitors based on their environmental attributes, and also helps vendors promoting their products as environmentally fashion. It evaluates electronic product through some categories such as materials, designing for the product's end of life, energy conservation, and more. Via score card, the EPEAT method attributes a score to each product, so manufactures have to boost their EPEAT score to achieve a higher level of registration.

- ENERGY 4.0 STANDARD: Rolled out by EPA (Environment Protection Agency) in 2010, it regulates energy performance of internal and external supplies, and gives power consumption specifications for idle and standby modes for a number of different devices, such as computers and desktops. In the U.S. and in Europe is not mandatory, but over the years is playing an important role in marketing. Therefore adhere to this

standard may lead to competitive advantages.
(Energy 5.0 is in works, and it's planned for May 1, 2012).

Note that to capture competitive advantages by adherence to a standard of qualification, it must be consolidated and, especially, recognized. Mostly in recent years are forming a myriad of consultants societies who aim to be a sort of precursor of the law, inventing all kinds of certifications. Is therefore important to assess the issuers of that standards, for avoid the risk of doing useless investments.

2.3.10 Data centres design, layout and location:

The big rising of web in the lasts few years is driving the extremely rapid growth of data centres. Consequently enterprises must expand their capacity, although a lot of data centre managers have maxed out the power utility's ability to deliver additional capacity. Some goals might be also improve airflow management to curb data centre's energy consumption and reduce cooling requirements adopting environmentally friendly design.
A study by HP (HP eco-programme) estimates that data centres in the U.S. consumed about 61 billion kilowatt-hour in 2006. this is more than electricity consumed by the nations colour televisions and similar to the amount electricity consumed by approximately 5.8 million average U.S. households.
Historically, data centre management has been focused on growth, performance, uptime, and reliability and IT organizations had responsibilities for its management. As a result of the significant growth and the lack of a holistic approach can be identified a lot of problems. Hence, one of the most inefficient issues of many data centres today revolves around cooling. In fact, corresponding to a sharp growth in energy demand, it's estimated that around 40% of the energy consumption in a data centres is used for cooling (Rodriguez, M.; Ortiz, L.; Jia, Y. “Wireless Sensors Network for Data Centre Environmental Monitoring”, 2010). Therefore, the rise of high-density computing infrastructure leads to a substantial methods that provide air for cooling; but, even if involved with it there are a lot of complexities, use liquid cooling is more efficient. It as been demonstrated that “localized, passive, low-power dissipation liquid cooling devices at either rack level or rack proximity, when compared to traditional air-cooled methods, have the capability of reducing the power consumption of in-room cooling devices by as much as 90%” (Novotny, S. “Green Field Data Centre Design, 2010).
It's necessary to mention also another current of thought supporting the use of so-called “free-air cooling”. Adopting this point of view, if a data centre is located where weather conditions are favourable, and a specific reference map is provided by the Green Grid, can be used external air for cooling. Also, from 2009, The Green Grid made available a tool that enables European data centre operators to easily assess the amount time they can operate their facilities with the use of external air for cooling.

The literature recognizes three broad measures of “greening” data centres:

- ENERGY CONSERVATION: It's estimated that a percentage of 30% of costs of data centres refers to energy costs, which is mostly spent in cooling. Hence the major IT vendors are working on new technologies such as nano fluid cooling systems, liquid cooling, and again in-server, in-rack, and in-row cooling. A technical deepening on these methods goes beyond this discussion.
  Another way to make a data centre more environmentally friendly is the “high density

server" solution: using hydrogen fuel cells as alternative green power source and applying virtualization technologies, the power consumption is reduced as the heat generated.

- ECO-FRIENDLY DESIGN: from the side of materials, in sense of eco-friendly design, are used a synthetic white rubber roof, paint, carpet that contain a low VOC (Volatile Organic Compound), energy-efficient mechanical and electrical parts, and countertops made of recycled products. It also should make use of green power to run the data centre. While building a new data centre, IT professional must do something to reduce the heat generated, and dispose toxic chemicals materials from the existing ones. For building a new data centre should be adopted the LEED standard, mentioned above.

- VIRTUALIZATION: even in data centre's field it remains a cornerstone to decrease the power consumption. As before described, the main concept is to develop a physical server that hosts multiple virtual servers. The objective is reduce data centre's energy demand as well as simplifying data centre's architecture. Also the floor space used becomes less.

In order to provide some data, from a survey by the Sun Microsystem Australia (2009), resulted that 50% of data centres' professionals have saved energy through server virtualization, 32% with underfloor air conditioning efficiency, 17.5% by power-down features on servers not in use, 11% by direct current power, and only 7.7% by liquid cooling. For provide some measuring meters, can be used the PUE ratio (Power Usage Effectiveness) delivered by The Green Grid. It conveys how much of the power is actually used by the computing equipment (in contrast to cooling and other overhead). A data centre should attain a PUE of 1.2 or better (an ideal PUE is 1.0), but currently a typical one is likely to achieve a PUE of 2.0 or worse.

A good roadmap for "greening" a data centre should start from an evaluation of the current energy-efficiency that will be also a baseline for calculating the improvements (e.g. ROI) after implementing changes, and for involve the top management.

Have therefore been given ten areas of reference as concerning the first part. It may perhaps be too much, especially if the company is small or medium size. The data collected from surveys, however, demonstrate the importance of each of these areas, even though it will obviously depends on the type of company the optimal degree of concentration of efforts and investments. The areas have been identified by myself through a careful analysis of the literature. It should be stressed that the publications on Green IT are scarce, as this type of strategy is becoming a topic of great relevance especially in recent years.
Later in the course of this document will be taken over all the key areas. Then, will be introduced methods of measurement and, where possible, targets to be achieved.

2.4 GREENING BY IT:

Once IT has become green, organizations should focus on the other macro-area of a Green IT strategy, in which the role of IT is to provide new business solutions across the overall enterprise. The main goal is to provide ICT systems in order to deliver business value based on sustainability objectives and that can be measured by sustainability metrics (Donnellan, B.; Sheridan, C.; Curry, E. "A Capability Maturity Framework for Sustainable Information and Communication

Technology", 2011). IT might also helps organizations developing a common language across the extended enterprise in order to leverage a common understanding.

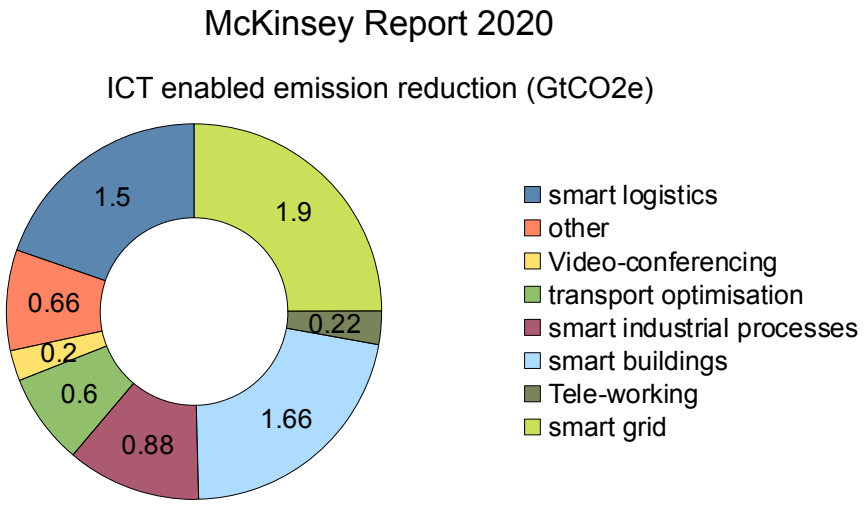


Figure 3: Smart report 2020 II, McKinsey;

Taking another time the McKinsey report described in the introduction of this chapter, can be broken down the components of the 7.8 GtCO2e of 2020 emissions potential savings by IT.
Therefore, it is very clear that one of the vital roles of ICT is in helping to improve energy efficiency in power transmission and distribution (Smart grids), in factories and buildings (Smart buildings) that require power to operate, and in transportation (Smart logistics). "These strategic CO_2 reduction areas could include smart city planning, improved appliance and motor system performance, smart industry and efficient and intuitive grids, smart work in energy efficient buildings, de-materialization of services and reduced travel" (McKinsey report, 2004).
An example of the potential benefits is referred to the smart metering implementation by Enel s.p.a.; between 2000 and 2005 Enel deployed smart meters to all of its customers. The system provides a wide range of advanced features, including the ability to remotely turn power on or off to a customer, or read usage information from a meter, and detect a service outage, detect the unauthorized use of electricity, and also change the maximum amount of electricity that a customer can demand at any time. The company estimated the cost of the project at about € 2.1 billion and the savings they are receiving in operation of € 500 million per year, an astonishing 4 years pay back time.
Another potential ICT technology identified in this study is video-conferencing. As known, transportation is one of the main causes for GHG emissions. Thus, reduction of physical travel and introducing ICT to meet the need for travel could bring about positive environmental effects, while saving time and costs especially in remote and rural areas. Hence, the scale of emissions reductions that could be enabled by the smart integration of ICT into new ways of operating, living, working, learning and travelling makes the sector a key player in the struggle against climate change, despite its own growing carbon footprint.
Freeing themselves from the vision of this report, can be identified a huge amount of others IT solutions that can lead, or give a significant help, towards sustainability objectives. There is also, for example, the possibility that the speed of introduction and the impact of new ICT technology could cut carbon emissions in ways currently impossible to predict.
To help understand where IT can have an impact, below will be discussed a few examples where IT can become an enabler of strategic economic and environmental benefits, thus moving beyond the traditional focus of looking for energy savings for IT infrastructure alone.

Again, as on the "Greening of IT" paragraph, will be presented the focus areas. As in the previous part are valid the same considerations about the applicability depending on the company, and the need for an appropriate strategy. In this case, however, the literature has been integrated with a personal reflection. Sometimes the speeches are indeed motivated by intuitive notions rather than actual data. For example, there is no need to prove that with a fleet management system for logistics planning, there is a saving in terms of travel and emissions compared to the case of the absence of technology.

2.4.1 Co-ordinating, re-engineering and optimizing:

It is referred to the extended enterprise, in order to minimize environmental impact of manufacturing activities, operational workflows and supply chain. ICT can provide numerous opportunities for increasing efficiency and decreasing resource use in existing systems. The objective is to develop an ICT tool (and database) that links financial and environmental accounting for the extended enterprise, enabling decision makers and staff to understand the environmental impact of these activities and support decision making towards sustainable manufacturing and procurement. Examples of IT optimization include also smart grids, office climate, crop irrigation and fertilization, window shadowing, and logistic systems. As computer technology becomes more pervasive in the physical world, the potential for optimization in other contexts will increase. However there is a risk of rebound effects, which will be discussed later (see paragraph 2.5).
Also can be introduced another field of the optimization, which refers to de-materialization, seen as the optimization of materials used in production or delivering a service. From the IT point of view it means focusing on the move from physical products and services toward virtual ones. Hence, IT can provide information systems that can replace material products in many cases. However, progress in the direction of de-materialization is only a necessary, but not a sufficient, condition for approaching the goal of sustainability. There is a high risk that efficiency gains will be compensated for by rebound effects, and that the material and energy demand as well as pollution caused by IT production, use and disposal will grow to serious problems.
From the suppliers point of view, a common approach will also reduce the time and costs incurred by them by avoiding duplication and inconsistency between customers. From a report delivered by the European Commission in 2006, ICT-based supply chain management could save 1.1% of total energy consumption in 2020.
Finally must be highlighted that far reaching opportunities exist for the IT sector to promote and drive a green change in business, but only if the IT that runs through each business unit and across all sectors is recognized as a driver and not a mere enabler. So, to design and launch a user-friendly business ICT tool connected to the overall financial system, is required an optimal information management system and sustainability must be embedded into the business practices.

2.4.2 Making business operations, buildings and other systems energy-efficient:

It is achieved by using simulations and optimizing envelope measures, improved ventilation and passive solar heating techniques, buildings can be more energy efficient.
In accordance to the McKinsey report, the potential total emission avoidance from the implementation of smart building solutions could be as high as 1.66 GtCO2e by 2020. So,

the implementation of IT capabilities could lead to a reduction of approximately of 7% of total building emissions.
The Smart Building Group Report identifies five areas where there is potential to improve energy efficiency through the use of IT:

- design and simulation tools: studies undertaken in Europe highlighted that designers can achieve significant improvements in building's energy performance if they apply IT tools to plan buildings that minimize energy consumption, for example simulating and optimizing envelope measures and passive solar heating techniques.
- interoperability / standards: the most appropriate solution would be one single control system governing all “Heating, Ventilation and Air Conditioning” (HVAC), lighting and other electrical applications, and related systems installed in a building.
- building automation: ICT has the potential to contribute to energy-efficiency through the use of improved control and management systems based on smart appliances and communication networks.
- smart metering: it enables more accurate measurement of consumption via the use of advanced meters which are connected to a central unit through a communications network, improving data collection for billing purposes. Hence, it provides informations on consumption patterns contributing to more sustainable consumption and energy savings.
- users-awareness tools: the provision of intuitive feedback to users on real time energy consumption has significant potential to change behaviour on energy-intensive systems usage. Different studies shows that a “reduction of between 5% and 15% of energy consumption could be achieved through the implementation of these tools” (Information Society and Media, “ICT for Energy Efficiency”, 2008).

There are also some obstacles impeding achievement of potential efficiencies in buildings that companies should consider. First there is a lack of common agreement of what sustainable and energy-efficient buildings are. Moreover each building is unique, so it's difficult to apply common standards for efficiency and operations. Another problem comes from the length of the building's renewal cycle (see paragraph 2.3.1).
The good news is that in recent times leading ICT manufacturers have developed specialized algorithms to calculate the actual ventilation and heating requirements of buildings.

2.4.3 Auditing, monitoring, and controlling:

It is referred to auditing, monitoring and controlling energy consumption and reporting energy savings. With these solutions an energy consumption data is obtained from a series of modules monitoring and controlling a variety of physical conditions, such as ambient light, temperature, pressure, air velocity, cooling, and heating, and devices. A central control station obtains the energy consumption data and stores them in an energy usage database. Energy management logic calculates and provides to the user an energy management solution, to reduce energy consumption and costs, by applying rule-based artificial intelligence to the stored energy consumption data. Studies have identified that these advanced technologies, such as Building Energy Management System (BEMS), could lead to energy savings of between 5% and 40% (ClimateTechWiki report, 2011). The BEMS is a system defined for the first time in 1997 by the IEA and developed over the years, which enables centralized management of all energy-related facilities and room conditions as well as remote monitoring by linking to a wide area network. It may lead to realize energy savings and increase comfortability of users of buildings and, at the same time, make full

use of state-of-art IT.

2.4.4 Calculating and managing carbon footprint:

Calculating a carbon footprint is not as simple as working out the gas and oil use, it covers all aspects and impacts of an organizations' operations, and also might be the first step in a program to reduce emissions.
Before introducing the unit, must specify that the ecological footprint refers to the six greenhouse gases defined under the Kyoto Protocol (adopted in 1997 and entered into force in 2005). A wider description will be provided later in the Green IT BSC (see paragraph 5.4.3 within the "Sustainability Perspective").
The main types of a carbon footprint for an enterprise are two: the organizational one, which refers to emissions from all the activities across the organization, including buildings' energy use, industrial processes and company vehicles; then, the second one is referred to products' footprint. It calculates emissions over the whole life of a product or service, from the extraction of raw materials and manufacturing right through to its use and final reuse, recycling or disposal. The most important for this discussion is the first.
Generally organizations' emissions are divided into three main groups:

- 1. Direct emissions: result from activities within the organization's control. Includes on-site fuel combustion, manufacturing and process emissions, refrigerant losses and company vehicles.
- 2. Indirect emissions: that is from electricity, heat or steam purchased and used by the organization.
- 3. Any other indirect emissions from sources not directly controlled by the organization. Some examples include: employee business travel, outsourced transportation, waste disposal, water usage and employee commuting.

Under the Greenhouse Gas Protocol, the most widely international standards regarding corporate greenhouse gas accounting and reporting, an organization must include the groups 1 and 2 emissions within its carbon footprint. There is broad discretion about which the third group emissions should be included in a business carbon footprint.
The main reason to exploit this process regard the necessity of an enterprise to always know where it is, in term of improvement toward sustainability.
There are many other reasons to calculate an organizational carbon footprint, such as save costs and emissions or prove environmental commitment to customers and stakeholders; it allows also to understand the level of carbon risk exposure and in which parts of your organization it can be reduced most efficiently. Again, trust that the information is accurate, relevant, complete, and consistent over time for management decision making, and assuring that the footprint is transparent and credible to voluntary or regulated reporting schemes, and implement systems ahead of emerging regulations and future requirements. Improve a carbon footprint control lead also to involve the staff in devising and implementing carbon reduction plans, giving them the ability to "make a difference" as well as benefiting from their business insight.

2.4.5 Integrating and aggregating data from environmental sensors and monitoring networks:

Monitoring environmental aspects through networks of wireless sensors has received interest for collecting physical and chemical samples. A central challenge to environmental monitoring applications of sensor networks is the short communication range of the sensor nodes, which increases the complexity and cost of monitoring commodities that are located in geographically spread areas (Jurdak, R.; Abdelhamid, N.; Barbirato, A. "Large Scale Environmental Monitoring through Integration of Sensors and Mesh Networks", 2008). To address this issue, IT companies propose a new communication architecture that integrates sensor networks with medium range wireless mesh networks, and provides users with an advanced web portal for managing sensed information in an integrated manner. Some examples of data from physical flows that can be sensed might be: geographic position, local temperature, soil nutrient level, atmospheric pollution, speed, user heartbeat, sunlight intensity, livestock position and more. So, sensors enable accounting of invisible environmental variables, with great granularity and in real time (Zabico, J.; Brandt, N. "Environmental Metrics", 2010). This brings obvious benefits of quality, effectiveness and efficiency of data.

2.4.6 Offering environmental knowledge management systems:

Normally a knowledge management system has the goal of providing "the right information to the right person at the right time". So, a typical knowledge management system "offers experiences in establishing communities of practice, that is, self-organizing groups of individual that cut across traditional boundaries of expertise to coalesce around a shared interest" (Wernick, I. "Environmental Knowledge Management", 2003). The integration of sustainability objectives with knowledge management tools could give rise to Environmental Knowledge Management Systems (EKMS) that use knowledge to "improve corporate environmental performance by lowering information barrier that prevents organization from realizing environmental opportunities" (Iddo Wernick, 2003).
The first step adopting an EKMS is to decide its level of integration with existing enterprise's business systems. Of course it depends on the sector in which the organization operates. For example for some companies it's sufficient to leverage their existing platforms of activity-based cost accounting methods for sophisticated environmental cost accounting; in other cases, like in the context of a commercial enterprise, there are more opportunities, such as the integration between EKMS and management's decision supporting systems to create some best practices with the scope to provide some practical industrial ecology innovations. Another higher level of adoption could refer to the integration with procurement systems; this approach, if extended to the all supply chain, may lead to its "digitalization". So, EKMS components can be embedded with supply chain management systems to monitor supplier environmental performance ratings, as well as the material composition of product components.
However the spectrum of applications is very wide and the two main components of these multi-functions systems, to create widespread awareness and develop environmental decision supporting systems, will be discussed later separately, because of their importance.
Finally, corporate experience over the last decade shows that investments in networks and software alone does not provide a great solution for effectively sharing knowledge. Time has shown that the utility of knowledge-sharing networks rests heavily on active participation and continued maintenance. So, it consistently shows how management support and teamwork are key issues to success in these initiatives.
Many organizations are developing or adopting information systems, which embed functionalities for information management on sustainability. For example, Microsoft

Dynamics and Sap enable the incorporation of environmental sustainability practices into their ERP systems.

2.4.7 Offering environmental decision support systems:

According to Fox and Das (2000), a decision support system (DSS) "is a computer system that assists decision makers in choosing between alternative beliefs or actions by applying knowledge about the decision domain to arrive at recommendations for the various options. It incorporates an explicit decision procedure based on a set of theoretical principles that justify the rationality of this procedure". Thus, a DSS reduces the time in which decision are made in a domain, and, mostly, improves the consistency and quality of those decisions.
Over the last decade, mathematical statistical models, numerical algorithms, and computer simulations have been used as an appropriate means to gain insight into environmental management problems and provide useful information to decision makers. To this end, a wide set of scientific techniques has been applied to environmental management problems for a long time and with good results. The effort to integrate new tools to deal with more complex systems has led to the development of the Environmental Decision Support Systems (EDSSs).
A typical EDSS integrates environmental data and simulation or conceptual models into a framework for making site characterization, monitoring, and cleanup decisions. Those are systems that facilitate the use of data, models and structures the process in decision making. They also tend to comprise complex interactions among social, cultural, physical, chemical and biological processes. These processes may not be known well or may be difficult to be represented, fact caused by considerable uncertainty. So, it's also important to realize that environmental problems are characterized by dynamics and interactions that do not allow for an easy division between social and biophysical phenomena. Therefore not all environmental systems present the same level of complexity in terms of both the degree of uncertainty and the risk associated with decisions.
Hence, the tasks to which EDSSs have been applied are varied, ranging from monitoring and data storage to prediction, decision analysis, control, planning, management, and communication with stakeholders and society. So, it's not only an efficient mechanism to find an optimal solution, but also a mechanism to make the entire process more open and transparent.

2.4.8 Creating awareness of environmental sustainability:

Another issue is then creating awareness of environmental sustainability and fostering collective wisdom to address environmental issues among IT professionals, businesses, and general public by assisting in building communities, engaging groups in participatory decisions, and supporting green advocacy campaigns. The most common example refers to the web portals. These are general knowledge management systems that provide the facility for organizations to share, create, exchange and reuse knowledge. In fact portals support knowledge management processes. Generally, a portal is defined as a web site with a highlighted feature: provides quick access to services and personalized information. Hence, an environmental web portal has to deliver information and facilitate communication to community so that they can share knowledge and experiences or hold discussion forums about environmental issues. It means that an efficient web portal is a community-based system to manage and present information and other resources. An optimal environmental

knowledge portal should embed an information part, to provide information to users, a collaboration one, in which users are connected and are provided facilities for them to collaborate in activities, and an expertise part, that allows users to communicate with each other and and share their experiences, special interests and services.
Initially the main objective is to overcome the "cultural barrier" to change. In fact, involve all people within a company is a key step to the success of a green strategy. As described in the IT Capability and Maturity Framework (IT-CMF, developed by IVI) overview, it's fundamental to "define, communicate, and use common sustainability language and vocabulary across ICT and other business units, including the extended enterprise, to leverage a common understanding". So, a behavioural change in an organization must be promoted and people have to be convinced about the utility of their effort. However a change in behaviour in this sense is brought about by a receptive attitude built through the interplay between scientific knowledge, as said before, and also social perspectives. Along these lines there are some others tools, such as blogs, wikis, and interactive simulation of environmental impact of an activity.

2.4.9 Offering platform for eco-management, ethical investing or emission trading:

A typical eco-management platform aims to enact a dynamic "learning by doing" process, supporting a structured evaluation and report of a company's impact on the environment, as well as the development of improvement strategies on a continuous basis. Zubaryeva (2007) said that "the advantage of this approach is that there is no rigid, finite solution for the future provided, but instead management is constantly re-shaped to the accurateness of the problem".
Also IT platforms engaged in ethical investments can bring benefits. It describes an investment strategy which try to maximize both social good and financial return. In fact ethical management is not only a tool for responding to the rapid changes in the global business environment, but also a vehicle for building trust with its various stakeholders including customers, shareholders, employees, business partners and local communities.
Finally another field in which IT can be a support tool is the emission trading, defined as "a market-based approach used to control pollution by providing economic incentives for achieving reductions in the emissions of pollutants. It's a form of carbon pricing" (Wikipedia). Based on this has been developed the European Union Emission Trading Scheme (EU ETS), a major pillar of EU climate policy, after the impositions of the Kyoto Protocol. The program aims to "cap the amount of carbon dioxide that can be emitted from large installations with a net heat supply in excess of 20 MW".

So, the ubiquity of IT in business provides the sector with an unique opportunity to drive innovative change while actively reducing greenhouse gas emissions. New technologies allow businesses and consumer to control and reduce their carbon footprint, creating a platform for radical change in the way that products and services are produced and delivered. The challenge awaiting the industry is to effectively demonstrate how IT can be used not just for individual process change, but instead for large-scale strategic efforts. IT has too often been considered a "driver for the business", and as such has been viewed in the silo of the specific project for which it is needed. By viewing IT strategically across the entire organization, IT can become "engine of the business".
So, IT is fundamental to support the necessary transformation to a low carbon economy and society. However, this will not be achieved without action and appropriate policy support.

2.5 THE REBOUND EFFECT

Freek Bomhof, from the Dutch Department of Innovation Management, affirms that “the effects of ICT on energy consumption are much less straightforward due to rebound effects: effects that have a negative influence on the intended positive effect”. And again he said that “Despite evidence that suggests otherwise, initiatives that focus on 'greening by ICT' do not account for a consistent analysis of these rebound effects”.
Hence the case is compelling, in fact it is also important to understand and address the rebound effect because only proper implementation of ICT initiatives can make them green and “cool”. Indeed, green and “cool” ICT might not need new investment or infrastructure. As briefly mentioned in the previous paragraphs, the introduction of ICT might not bring about desired environmental impacts, if, for instance, e-mail and other information are printed on paper. Furthermore, a research paper points to some uncertainty in the net impacts of increased efficiency through ICT. In theory, greater efficiency should result in less energy and material use and fewer emissions. However, there are concerns that these gains may lead to rebound effects, whereby overall consumption continues to increase as a result of increased efficiency resulting in more overall emissions. For example, using technology that saves time (e.g. telecommuting which reduces the commute to work, for example) may mean more time is available for other, potentially higher-carbon emitting activities.
Though ICT has the potential to improve efficiency leading to reduced emissions and use of materials, prevention of the rebound effect requires an emissions-containing framework (i.e. emissions caps linked to a global carbon price structure) to facilitate the transition into a low carbon economy. Without such a framework there is no guarantee that efficiency gains from green and cool ICT would not be off set by increased emissions.
In the literature are also proposed frameworks developed for considering these kinds of side effects in some way. In the Green IT Balanced Scorecard, which will be described later are not taken into account the rebound effects. The decision to exclude them does not derive solely from the fact that analysis means difficult and very long calculations and reflections, but also by the fact that there are no possibilities to provide measures. It is pretentious to estimate the quantitative and qualitative data on potential rebound effects. But remains the fact that the literature is putting much effort in this way. The reason why was proposed a short general presentation in this document is for completeness and to emphasize once again that the mere adoption of technology tools or strategies is not sufficient but also necessary to introduce complementary aspects that mainly concern the behaviour of people.

With the introduction of the rebound effects ends the second chapter of the document. The intent was to give a detailed definition of Green IT. Have been emphasized technological and infrastructural aspects, or at least those that refer to the achievement of potential competitive advantages, with hints on strategies and some data to support claims made.
This overview will be the basis on which will be built the Green IT Balanced Scorecard. In fact it is from here that will be set the goals of a Green IT strategy. So, can be concluded, that these Green IT initiatives figured out from the literature compose the Green IT strategy. So, these are the objective of the solution (the Green IT Balanced Scorecard) to the problem introduces and described in chapter 1.

Chapter 3: the Balanced Scorecard

3.1 INTRODUCTION:

The goal of this chapter is provide a complete and comprehensive description of the structure of the balanced scorecard (BSC). In particular it is necessary to underline its characteristics of both a constructional point of view and how it is used in practice. Will be presented in the following paragraphs some of the BSC introduced in the last two decades. Obviously the first, and most important, is the one invented by Kaplan and Norton, the inventors if this kind of model for the strategic analysis. Then the discussion will focus on the IT field, with the introduction of the IT BSC developed by Wim Van Grembergen. Finally for a better understanding its usage will be briefly presented a BSC implemented for the public sector and the Lauchlan's idea to apply the BSC model to a "personal life assessment".
So, what is really important to grasp from this chapter is not only the structure of the BSC, but also its great potential as a framework for a holistic approach to the balanced evaluation of any strategy.

3.2 KAPLAN AND NORTON BSC:

The Balanced Scorecard was invented in early 1990s by Robert Kaplan and David Norton (Harvard Business School) and was originally conceived as a model for measuring and assessing performances of an organization, from the strategical point of view. It has become soon a complete system of strategic management. Hence, it is a holistic approach from the strategy definition to its execution and verification, across the extended enterprise. The main innovation of the model refers to the abandonment of the perspective to assess the performances only through economic and financial indicators. It is then introduced a dash of assessment divided into four balanced perspectives: financial, internal business processes, customer, and learning and growth.
Economic and financial indicators suffer in modern times some obvious limitations. In fact this is the age of information, communication and knowledge. Some limitations of such indicators might be:

- financial measures are an excellent indicator for the activities of the past, but have no predictive power for the future.
- Activities that create value in today's organizations are increasingly less related to tangible assets. The value lies in the ideas of the people who work there, in relationships with suppliers and customers, in databases, in the culture of innovation, in the quality of internal processes.
- With those indicators, are preferred short-term performances, sacrificing long-term value creation activities.
- Financial measures alone don't allow to communicate priority and strategy to management and staff.

To overcome these limitations, the economic and financial measures of the past performances must be integrated with indicators related to the drivers of future performances.
The main objective was to balance indicators which allow to evaluate the effects of actions previously taken, with some drivers of future value creation of the organization. Hence, Kaplan and Norton considered the four balanced perspectives constituted by a mixed and varied ensemble of lag indicators (about the past) and lead ones (driver of future's performance).

The Balanced Scorecard was quickly evolved into a complete management system to implement and execute the strategies and to align daily operations and resources with the strategy intents, allowing top management to develop new organizational solutions from highly oriented strategy.
It must be highlighted that it is not prohibited to use more than four perspectives if it is necessary to a better description of the business strategy. However, it is believed that in most of cases the four perspectives are more than sufficient to translate the strategy into actions.
For each perspective are considered:

- objectives: strategic goals which a company aim to achieve to be successful;
- measures: which parameters can be used to measure the performance;
- targets: which are the quantitative values that a company wants to achieve in any measure deemed to be satisfied with its performance;
- initiatives: which strategic initiatives put in place to achieve the goals.

Have been then taken into account all the possible aspects that affect the business strategy. And the assessment is, as the name of the model, balanced between them. But this is not enough. Indeed the strength of the BSC is that it makes it possible to describe the cause-effect relationship between all these elements, which underpin the strategy. Each size range is part of a chain of causes and effects relationship that allows the organization to communicate the meaning of the strategy. In addition, a representation of this type, is developed in terms of both the perspectives point of view (high level) and in terms of objectives. With this cause-effect map is not only given a mean to the model, but also makes it easier the BSC use in daily work. In fact it is possible to go back, just through this chain, to the causes of any possible anomaly that can be found in the values of the indicators, and then the chain of cause and effect turns out to be a fundamental tool in case of intervention.

3.2.1 The 4 perspectives:

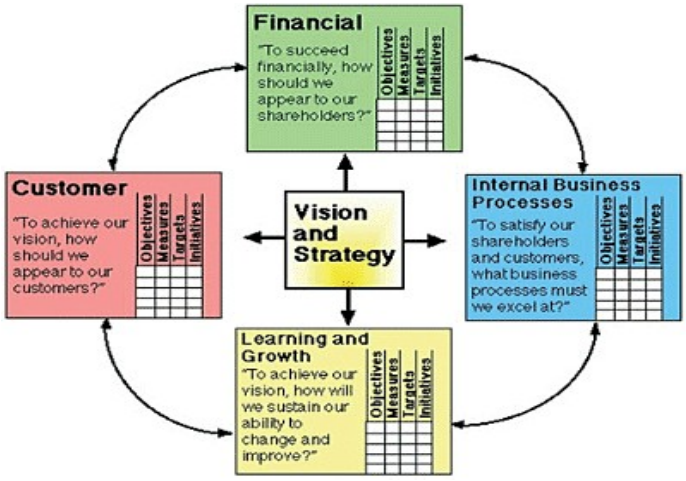


Figure 4: The 4 perspectives of the BSC; source: www.balancedscorecard.org;

- FINANCIAL PERSPECTIVE:

The measures in this context indicate whether the actual implementation of the strategy is leading the economic results proposed. Hence, are included almost lag indicators. Kaplan and Norton said that "timely and accurate funding data will always be a priority, and managers will do whatever necessary to provide it. In fact, often there is more than enough handling and processing of financial data". The point at that time was that the emphasis on financial leaded to the unbalanced situation with regard to the other perspectives. They also suggested to include additional financial-related data, such as risk assessment and cost-benefit analysis in this perspective.

An example of unbalanced situation could be, if customer satisfaction decreases, it is thus a leading indicator of future decline, even if the current financial situation may look good.

Generally the most common indicators are:

- EVA (Economic Value Added) : is a method that compares the return on capital invested in the company with the cost of the factor that have generated. It allows to understand whether management is able to make a profit higher than the return that capital invested in the company would produce if it were invested in risky assets.

  $$EVA = NOPAT - (WACC * c)$$

  where:
  NOPAT: Net Operative Profit After Taxes;
  WACC: Weighted Average Cost of Capital;
  c: net invested capital;

- Shareholder value approach (Jack Welch, General Electric): for a publicly traded company, Shareholder Value (SV) is the part of its capitalization that is equity as opposed to long-term debt. Things like dividends augment shareholder value while issuing of shares (stock options) lower it.
  For a privately held company, the value of the company after debt must be estimated using one of several valuation methods, such as discounted cash flow.

- Other common indicators such as ROI, ROE, ROS.

It is also necessary to add some approaches that consider the value creation as a primary objective and as the satisfaction of all the stakeholders.
The structure of this perspective is basically standardized. As will be described later, the BSC was later reused for balanced assessment of business strategies in different fields. However, the financial perspective is similar in all cases, because the indicators are always designed to evaluate economic-monetary or longer, as in the case of Green IT BSC, of business value.

– CUSTOMER PERSPECTIVE:

This perspective was born for the strategic movement towards the consideration of customer focus and customer satisfaction in any business, that characterized the world competitive context in the 1990s. It's concentrated on two main factors:

I. who are the clients;
II. what's the value of the proposal to them.

The measures in this perspective give an indication on how customers perceive the value proposition. The base from which to start is the careful segmentation of customers into homogeneous groups to which address the actions and determination of specific critical success factors. Within this perspective there are mostly leading indicators; for instance, if customers are not satisfied, they will eventually find other suppliers that will meet their needs. Referring again to the previous example, poor performance from this perspective is a leading indicator of future decline, even though the current financial picture may look good.
Some classical examples of indicators might be:

- customer satisfaction;
- acquiring new customers;
- customer loyalty;
- customer profitability (single or segment);
- retention rate;

- customer relationship;
- perceived image and reputation;

Kaplan and Norton said that “In developing metrics for satisfaction, customers should be analysed in terms of kinds of customers and the kinds of processes for which we are providing a product or service to those customer groups”.

– INTERNAL PROCESS PERSPECTIVE:

This perspective identifies which are the key processes in which the organization must excel to support the proposed value to customers, be competitive and create value for the company. What is different from other approaches to performance measurement, is that these are focused on the process needed to deliver existing products and services to existing customers. The BSC instead allows to identify entirely new processes for the organization in which to excel more and more to meet the expectations of customers and shareholders.
Some classical examples of indicators might be:

- ABC (Activity Based Costing): method that assigns the costs of different resources on the basis of the business they generated;
- ABM (Activity Based Management): improvement of standards of quality, efficiency and effectiveness through the management of business processes and through the evaluation of their performance. The goal is to address the resources towards activities that have a significant contribute to business value.
- BPR (Business Process Reengineering): to assess the quality of processes.

These measurements can not be developed by outside consultants. In fact these metrics have to be carefully designed by those who know these processes more intimately.

– LEARNING AND GROWTH PERSPECTIVE:

The last perspective is the engine of the company, and it's at the lowest level of the cause-effect chain. It constitutes the essential foundation for success of any knowledge-worker organization. It also identifies what are the enablers of the other three perspectives, to build the infrastructure to create over time a sustainable growth and improvement. It includes how should be the skills and attitudes of people, which technologies are needed, and which environment must be created. In other words, how should be the intangible part of the company. Hence here it is included employee training and corporate cultural attitudes related to both individual and corporate self-improvement. Metrics can be put into place to guide managers in focusing training funds where they can help the most. Kaplan and Norton emphasize that “learning is more than training”; it also includes things like mentors and tutors within the organization, as well as that ease of communication among workers that allows them to readily get help on a problem when it is needed.

3.2.2 Cause-effect relationship:

Even if treated separately, all perspectives are an integral part of the organization. To explain the basic reason of why the four perspectives, and their underlying metrics, are define as they are, can be introduced the causal chain, that perfectly shows general the cause-effect relationship in a common organization.
Referring to the figure in the next page, the fundamental cause for strategic success has to do with people. “Innovation from creative people provides the only assured source of long-term success and competitiveness, because every other aspects of an organization can be duplicated by others” (Peter Drucker). Hence, the right people must be hired, properly trained and mentored, and the learning

process should become continuous and endless. Conversely an organization that ignores new ideas from employees is probably doomed. The BSC, using efforts such as employees surveys and analysis of training data, is able to measure the degree of learning and growth, allowing leaders to assess the potential for long-term success, and to improve business processes. Therefore the wealth of skills and knowledge possessed by the organization's staff, coupled with the process of planned updates and well managed, not only serves as a basis for continuous improvement, but it involves a rethinking of how to work within the company. As a consequence, product and services are improved too. For example if a process become more efficient, this result directly in a shorter time to market, extremely appreciate by customers. So, the BSC measures customer satisfaction, but improving processes produces it.
Finally increase customer satisfaction leads to loyal customer and improve market share, which directly affects the financial point of view, increasing corporate profit margins resulting in increased shareholders satisfaction.
An example of its structure, in the traditional BSC, is given by the following picture:

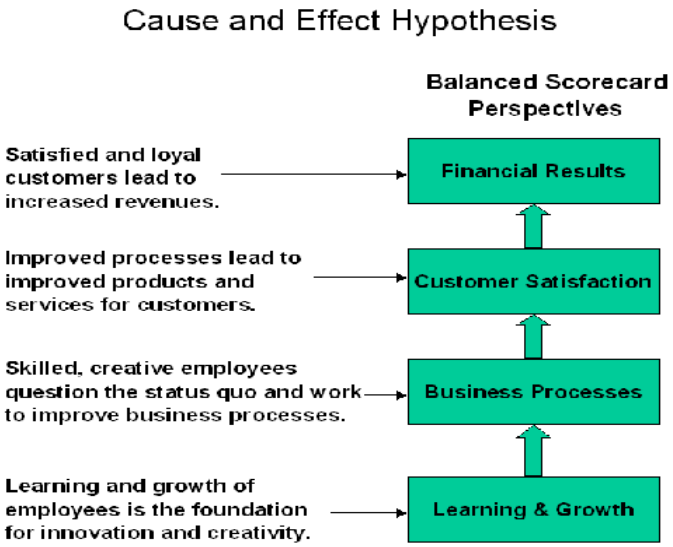


Figure 5: The Cause-effect Relationship; source: www.balancedscorecard.org;

3.2.3 Reflections:

It was then given a brief introduction to the original BSC. What is really interesting about this paragraph, for the purposes of this document, is not the content of each perspective, but the structure of the model. In fact this will be the basis for Green IT BSC that will be built step by step later. Finally, what must be understood is the overcoming of the evaluation of a strategy only from a financial standpoint, and the introduction of balanced perspectives to describe a chain of cause and effect on the functioning of the organization, in the process of achievement its main mission.
According to questionnaire-based research, BSC seems to be widely used by Scandinavian firms. Bengtsson, from Oxford University, UK, affirmed that "32% of firms within the Swedish engineering industry in 1999 used some variant of the balanced scorecard concept with an even higher adoption rate in large firms" (Dabhilakar, Bengtsson, "The role of BSC in manufacturing", 2002). It was also reported that "in 2000, 23% of top 500 firms in Finland used BSC and 15 % were implementing it" (Toivanen, "The Implementation Of BSC and the Current Practice in Finland", 2001). Similarly, a survey among Danish manufacturing firms in 2001 indicated that "82% of the respondents had a high knowledge of BSC while 32% used the concept" (Nielsen, Sorensen,

"diffusion and utilisation of the balanced scorecard in Denmark", 2004).
Here are more examples of BSC built subsequently. These are useful to understand that the framework developed by Kaplan and Norton can also be used for the evaluation of other minor factors, which at the enterprise level are often contained in those previously considered, i.e. the business strategy.

3.3 INFORMATION TECHNOLOGY BSC:

Will be now provided a brief presentation of the Information Technology BSC. This is described in this document for two main reasons: firstly to see how to adapt the model to another circumstance and also to get closer to what is the general topic of interest in this work (IT) and provide an example of an approach in this sense.
The intense focus on IT governance within today's organizations has renewed the importance of management frameworks that help stakeholders to manage risks coming from technologies. Among these methods there is the IT BSC introduced by Wim Van Grembergen, in mid-1990s. Its main goal was to support the alignment of business and the IT strategy, but it evolved in design complexity and content over the following decade.
It is really interesting to observe how the Information Systems Audit and Control Association (ISACA) characterized IT BSC progress into three distinct stages:

- Introduction (1994-1996): early development focused on IT assess techniques and the potential benefits that the new scorecard could provide. In this phase were maintained the Kaplan and Norton's perspectives. Here the developing driver was the application of BSC to IT including concept about IT issues and its evolution in the original organization's BSC.

- Refinement (1997-2000): as the experience with IT BSC increased the tool has been refined towards IT and business integration, measurement and strategy. In this period there was a big pressure to demonstrate the value of IT. Hence, in this stage the four original perspective have been changed and publications became more implementation oriented.

- Specialization (from 2000): the content has become increasingly specific, to track individual components of IT management issues. In fact it covers now aspects such as IT governance, service level management, ERP, knowledge management, and IT audit. So, the new developing drivers revolve around IT value and cost-cutting/efficiency.

The current drivers can be classified into three areas:

I. Demonstration of IT value: IT BSC provides a straightforward method of reporting on a range of IT metrics, enabling the value of IT to be quantified for business stakeholders.

II. Cost cutting and efficiency: to explain this issue I took an extract from a Martinson and Davidson article (1999), "BSC, a foundation of the strategic management of Information Systems"(IS): "IS can be evaluated in terms of the efficiency of the activities associated with IS development and operations, and its contribution to the effectiveness of those that use IS to improve personal productivity and strive to help attain corporate goals. The IT BSC integrates these two dimensions".

III. IT governance: IT BSC can specially customized to address IT governance issues.

From an article on the Information System Control Journal (2005), Wim Van Grembergen presented the new four perspectives: future orientation, operational excellence, user orientation, and business contribution of IT function.
As described for the strategic BSC, is also here required the scheduling of the cause-effect relationship between the objectives across the perspectives. Also the connections between the two types of measures (outcome measures and performance drivers) have to be clarified. In this way the model can communicate how the outcomes have to be achieved.

In the following table are listed and summarized the main differences between the two tools.

KAPLAN AND NORTON BSC	VAN GREMBERGEN IT BSC
Financial perspective: check if the implementation of the strategy is leading the economic result proposed. - increase net incomes.	**Business contribution**: captures the business value of the IT investments. Through this perspective IT BSC is linked with business. - higher business value.
Customer perspective: give an indication on how customers perceive the value proposition. - individual relationships - new distribution channels	**User orientation**: it represents the user's evaluation of IT. - internal users. - external users (consumers and businesses).
Internal process perspective: identifies which are the processes in which must excel to support the proposed value to customers. - CRM	**Operational excellence**: represents the IT processes employed to develop and deliver the application. - web site. - Business Intelligence (Data warehouse and Data mining development)
Learning and growth: identifies what are the enablers of the other three perspectives. - teach the employees to use the new approaches.	**Future orientation**: identifies human and technology resources needed by IT to deliver its services. - research into emerging technologies. - training to IT professionals and business users to use the new approaches.

Table 1: Differences between BSC and IT BSC; source: ISACA;

A further application of the IT BSC is its union with the COBIT (Control Objectives for Information and related Technologies) framework, introduced for the first time in 1996 by the ISACA and the IT Governance Institute (ITGI). Its main mission is to “research, develop, publicize and promote an international set of generally accepted control objectives for daily use by managers and auditors”. So, the COBIT aims to link business goals to IT goals and the IT BSC provides the performance management tool that translate those IT goals into an effective measurement system.
According to a report by ISACA (2007) on the “Information Control System Journal”, can be identified the IT BSC success factors:

- leadership commitment: refers to obtaining a strong senior leadership commitment from both the business and the IT, so with the contribution of the CEO, the CFO and the CIO.
- Design: in order to ensure that the IT BSC maintains several links to financial outcomes and

organizational and IT strategy.
- Oversight: create a project management structure to assist in the oversight , construction and implementation of the IT BSC.
- Teamwork: in order to achieve consensus between the business and IT.

Also it's important to consider that the associated cost of development, implementation and ongoing maintenance of the BSC can be significant, of course depending on the program scale and the organization size.
The importance of this framework is demonstrated by its current use in the companies. A CIO research report published in 2003 indicates that 30% of organizations use the IT BSC ("Best practices of resourceful CIOs", www.cios.com). Instead the Working Council of CIOs estimates that 39% of organizations had deployed an IT BSC. Moreover, B. Kirwin (Gartner) (in the article "IT performance reporting inadequacies impact IT value proposition", 2006) reported that 23% of IT departments share BSC results with the leadership; however, an additional 16% plan to use the BSC as an additional reporting method in the future.
Furthermore management guidelines and case studies are available to share the expertise from organizations that have implemented an IT BSC. Again, an ISACA report said that "the information in these publications provides not only useful scorecards templates, but also specific guidance on key success factors and cautions regarding common pitfalls".

3.4 OTHER BSCs:

Given the usefulness of the method, and its effectiveness, it has been also adopted to several other contexts. For example, the city managers of Charlotte, NC, proposed a new balanced scorecard architecture for the public sector.
Differing from a private company, here the model is referred and adapted to the mission-oriented organizations. Hence, the focus is different because the profit is not more the main component at the top of the chain. So, the cause-effect relationship used to describe the strategy is different and the perspectives that inspire it have to change too.
In particular, they proposed a new order in which perspectives are arranged, identifying new drivers and outcomes. These are:

- Community;
- Internal Processes;
- Financial Resources;
- Learning and Growth.

In fact, for the public sector the main scope is to create public value for the community they serve, and this value is created by the internal processes. Here it does not matter the traditional financial perspective. In fact the financial resources are the enable components and are considered as a constraint. Finally the Learning and Growth perspective is similar to the original one, focused on the development of intangible assets.
Fabrizio Bocci in 2005, from Bocci Consulting, summarized the public sector strategic map as a thing which should describe how "intangible assets, making the most of available financial resources, through the perfect execution of the few strategic processes, create the desired public value for citizens".
So in the Public Sector BSC is presented a radical change of the model. It is interesting to see how to change the outlook and the general conception. The company in this case is no longer turned to business value, and nevertheless this model continues to be highly qualified.

A further example of application of the BSC in other context refers to Lauchlan's idea.: a Personal BSC (PBSC) . In his opinion a man reaches results in a sector (e.g. career and wealth) maybe neglecting others (such as health, religion, relationships). The result is that the man is not happy. Hence, it is “very important” that the different perspectives, or the different sectors, are balanced. So, Lauchlan proposed the PBSC as a tool for maintaining the balance between these different perspectives. His approach considers the following ones:

- Performance (how things are going in our life);
- Stakeholders (partner / children / head..);
- Processes and Practices (usual activities);
- Skills and learnings;
- Motivation and Emotion;
- Mental state and Beliefs;

In each perspective Lauchlan want to define variables or areas of interest and for each of these aims to define a current state, an optimal state, measures, targets and actions to achieve the ideal state.
But Lauchlan was not the only that introduced the BSC o individual aspects.
To further demonstrate the versatility of the approach and the several different way in which it has been considered, is shown also the Elena Salazar (Organizational Change Management Consultant) idea. She considered different individual perspectives. According to her in fact, the prospect of internal processes, to an individual, must understand variables and indicators, related to physical health, mental, spiritual, energy and motivation. Moreover, the customer perspective for individual must include variables and indicators related to family, colleagues and the partner. The financial one should enable a man to support his short and long term objectives and must therefore include objectives and indicators that allow him to measure the state of supporting these types of goals. Finally the perspective of learning and growth must, in her opinion, include variables and indicators that allow to understand how the individual is getting closer to his mission and to his vision. Hence, unlike Lauchlan, Elena Salazar starts from the purely business point of view and sees the PBSC as a way to facilitate change and make business work better.

Chapter 4: The Approach

4.1 DESIGN SCIENCE RESEARCH METHODOLOGY:

In this chapter will be discussed the approach used for the research. The Design Science Research Methodology has been taken as the guideline to develop this project. Before introducing the steps that have been followed for developing the Green IT BSC, must be made a step back.
Historically the Design Science Research (DSR) term was first introduced by Joan Ernst van Aken, Professor at Technische Universiteit Eindhoven, Netherlands ("Management Research Based on the Paradigm of the Design Sciences: The Quest for Field-Tested and Grounded Technological Rules", 2004). However, the concepts on which the DSR field is based, are much older. In particular should be mentioned Herbert Simon and his "The Sciences of the Artificial" (1969), and, referring to the information systems, someone recognizes Joseph Walls (with Widemeyer and El Sawy) as the first pioneer, with the book "Building Information Systems Design Theory for Vigilant EIS" (1992).
Generally the mission of the Design Science is to "develop general knowledge which can be used in the field in question to design a solution to a specific problem" (Wikipedia). In other words, the DSR field aims to provide a pattern in order to generate knowledge to be used in designing solutions to solve problems. Can be already seen, just from this general definitions, how the DSR method can be suitable for the topic that is being developed in this master thesis. For a greater understanding, it is good to deepen this discussion. In particular, DSR is made of:

- Research: it can be generally defined as "an activity that contributes to the understanding of a phenomenon" (Lakatos, "The Methodology of Scientific Research Programmes", 1978). In the case of DSR, "all or part of the phenomenon may be created as opposed to natural occurring" (Association for Information Systems, "Design Science Research in Information Systems").
- Design: it means "invent and bring into being" (Webster's Dictionary and Thesaurus, 1992). So, it can be seen as an activity which goal is to create something new, that did not exist before.

Hence, contextualizing the concept in the IT field, "Design Science creates and evaluates IT artefacts intended to solve identified organizational problems" (Hevner, A.R.; March, S.T.; Park, J. "Design Research in Information Systems Research", 2004). What is necessary now is to make a comprehensive distinction between "natural science" and "design science". According with Herbert Simon, a natural science is defined as "a body of knowledge about some class of things in the world (nature or society) that describes and explains how they behave and interact with each other". A design science, on the other hand, "is a body of knowledge about artificial objects and phenomena designed to meet certain desired goals". So, "whereas natural sciences and social sciences try to understand reality, design science attempts to create things that serve human purposes" (Simon, H. "The Sciences of the Artificial", 1969). Then, the goal here was to use design science as a research approach and, in doing so, realize benefits from the practical applicability of research outcomes. In accordance again with Hevner (2004), "in recent years, several researches succeeded in bringing design research into the IS (Information Systems) research community, successfully making the case for the validity and value of design science as an IS paradigm, and actually integrating design as a major component of research". So, summarizing, the definition provided of DSR integrates any designed thing with an embedded solution to a clear problem. The most important practice rule identified by Hevner (2004) is that "the research must produce an artefact, created to address a problem". Furthermore he said that "the artefact should be relevant to the solution of an unsolved and important business problem". Thus, "the development of the artefact should be achieved from existing and proved theories and knowledge and should be a

solution of a defined problem" (Peffers, K.; Tuunanen, T.; Rothenberger, M.; Chatterjee, S. "A Design Science Research Methodology for Information Systems Research", 2007). In his document Peffers identified six steps for implementing the design science process:

1. problem identification and motivation;
2. definition of the objectives for a solution;
3. design and development,
4. demonstration;
5. evaluation;
6. communication.

This steps are also known as DSRM (Design Science Research Methodology). In the next figure (left side) are graphically represent all of this steps, with their connections. In this document, as a first approximation, can be said that the problem refers to the issues presented in chapter 1, such as for example the environmental impact of IT, the impact of e-waste, and so on. So, a solution is needed, and were defined the objectives for this solution in chapter 2 (manage a Green IT strategy, "Greening OF IT", and "Greening BY IT"). Then the artefact (i.e. the solution itself) is the Green IT BSC. A summary is provided in the following figure (right side):

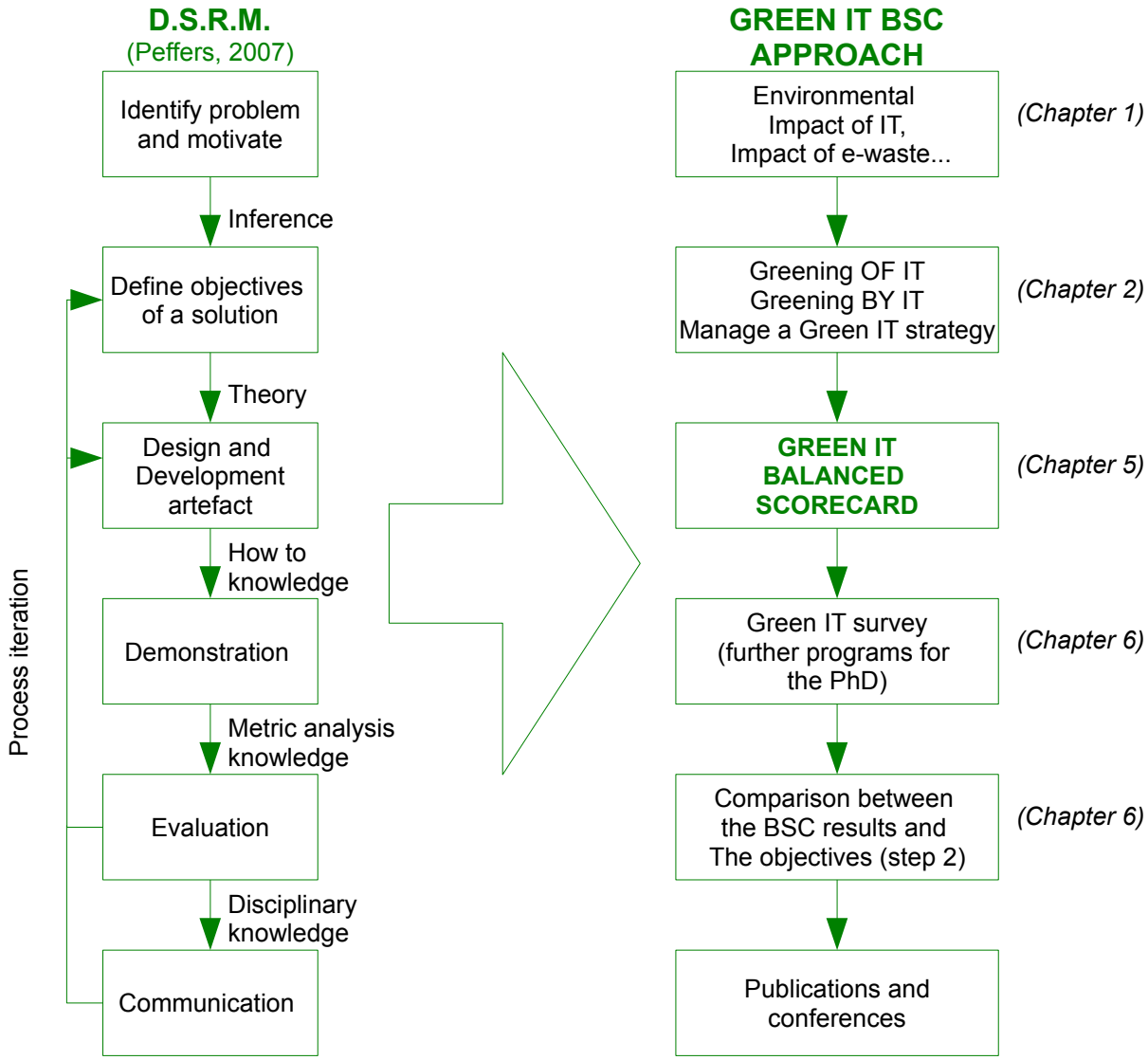


Figure 6: Design Science Research Methodology; source: Peffers, 2007;

Hence, in the next paragraphs will be contextualized all the steps of the Peffers method.

4.2 PROBLEM IDENTIFICATION AND MOTIVATION:

This is the first step in the DSRM. Here should be defined the specific research problem. Moreover the value of a solution must be justified. It is fundamental to define the problem in the right way, because this definition is the base of the artefact, that can effectively provide a solution to the problem itself. In this document this part can be found in the very first chapter. Summarizing the problems (still unsolved) from which this research have started are various, starting from the steady accumulation of GHG, then the climate change issue (droughts and floods phenomena are growing all around the world). Subsequently, the issue moved to the companies' carbon footprint. Then the problem has been focused on the environmental impact of IT, from its production, through its usage, to its disposal, and on how to use the IT to reduce the overall impact. So, in short, the problem is unsolved, and important for the business. In fact, behind it, there are a lot of opportunities to achieve benefits, and sometimes competitive advantages for the organizations. Finally, so far there is lack of a holistic approach to manage it, and for these reasons a solution is extremely needed.

4.3 DEFINITION OF THE OBJECTIVES FOR A SOLUTION:

Peffers affirmed that it consists in "infer the objective of a solution from the problem definition and knowledge of what is possible and feasible" (Peffers, 2007), and again, "the resources required for this include knowledge of the state of problems and current solutions, if any, and their efficacy". I tackled this issue transforming the problems into artefact's objectives. This kind of goals are called in literature "meta-requirements" (Walls, J.; Widmeyer, G.; El Sawy, O. "Building an Information System Design Theory for Vigilant EIS", 1992), or simply "requirements" (Eekeles, J.; Roozenburg , N.F.M. "A Methodological Comparison of the Structures of Scientific Research and Engineering Design: Their Similarities and Differences", 1991).
Generally these objectives can be:

- quantitative: it represents the situation in which "a desirable solution would be better than current ones" (Peffers, 2007), or
- qualitative, such as the description of "how a new artefact is expected to support solutions to problems not hitherto addressed" (Peffers, 2007).

In this step the approach used is a mix of both of them. In fact, with a management framework for a Green IT strategy, is addressed a new solution for managing the environmental impact, and the benefits that could be captured from its reduction. At the same time it aims to tackle the problem with a holistic approach (as the Green IT BSC is), rather than what was mostly done so far, i.e. not integrated interventions, and deployed singularly. This contents were presented before in chapter 2 of this document. In particular the objectives are to implement all the focus areas presented, referred both to the "Greening OF IT" and to the "Greening BY IT". However, the main goal of the artefact (the Green IT BSC) is to "provide a management framework to systematically align IT strategy with business strategy from an environmental sustainability perspective in order to achieve competitive advantage".

4.4 DESIGN AND DEVELOPMENT:

In this step the goal is create the artefact. It is the core of this document (Chapter 5): the development of the Green IT BSC. In this section I will try to give an explanation of the steps of the

approach used to build the structure of my Green IT BSC, and some usage descriptions.
As seen previously with the BSC's examples it's needed a movement from the four original perspectives. In fact, as Phil Jones (strategy and performance specialist, Excitant Ltd, UK) mentioned, a common mistake made designing an environmental scorecard is the simply addition of the environmental perspective in the original model. “It does not work”, he said, “because the other perspectives might be affected as well”. But it has been historically done by managers, and in literature can be found three problems as a consequence of this simplistic approach:

- environmental issues are separated and isolated rather than integrated;
- the focus is just on the impact without considering the drivers and the enablers behind it;
- it is not possible to build and recognize the cause-effect relationship that the strategic map and the BSC should have.

It is therefore needed a more profound and radical approach. In the following figure are represented the main steps used in the development of this model.

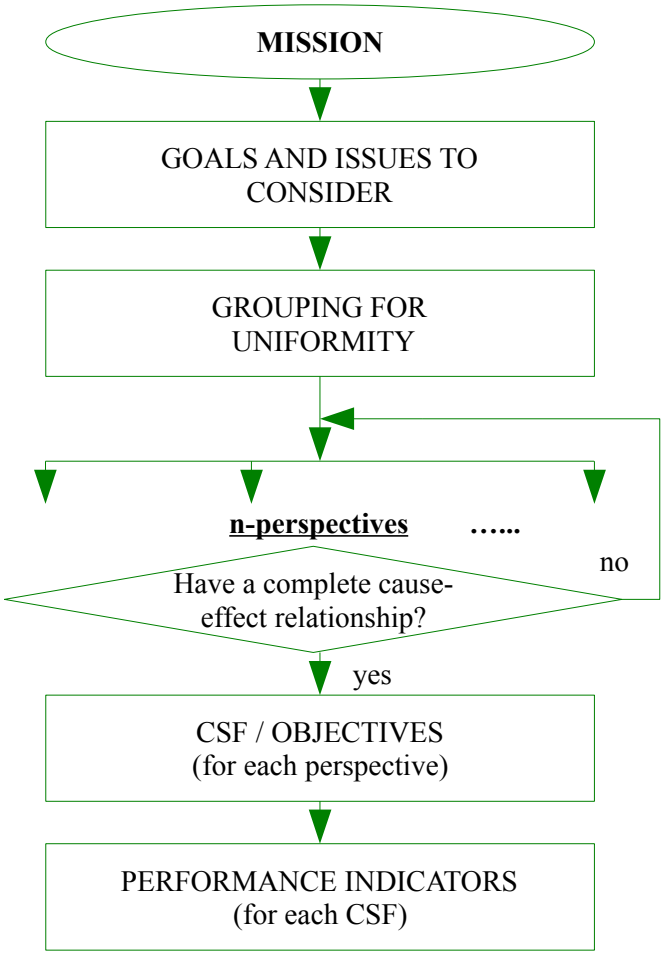


Figure 7: Design and development approach;

The first step is define the mission. This must be something stable, that does not change, and that guide and fully satisfies the green IT strategy. Here we must to be focused on the result, and not on the actions to achieve it. These will be considered in the next steps.
Consistent with the figure, the next step is to provide a complete list of goals in a defined time horizon, to help us move toward the achievement of the vision and the compliment of the mission. To do this I identified all the issues met in the overview of the literature, previously presented (see chapter 1). Then, we are ready to develop the strategic map. The goal is to identify areas in which

the green IT strategy is involved and which make up its mission. These areas in the Kaplan and Norton scorecard are the four perspectives, but, as seen, can be different depending on the objectives of the model. So, I tried to join the issues in homogenous groups. Before going ahead, must be understood that those areas, variables and factors considered are not independent. In fact, representing the different areas in a diagram, where the areas are the nodes and the ties are the bows, we obtain the strategic map (cause-effect relationship). So, this process was repeated until those choices did not have a precise meaning in the cause-effect chain that describes and validates the framework itself. In this sense, from a more practical point of view, setting goals means break away from the "comfort zone". For example, it must also take into account the possibility of not achieving the goal and fail. This step is crucial, because without goals we do not have a route. Moreover, the goals must be S.M.A.R.T.: Specific, Measurable, Achievable, Realistic, Timely; in fact they specifically are the guide for the subsequent definition of the CSF (Critical Success Factors) and the indicators. It is important to underline that is extremely needed a moment of "serenity" to define them. For example if a company is going through a liquidity crisis, it is unlikely that the top management is able to reason in clarity to strategic objectives. Hence, we have to ask questions like, how are these areas going? Or, is everything managed?
Once I have found a consistency between the perspectives and the cause-effect chain, I started working with the inner content of each perspective. So, I must to find a way to keep these perspectives at a predetermined level, but also ensure a balance and harmony between them. Now we are ready for the development of the Green IT BSC. This is nothing more than a table that enriches the strategic map with additional important informations. The map itself provide a view from above, to look at the situation of the important variables, to monitor the areas of responsibility, as they are connected and whether they are properly balanced, and if there is something that requires special attention.
Now that the areas are defined, indicators should be associated to them, and measures that have to be as clear as possible to understand the situation.
In a situation of imbalance, or where is necessary to improve the different areas, must be defined a list of goals for each of them. These kind of objectives are here defined in term of targets compared to indicators. They must also be associated with the time within which it is proposed to reach by, and must be defined the actions to do it as well.
Now we can implement a strategy and have an outlook. As David Allen wrote in his latest book, ("Making it all work", 2008), "Perspective is maintained together with the control". If there is not control, an outlook is of little use; but if there is not perspective we do not know where to go, and we are not able to take advantages of favourable opportunities as they arise. As Seneca said two thousands years ago, "If one does not know to which port on is sailing, no wind is favourable".
Once developed, the Green IT BSC is easy to use. Periodically must be checked the level reached in the different perspectives, updating the value of the indicators, reviewing the targets that have been set, and verifying the distance from the objectives. From these informations can be understood if we were effectively, or we should find another way. Moreover, from this step we know where to act, which are the most important aspects, and where to focus our efforts.
Finally, over time we have to ask ourselves if the Green IT BSC is still valid, or if the world below has changed so much till render obsolete the variables and the indicators.

4.5 DEMONSTRATION:

This step consists in "demonstrate the use of the artefact to solve one or more instances of the problem" (Peffers, 2007). This could mean the usage of the artefact for experimentation, case study, or simply simulating it. This phase will not be fully implemented. The goal here is to validate the model. A perfect way to do it would be a case study. However, a lack of time (this is just a master

thesis) is the main reason because I couldn't effectively do it. Instead, what has been done in order to collect empirical data is a survey on Green IT. In particular, it was distributed to domain expert. Actually what is fundamental to be demonstrated in this Green IT BSC is the veracity of the connections proposed in the cause-effect chain. Another way used to prove the truthfulness of the model was demonstrating step by step all benefits mentioned for all Green IT initiatives. This was achieved mentioning surveys conducted by various organizations on that specific theme, or from publications on that topic, or from conferences papers. Furthermore, have also been mentioned actual cases (see as an example the smart metering implementation by Enel S.p.a., chapter 2), from studies and researches released by institutional organizations, as well as by various consulting societies. A further deeper validation will be given within the subsequent three years PhD program on this topic.

4.6 EVALUATION:

Within this step what must be done is "observe and measure how well the artefact supports a solution to the problem". So, what is actually implemented here is a comparison between the results coming out from the demonstration step (i.e. the results that comes from the artefact's usage) and the "objectives of a solution" (defined in paragraph 4.3). In this document this step will be treated in chapter 6. What will be particularly done, is an analysis of the data collected through the survey.
Concerning those statements proved by citations of external surveys, field investigation, and case studies, they were taken as valid, after an assessment of the issuer. In other words they do not need to be evaluated as the issuers were considered trusted (McKinsey, Gartner, governmental authorities, etc.).

4.6 COMMUNICATION:

It is the final step in the DSRM proposed by Peffers (2007). It consists in "communicate the problem and its importance, the artefact, its utility and novelty, the rigour of its design, and its effectiveness to researchers and other relevant audiences such as practising professionals, when appropriate". It meaning refers to the usage of the structure of the DSRM process to develop the document. As shown in the figure above, each step has its correspondent chapter in this document (except for chapter 3, that was an introduction to the BSC structure). So, this master thesis will be the first communication tool. Then other initiatives will be implemented, mostly during the PhD program. In particular we will try to attend to as many conference as possible, in order to publish some pages on this Green IT BSC.

In this chapter has been presented the research approach used in these months. In the next chapter, the core of this document, will be presented the artefact, the Green IT BSC.

Chapter 5: the Green IT Balanced Scorecard

5.1 INTRODUCTION AND DEFINITION:

In this part is presented the Green IT BSC. Generally it is defined as a management framework to systemically align the Green IT strategy with the overall business strategy, in order to capture business value. The reference model is the BSC, that has already broadly explained in chapter 3, and the topic was tackled consistently with the approach described in the previous pages (see chapter 4). Now it is needed to switch from a theoretical discussion to a more practical one. Then, in order to provide an explanation on how the perspectives have been selected must be taken a step forward. As described in the section on the approach in fact, these perspectives must have a specific meaning within the strategy. In particular, as will be detailed in the chapter on cause-effect relationship, they must identify a precise path that lead to the final mission, i.e. create business value. The same thing will happen as a result of the goals that make up these perspectives, but this will be analysed later. From a general point of view, can be argued that this Green IT BSC needs initially two fundamental structural constraints:

- the model must take into consideration every single aspect that characterizes a Green IT strategy. In practical terms, it shall include all of the focus areas identified in the review of the literature (see chapter 2);
- it should provide a strategic path through which the mission is reached. In other words, the perspectives must have a precise strategic meaning, and it is not sufficient to provide homogenous assessment groups in order to formulate this BSC.

Hence, once identified all the issues from the literature, these were clustered into homogeneous groups with a specific strategic meaning. Then, after several attempts has been reached this formulation:

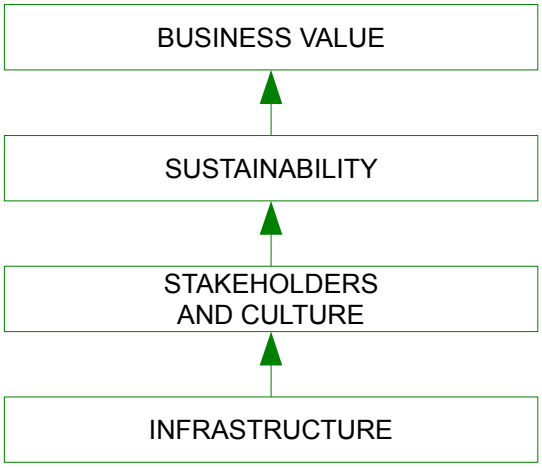


Figure 8: Perspective's cause-effect relationship;

This figure is crucial to understanding the meaning of this Green IT BSC. What have to be deduced from the figure above, is explained as follows:

“with the proper technology infrastructure, and an internal culture turned to green, through the organization and its internal processes, can be captured business value”.

This sentence just quoted seems pretty trivial but it is not. In fact, one sentence has been able to explain a whole model consistent with the definitions given so far of a Green IT strategy.
So, from a strategical point of view, the starting point is develop a Green IT infrastructure. Hence, the technology have to become green itself, and must be guaranteed the technological base of the "Greening BY IT" step. Furthermore, difficulties being green are that, while staying efficient, a company also has to change its behaviour and daily operations attuned with its overall business strategy. In this way can be captured business value from a Green IT strategy. Then, can be seen again the structure in the figure above. From infrastructure, through culture and processes, to business value. This structure is therefore definitely consistent and meaningful.
Moreover, as will be soon demonstrated these perspective have also a specific meaning as categories that include all the Green IT issues previously identified. What is needed now, is to provide a detailed description of these perspectives, in order to clarify what has been said:

- Infrastructure perspective: it is referred to the technological point of view. It is at the lowest level because of two reasons: none of the other perspectives has a direct impact on the IT infrastructure, and at the same time it is the starting point of the overall Green IT strategy. In this perspective will be included objectives in order to reach the "Greening OF IT", and also to ensure that the proper technologies are provided to implement the "Greening BY IT" initiatives. In other words, are assessed efficiency required performances and capabilities requirements.
- Stakeholder and culture perspective: it is at the third level of the cause-effect chain, and considers the stakeholders' central role both in the costs/revenues for the short term and in terms of corporate performance in the long run. Here are also included cultural aspects. As have been observed, create awareness of the importance of the Green IT strategy among the extended enterprise, is one of the major intermediate goal in order to capture business value from Green IT.
- Sustainability perspective: the name attributed to this area seems a little vague. This perspective treats the organizational level. So, are included processes and strategical issues. Its existence can be explained as follows: an organization, once it has developed a green infrastructure, and it has settled inside the correct cultural mechanisms, must pursue objectives at process and strategic level, to effectively capture business value from the Green IT strategy. Objectives here will take into account all the key stakeholders (governments, suppliers, local communities, investors, customers, and so on).
- Business Value perspective: it is the highest perspective in the cause-effect chain. It includes the ultimate goal of the strategy: create business value. In this area will be provided a broad discussion on what business value is, and on the reasons because it has been preferred to a purely financial one. One of the fundamental outcomes that will come out from this perspective, is the complete costs-benefits analysis, crucial for demonstrate the real economic and financial impact of such initiatives.

In order to understand how to use this Green IT BSC, and at which step of the strategy it is placed, now will be given a brief example of implementation. So, first it's needed a complete assessment in order to create an overall plan towards Green IT. Then, the planning phase must contain detailed initiatives such as recycling programs, increase data centres efficiency, or, for instance, positioning IT to support a green business. The next step refers to the implementation. Here the companies should purchase and install appropriate technologies and software to make the implementation happen (virtualization, power management features, etc.). Hence, when the plans are implemented, with key issues identified to measure, the company needs ongoing projects to sustain the progress and keep the organization on the right way towards the objectives established. This is the enforcement phase. Educating the staff should be one of the firsts steps. Then, create further

commitment by placing the new policies on the agenda of internal planning and of conferences with partners. Hence, the enterprise has to cover all parts of the organization, for example placing demands and informing the supply chain about the Green IT project. Also regulations can suddenly change, then new laws and publications should be continuously monitored, communicated and reported (note the consistency with the figure above). The cornerstone of the success of the enforcement phase, is the development of a clear, and easy understandable, roadmap.
Next comes the Green IT BSC. In fact, it is required that in the action plan are placed measurable goals in order to review any progress. It is absolutely required that an organization continuously assesses and understands its capability and maturity level. So what is needed is a holistic meaningful framework, that is the Green IT BSC. For this reason it is necessary to introduce another figure that represents how to use the model in practice:

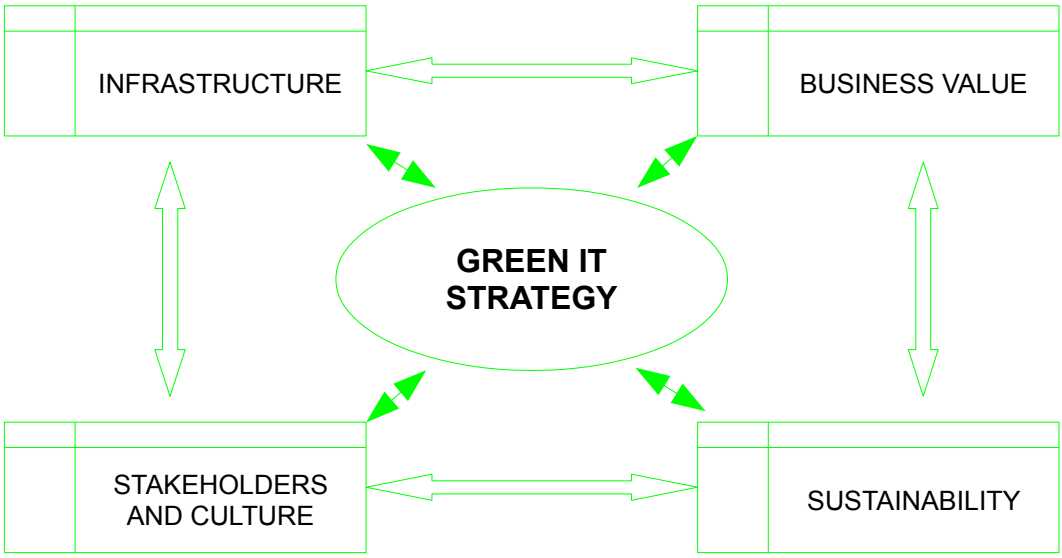


Figure 9: Green IT BSC;

Here the perspectives are represented in a different way. The figure above aims to explain how these outlooks are meant in order to be a useful approach to the Green IT strategy management. In other words, this picture explains how the BSC has to be used in practice. The basic idea is that all the perspectives must be, as suggested by the model's name, balanced. It means that for assess the strategy is used an holistic approach. Hence the various indicators that make up the evaluation of the objectives within the perspectives, have to be continuously monitored in parallel and must be encouraged a constant communication between the parties concerned. This is the only way by which translate the Green IT strategy into actions, through the BSC. This kind of approach also allows to link budgeting to strategic planning, process non-trivial otherwise.
So, the assessment must be able to engage both the top management and the various areas in which the organization is divided. The aim is to provide a vision of the Green IT strategy in clearly measurable results, which define the success and that are shared both within the company management, and outside with customers and stakeholders.
Finally, some words must be spent on the feedbacks that this model could provide if well used. In fact, continuously monitoring the objectives related to strategy through the BSC can be checked not only whether the strategy is actually performed but also its validity. The strategic feedback allows also to reach maximum flexibility and readiness. The BSC enables to create information flows from top to bottom and feedback from the bottom up for a different strategic management of the Green IT. The key is adopt broad actions, across both IT department and the overall business.

In the next part will be explained in detail the all perspectives, from the lowest to the highest level of the cause-effect chain. For each perspective will be provided the objectives. Finally, each objective will have its set of indicators, in order to allow a proper assessment and management.

5.2 INFRASTRUCTURE PERSPECTIVE:

It's the perspective at the lowest level of the cause-effect chain. Here are included all the variables and objectives that's necessary to consider in relation to the physical existence of IT. There are two main reasons because this perspective is on the lowest level:

- none of the other perspectives has direct consequences on this area;
- if look at the chain with a bottom-up approach, it's clear that the impact of infrastructure is due, and connected with the objectives of the other three areas.

A better view of these facts will be explain later in the "cause-effect relationship" section (see paragraph 5.6). Then, decomposing the overall mission and analysing the variables of the model identified in the first phase (see chapter 2), I have tried to find out all of those components that are related to the technological infrastructure. Hence, the starting point for an effective definition of the objectives is a careful review of the Green IT focus areas previously described. Before going any further, should be noted how the situation can vary depending on the context. In fact the priority, or even the general consideration of an objective, is strongly dependent on the sector in which the company operates. For example in a sector "knowledge-intensive" the drivers and the general situation is different if compared with a "resource-intensive" one.

In my opinion there are two main fundamental targets for this perspective:

- Set objectives in order to "greening" as much as possible the IT infrastructure itself.
- Start with a top-down approach in the cause-effect chain and identify the technologies that are needed to achieve the objectives in the higher levels perspectives. So, for instance, to create awareness among the extended enterprise (a CSF of the "Stakeholder and culture" perspective) it's necessary to implement capabilities in order to allow sharing, exchanging and reusing of knowledge.

In other words, the infrastructure to be consistent with the green IT strategy, must meet performance and efficiency requirements (first component) and capability requirements (second component).
Below are presented the objectives, and the indicators for each of them.

5.2.1 Reduce power consumption (while keeping the performance):

this is probably one of the main objectives of the overall balanced scorecard. In this case we will provide a general measure which summarizes under him most of the next goals. Additionally other indicators refer to the IT infrastructure, in line with the objective of the model. In fact this issue, together with the e-waste one, were (and are) the facts which mainly triggered the Green IT existence, because of their major impact on the environment.
It is important to underline that this is also an efficiency issue. All the solution proposed here and their measures, are developed in order to maintain at least the current level of performance. If related to a reduction of energy consumption occurs a reduction in performance, the entire model would lose its meaning.

- INDICATORS:

  - TOTAL ENERGY CONSUMPTION:

t is one of the most significant measure of how sustainable a business is. To do it, there are

available on the market devices that allow to monitor and report energy consumption in real time and to see it rise and fall as devices such as computers and all the other various appliances are switched on or off , thereby identifying how much power requires each one.
These devices work by attaching a clip-on sensor to the live cable of an electricity meter and wirelessly transmitting usage to a display unit.
Moreover can be calculated the rapport between the total energy consumption and for example a variable indicating the size of the company (e.g. number of employees), in order to facilitate a benchmark with similar businesses operating in the same sector.

- PSUs (Power Supply Unit) EFFICIENCY:

the average computer power supply efficiency is about 70-75% ("High performance Power supply unit", Tom's Hardware). That means in order to a 70% efficient power supply to produce a 70W in DC (Direct Current) output, it would require 100W of AC (alternating current) input and dissipate the remaining 30 W in heat. An objective could be reach the Energy 4.0 Standard value. In fact from 2007 all new Energy Star 4.0-certified desktop PSUs must be at least 80% efficient. Should be also noted that a higher energy efficient PSUs waste less energy in heat and require less airflow to cool. For give a benchmark, Google's server power supplies are more than 90% efficient. HP's ones have reached an efficiency rate of 94%.

- PPW (Performance Per Watt):

The Performance Per Watt is an energy efficiency measure. It provides the rate of computation that can be delivered by a computer for every watt of power consumed. The rate of computation is characterized by the amount of useful work accomplished by a computer system compared to the time and resources used. The unit of measure is FLOPS/Watt. The Floating Point Operation Per Second (FLOPS) is a common measure for computer's performance.

- POWER MANAGEMENT USAGE:

As underlined in the overview, enable power management features is a key initiative to reduce power consumption. But before trying to assess its implementation must be mentioned some issues for its measurement. First user behaviour is a big factor in energy waste by PCs, through people not turning off their PCs when they leave work, but network processes also compound the problem. Also managing energy use by PCs attached to IT networks is difficult due to network processes making a PC's internal power profiles ineffective. Because processes on the network are constantly providing inputs to the PC, the machine fails to recognise that there is no user input, and fails to go into its low-power mode. However, some indicators on its level of usage and integration in the infrastructure might be:

- number of components supporting power management software vs total number of components;
- component performance vs observed level of its utilization;

The University of Leeds discovered in 2006 that 70% of its desktop PCs ran "24/7" (24 hours a day/ 7 days a week), so they began a campaign to reduce this issue. Between 2006 and 2007 the overall electricity consumption fell by 2%, while previously it had been rising at a rate of 3%.
So, while the effect on a single desktop may be small (a report by Accenture estimates it in $65 a year per desktop), the benefits across the enterprise are significant. Hence the deployment of usage and time-based configurations can be completed quickly and easily and could provide a 1,000 device organization with annual saving of $65,000.

An other example of device efficiency refers to a Sky product released in 2007; it is a satellite set-top-box with automatic functionality to turn itself off completely, rather than go into standby mode when not being used.

- TDP (Thermal Design Power):

the Thermal Design Power, is "the maximum power a processor can draw for a thermally significant period while running commercially useful software" (Intel report, April 2011). So, the TDP is the maximum thermal power the processor will dissipate, but not the same as the maximum power a processor can consume. For example, a processor might consume slightly more power than the rated TDP value for an instant but then consume less power for a long period of time. It's unit of measure is watt. This allows to take a cooling solution cheaper and still fit for use. For example a TDP of 20W means that the component can dissipate 20W of heat without exceeding the junction temperature (maximum temperature of operation) of the equipment.

- ACP (Average CPU Power):

the Average CPU Power is also an indicator for the assessment of average daily power consumption of processors developed by the AMD (Advanced Micro Devices) Inc. (U.S.). It provides a rating which is "a better method as a power consumption measurement for data centres and server-intensive workload environments"(AMD).

To compare these last two indicators, TDP and ACP, will be reported two points of view of both organizations. AMD said that "for years, TDP was the guideline that was employed, but as more and more power saving features are integrated into the processor, the delta between the TDP specification and the typical CPU power consumption has grown significantly". On the other hand Intel affirms in a report (2011) that "ACP does not equal TDP. Its specifications are quite different and are not comparable".

- WATTS PER ACTIVE PORT:

whit the purpose to have a broader view on the IT infrastructure consumption, for some company it is also recommended to monitor the network energy consumption. So, 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.

- UNIT POWER CONSUMPTION OF A SUPERCOMPUTER:

This indicator is addressed only to those (few) companies that have a supercomputer within the infrastructure. There are multiple ways to measure the unit power consumption of a supercomputer. "Probably the simplest way is by a power meter reporting the RMS (root mean squared) value" ("Power Measurement Tutorial for the Green500 List", 2007). the problem is that often the unit power exceeds the upper limit of the power meter. In this case it can be measured via a current probe and a volt meter. So, the power consumed by the unit can be calculated by:

$$P = V * I$$

Here "I" is the electrical current measured with the current probe, "V" is the supply voltage.

Some words must be also spent on the benchmark issue in this field. So can be introduced the EEMBC (Embedded Microprocessor Benchmark Consortium), a non-profit organization with the aim of "developing meaningful performance benchmarks for the hardware and software used in

embedded systems". In 2006 the EEMBC released its EnergyBench test to provide data on the amount of energy a component consumes while running EEMBC's performance benchmarks. It is now recognised as a standardize methodology. Finally from 2008 it has been modified in order to allow an utilization in multi-core systems.

5.2.2 Prevent amount of e-waste:

E-waste, the garbage generated by the disposal of electronic equipment like computers, peripherals and monitors, as said, is becoming a major concern. The United Nation's Environment Programme (UNEP) estimated in 2006, that up to 50 million tonnes of electronic waste are generated every year, creating extreme health hazards. In particular the inhabitants of many African and Asian countries are contaminated with illegally dumped scrap.
Here in this perspective is treated only the prevent issue; e-waste minimization due to responsible use, recycling and disposal, will be analysed later (see paragraph 5.4.8). It is very important in this objective to consider the procurement point of view. In fact a company can influence the future when it buys a new electrical or electronic equipment by bearing in mind how the equipment will impact the environment at the end of its life cycle. Buying energy-efficient and environmentally sound components, computers, servers and other ICT equipment helps actually to reduce the contaminant factor of e-waste.

- INDICATORS

  – TOTAL AMOUNT OF E-WASTE (E-WASTE RATIO):

it is the first main indicator and is a significant measure on how a company affects the environment through e-wastes. This measure was taken into account by several non-profit organizations, however was never developed an universal standard. As Esther Müller said "in many countries flow of electric and electronic waste have never been quantified due to the lack of data and missing take-back schemes". Furthermore, "studies to collect the data and to assess the e-waste quantity are often expensive and very complex. To close this knowledge gap, the EMPA (the Swiss Federal Laboratories for Material Testing and Research) in 2010 has developed a model to derive e-waste quantities. This model considers the life cycle of electronic equipment reflecting the three processes "Production, Consumption and Disposal". The only unknown variable is the output of the process "Consumption" because it depends also on a particular obsolescence behaviour of the respective equipment. This behaviour was calculated by the EMPA as a time dependent obsolescence rate represented as a probability density function. They selected a Gaussian obsolescence rate distribution with mean μ (average life time) and standard deviation σ. Then the calculation is easily integrated numerically in MS Excel.

  – EPEAT SCORE OF ICT PRODUCTS:

as introduced in chapter 2, the Electronic Product Environmental Assessment Too (EPEAT) is a standard which aims to assist buyers to evaluate, compare, and select desktop computers, notebooks, and monitors based on their environmental attributes evaluating electronic product through some categories such as materials, designing for the product's end of life, energy conservation, and more. It attributes a score to each product, and a higher score could be a great way to demonstrate the low impact of that product. For an overall assessment could be considered the average EPEAT score for the single offices, or the business units, or the wider enterprise.

- ADHERENCE TO RoHS DIRECTIVE:

As already stated, the RoHS (Restriction of Hazardous Substances, mandatory in Europe from the 1st of July 2006) seeks to ban the use of certain hazardous substances such as lead, cadmium, mercury, hexavalent chromium, polybrominated biphenyls and polybrominated biphenyl ether. The directive is addressed to all products manufactured or imported into the EU. Although it is true that the directive is oriented mainly to the producers of electrical and electronic components, that "must review the procedures for using alternative materials and testing procedures" (EU RoHS Enforcement Guidance Document). In my opinion it can also be considered a good benchmark for buyers. Therefore I believe that the adherence to this directive could be one of the ways to reduce e-wastes going to landfill.

- DEPRECIATION TIME FOR ICT:

this is a good indicator for evaluate the life span of an IT equipment. Extending the depreciation time for ICT equipment, i.e. the minimum time to write off ICT equipment investments, could lead to a longer life span of those and hence to a reduction of the amount of waste electrical and electronic equipment.

- INCENTIVES TO SUPPLIERS:

in this case it is measured the contribution of the procurement. In fact providing incentives for producers (or suppliers) to design and sell ICT products with a long life span, means somehow purchase sustainable ICT products. This process reduces the IT churn rate and as an immediate consequence reduces the amount of e-waste going to landfills.
Another way to push suppliers towards sustainability is the effectively implementing of the WEEE directive; it would encourage product designers and producers to minimize the waste stream. As a consequence on the discussion previously done on the extended producers responsibility (see paragraph 2.3.6) they are held responsible for managing the waste resulting from their own products. This issue will be largely treated in the objective "Regulatory Compliance".

5.2.3 Generate knowledge (provide EKMS):

What is needed to evaluate in this case is the infrastructural capability for an effective Environmental Knowledge Management System, in order to improve corporate environmental performance by lowering information barrier that prevents the organization from realizing environmental opportunities. Hence, the intent here is to provide an assessment from a technological standpoint, but it is no sufficient to assess the overall effectiveness of an Environmental Knowledge Management System (EKMS). In fact the experience shows that it is not enough do significant investments in networks and software for an effective sharing, exchanging and reusing of knowledge. The effectiveness of an EKMS is then strictly connected with people, in terms of their active participation, continued maintenance, and management support. Anyway, this second issue will be treated in the "Stakeholder and Culture" perspective.

- INDICATORS:

in this case will be offered two different general kinds of indicators. First of all some to evaluate the system itself, and then another class of measures to assess the knowledge-base.
Hence these first indicators aim to evaluate the overall EKMS:

- NUMBER AND QUALITY OF VIRTUAL COMMUNITIES:

this can be regarded as a general indicator to test the infrastructure requirements of the EKMS. In other words, with a proper number of communities and a proper level of quality, it results satisfied the technological support for exchanging, reusing, and sharing of knowledge. A possible way to assess the quality of those communities is deploy a survey for users on the its ease of use, its comprehensiveness, and also for example the system's ability to provide the information he's looking for.

- LEVEL OF INTEGRATION:

as said in chapter 2 (see paragraph 2.4.6), presenting the focus areas of "greening by IT", there could be different level of integration of an EKMS. Of course the optimal one depends on the sector in which the company operates. In order to provide an example at a low level of integration, a sophisticated environmental cost accounting could simply leverage the existing platforms of activity-based cost accounting methods; instead an example of high level might be the integration with the procurement system, across the extended enterprise. Anyway it is clear that as much high is the level of integration as much increased result the quality, consistency, relevance, and usability of knowledge.

- % OF STAFF CONTRIBUTING DOCUMENTS:

it wants to be a proxy indicator of the level of depth of the system. In fact, with many people involved with the system, it enters more into the knowledge of the different levels of the organization. Moreover, a high percentage of staff involved also means a high level of accessibility to the system.

Secondly the following indicators refer to the second main topic to assess into this objective: the Knowledge-base. Assess the organizational knowledge-base here means describe the content of the EKMS at time in quantitative and qualitative terms.

- PORTFOLIO OF EMPLOYEE SKILLS,
  according to both Green IT competences and core competences.
- NUMBER AND QUALITY OF EXTERNAL KNOWLEDGE LINKS;
- NUMBER OF INTERNAL CENTRES OF COMPETENCE, OR CENTRES OF EXCELLENCE;

it is clear how all of these three factors affect in a positive way the knowledge-base contents. In fact are assessed almost all the sources that constitute the knowledge: people within the company, the organization itself from a higher level, and those who contribute from outside the enterprise. Explain the process in which the competences are transformed in knowledge goes beyond this discussion, but it's obvious that as a result of the improvement of these indicators, the quality of the knowledge-base is also improved.

5.2.4 Provide environmental decision supporting systems (EDSS):

To be able to evaluate an EDSS must be seen specifically how it is made. In this case the main objective is to ensure the proper existence of the system itself. As said, an EDSS is a computer-based information system that supports business or organizational decision making activities (see paragraph 2.4.7). The overall objective of the system is to collect, process, and disseminate information in an intelligent way. Must be also reminded that it does not replace the user, because the final decision is obtained by combining human assessments with the information processed by the system.

To ensure its effective existence, must be checked the presence of its physical and logical components. Therefore the approach used here is to watch to an EDSS from two different points of view: one regarding the physical/infrastructure part, and the other the logic one.

– INFRASTRUCTURAL EVALUATION:

the main prerequisite is the existence of an EKMS. This is necessary to organize data and information in order to provide knowledge, experience, learning, and to know well the organization of data and the type of research. Then, typically an EDSS consists on the following main components:

- data base: it collects information and data that affect the user. These data are independent from the management data and are often integrated with external information.
- model base: it is an important resource of information. It analyses data in relation to a given environmental problem. A model base contains the procedures needed to solve user problems, so its function is to organize the management of all the models in order to consolidate the process of data processing (Fox and Das, 2000).
- software platform: here there are three different components; the DBMS (Database Management Software) for the systematic organization of data, the MBMS (Model Base Management Software) for storing, editing and use of models, and the DGMS (Dialogue Generation Management Software) for the user interface.
- data mining solutions: identify and extract information such as relationship or associations between the data in the database, previously unknown by the users.
- Query: it is tool to interrogate the database using specific instructions.
- OLAP (On Line Analytical Processing): is a technique that analyses in depth a large amount of data, and that provide evidence to confirm or disprove the assumptions made by decision-makers.

– LOGICAL EVALUATION:

from the logical point of view, the EDSS is considered as a source of knowledge and as an exploitation of knowledge resources. Here the EDSS is a tool that aids to solve problems, playing a strategic role in hazard identification, environmental risk assessment and intervention/decision making. Hence, the goal is to guarantee the existence of the processes on three levels:

- Data gathering and interpretation;
- diagnosis or prediction;
- decision support;

The knowledge that should be integrated and connected to the Artificial Intelligence techniques, is data from sensors, knowledge used in decision making and knowledge from people related to the EDSS.

Indicators to measure the effectiveness and the efficiency of the system are very complicated. Historically a significant indicator revolved around its frequent usage. But then it has been demonstrated by Godwin J. Udo (Professor of Decision Science at Tennessee Technological University) that “system usage has a significant relationship with only one of the eight effectiveness measures”. In this paper I propose a qualitative assessment by users on the degree of compliance of the purposes for which the EDSS was designed, and an evaluation on the optimal execution of actions.

5.2.5 provide environmental sensors and monitoring network:

here it is necessary to ensure the implementation of building management technology to reduce the heating and lighting cost for office locations through automated control of devices coupled with the use of advanced sensors to improve monitoring and reporting. Also energy consumption by facilities resulted reduced.
As broadly explained before (see paragraph 2.4.5) this is not the most important issue towards the implementation of a Green IT strategy, but the adoption of this kind of technology could lead to advantages and savings in some sectors.
A possible example refers to the hospitality sector (study conducted by The World Economic Forum, 2008). After learning that hotel rooms were left unoccupied for an average of 11,5 hours per day, some hotels began installing small infrared sensors to detect if somebody was in the room. After 30 minutes, the temperature was automatically reduced by three degrees; has been demonstrated that these technologies have saved as much as 37% of hotel heating costs. Other examples might be motion sensors in light ballasts that turn off the light when nobody is inside, and similarly daylight sensors that turn off light in office buildings when artificial light is not needed.
As said literally by the objective's name, in this case the most issue is to ensure the availability of the technology. In fact goes beyond this discussion the assessment of the quality of the data transmitted and their timeliness and granularity. The main reason is that usually those performances are guaranteed by all of them. For instance, it's useless to make an assessment on the timeliness of data transmission because it's sufficient to ensure the availability of sensors integrated with the wireless network for guaranteeing data in real time.

- INDICATORS:
  - NUMBER OF PHYSICAL FLOWS SENSED,
  - NUMBER OF VARIABLES SENSED:

these two indicators are introduced to assess the actual presence of a sensor system and the effectiveness of the monitoring process. However, must be underlined that it is required a previous analysis of which are the key variables to be monitored. It is impossible to provide a list because some may be significant for an organization, but completely useless for others. So, it depends on the processes that characterize them. Some examples of data that can be sensed might be: geographic position, local temperature, soil nutrient level, atmospheric pollution, speed, user heartbeat, sunlight intensity, livestock position, and much more.

  - EFFECTIVENESS OF REPORTING:

once the right data were properly monitored, it is necessary to evaluate how these informations are presented to the end users. Hence, the data collected must be reported in an integrated way, in order to allow an effective use of them. The first step is to provide an advanced web portal with interactive functions. Of course, it must be connected with the sensor's network, and must contain a single interface for data that are coming from different sources. Otherwise, for example with legacy systems managing geographically-distant sites is done through completely different interfaces; as a consequence the user don't have an integrated view of the sites, which hampers the data analysis and the decision making process. So, it is necessary to evaluate the level of integration of the sensed data and its comprehensiveness in order to facilitate its analysis for the end users. An estimate can be made through interviews to them, and comparison between the data usage and the goals set, when had been decided which data have to be monitored.

5.2.6 Reduce data centres environmental impact:

This objective refers to the introduction of energy efficient data centres solutions and tools to enable virtualization and automation within an organization's data centre. Some immediate consequences are a reduction in operating cost for data centre as well as increased energy efficiency.
Moreover, must be also assessed the data centres facilities re-engineering, seen as the re-design of the facility in order to improve power and heating requirements and achieve a reduction in power consumption.
Another important factor is its consolidation and rationalization in the number of data centres supported by an organization through consolidation of the infrastructure in to more efficient locations in order to achieve a reduction in the energy demand due to the ability to better leverage shared service components.

- INDICATORS:

  - PUE (Power Usage Effectiveness):

for evaluate how efficiently a computer data centre uses its power, the most appropriate unit of measure is the PUE (Power Usage Effectiveness). It was first introduced by the Green Grid consortium. In particular it describes “how much of the power is actually used by the computer equipment in contrast to cooling and other overhead” (Wikipedia). PUE is determined by dividing the amount of power entering a data centre by the power use to run the infrastructure within it. It is a ratio, and therefore an ideal PUE is 1. in order to provide a benchmark, Frank Frankovsky (director of hardware design of Facebook) affirmed that his company reached a PUE ratio of 1.05. Google's data centres of 1.21.

$$PUE = \frac{Total\ facility\ power}{IT\ equipment\ power};$$

  - PPW (Performance Per Watt):

it was already introduced for another objective, but it could be also seen from another point of view. In fact most of the power a computer uses is converted into heat, so a system that takes fewer watts to do a job, will require less cooling to maintain a given operating temperature. Reduced cooling demands, as underlined before, is a cornerstone for greening a data centre.

  - SWaP (Space Wattage and Performance):

it is a metric introduced by the Sun Microsystem company (U.S.) for the data centres. It means Space Wattage and Performance and it's very useful because incorporates energy, performance and space variables. For example, the SWaP is used to calculate the impact of a new server in a data centre, or even to design a new infrastructure in accordance with new parameters.

$$SWaP = \frac{Performance}{space * power}$$

The most unit of measure of the space is the RU (Rack Unit) that describes the height of the equipment. A RU corresponds to 44.45 mm.
An example of application could be in comparing two servers. Supposing the server A (500 operations, 2 RU, 300 watts) and the server B (500 operations, 4 RU, 800 watts) we can conclude that the SWaP scores are 0.83 for the first one and 0.16 for the server B. It

means that the server A is 5 times more efficient than the other, although they reach the same performances.

- CADE (Corporate Average Data Efficiency):

The CADE is an indicator introduce by McKinsey in their report "Measure Data Center Efficiency like Car Fuel Efficiency" (2008). It aims to measure the data centre efficiency across the corporate footprint:

$$CADE = Facility\ efficiency * IT\ asset\ efficiency$$

where:

$$FACILITY\ EFFICIENCY = \%Facility\ Energy\ Efficiency\ x\ \%Facility\ Utilization$$

and

$$IT\ ASSET\ EFFICIENCY = \%IT\ Utilization\ x\ \%IT\ Energy\ Efficiency$$

the unit type is percentage, and the goal of course is to maximize it.

- DCiE (Data Center infrastructure Efficiency):

for completeness is also presented the PUE's inverse. It is the Data Center Infrastructure Efficiency, and it is expressed as a percentage that improves as it approaches 100%. From a World Economic Forum report, "a typical legacy data centre today operates with an efficiency ratio of 1:3" (it is actually the DCiE, where one unit of power reach the computer infrastructure, from every 3 units delivered to the centre). They also affirmed that with newer design solutions, using the principles previously described, "should enable a ratio of 1:1,6 to be achieved providing a saving of about 50% on both power consumption and emissions". The newer solutions should also offer improved level of reliability to users with less downtime.

$$DCiE = \frac{IT\ equipment\ power}{Total\ facilty\ power}$$

From a report by Alliance Bernstein (Raskin, A. "Abating climate change: what will be done and the consequences for investors", 2008), "the current trends in technology use will lead to a 10% energy requirements reduction for data centres, while simple management actions could decrease consumptions by a additional 20%. implementing current best practice can lead to a 50% reduction".

5.2.7 Increase usage of green power:

It is one of the most important objective, because the usage of green power is definitely a cornerstone to become green. Must be reminded that the adoption of green power solutions comes after that IT managers did as much as they could to reduce the need of energy itself (see paragraph 2.3.8). As it is very difficult to make an analysis of the sources, since their optimization is strictly dependent on geographic factors and governmental issues ("the best choice depends upon the status of the electric utility restructuring in the country where the purchase is being made"), the evaluation will take into account absolute and embedded values and also some contingent factors.

- INDICATORS:

- CONSUMPTION FOR SOURCE OF ELECTRICITY:

it is very helpful for an organization to distinguishing and monitoring energy consumption from the different sources. This allows to understand the level of use of each energy source and to compare it with the total consumption. For a better analysis are needed an effective monitoring system, and must be available the data of the previous years. An example can be a table like the following:

Source of electricity	Amount previous year [Megawatts]	Amount current year [Megawatts]	Benefits / Concerns

Here must be considered all the sources: solar, hydroelectric, nuclear, coal, gas/oil, wind, biomass, etc.

- % OF ELECTRICITY GENERATED AND CONSUMED FROM RENEWABLE SOURCES (ECRS):

this indicator measures the total quantity of electricity consumed from renewable sources as a percentage of the total quantity of electricity consumed.

$$ECRS = \frac{electricity\ renewable\ sources}{total\ quantity\ of\ electricity}$$

the indicator is a good measure of the degree of adoption of green power. It can be integrated with the measure of the percentage of the primary energy consumption resources that are effectively renewable. It is a measure of the amount of primary energy consumed before it is transformed into electricity or other forms of secondary energy. Primary energy resources are petroleum, natural gas, coal, hydroelectric power, nuclear electric power, wood and waste, geothermal energy, solar thermal and photovoltaic energy, and wind energy.

- GPUE (Green Power Usage Effectiveness):

the Green Power Usage Effectiveness is an indicator developed by Greenqloud, an Icelandic organization born in 2011. It aims to be an evolution of the PUE, already mentioned. It is a "measurement of both how much sustainable energy a computer data centre uses, its carbon footprint per usable KW/h, and how efficiently it uses its power" (Greenqloud, 2011). It is considered an important indicator toward this objective for the importance of running data centres with green power towards the Green IT mission.

$$GPUE = G * PUE$$

where the "G" is the key factor here, and it is a simple value calculated as:

$$G = \sum(\%EnergySource * (1 + weight))$$

The weights taken directly from the "life cycle CO2/KWh for electricity generation by power source" table from the 2008, Sovacool study.

- AMOUNT OF FINANCIAL INCENTIVES BY GOVERNMENT:

a bevy of financial incentives exist to help organizations purchasing wind, solar and other alternative power technologies. Utilities offer discounts, and governments usually offer tax incentives. Hence obviously the amount of financial incentives grows together with the effective adoption of green power solutions. It is assumed that the provision of incentives by

local governments, has an established criteria of evaluation. So, viewing it from another point of view, can be concluded that to high financial incentives correspond a good level of adoption of green power.

- NUMBER OF SYNERGIES (for SMEs):

this indicator is aimed predominantly at small and medium enterprises. In fact for this companies the risk that entails a small scale solution is very high. So find businesses that have similar value to join the forces constructing a common project may lead to the mitigation of that risk. Hence it can be concluded that to a higher number of synergies, corresponds a more efficient and effective usage of green power.

5.2.8 Enable tele-working:

tele-working (or e-working, or telecommuting) was defined by G. Sciadas ("Our Lives in Digital Times", 2006) as "home-based work that is enabled by ICT". However, there is not an international agreed definition, nor recommended methods of data collection. For example, the Statistic Canada Organization distinguishes work at home that is undertaken at the workplace, from work at home as a substitute for working at the workplace.
So, this objective refers to "work from home capability". It includes also the ability to use technology to provide call agents from everywhere using VoIP ("Voice over Internet Protocol") and thin client technology, and others "Tele Presence Capabilities" (G. Sciadas, 2006) referring to the use of video conferencing for example for international executive meetings. The main effects are a reduction of travel and facilities cost, increase flexible workforce and a reduction of CO_2 emissions. In order to provide some data, a research from the World Economic Forum showed that a "deployment solution to 13 major offices led to a saving of over than $9m (thousands) in avoided transportation and associated hotel accommodation in the initial ten months of use, to an additional reduction in carbon emissions equivalent to about 2.500 tons, and with a solution payback time of under a year".
To estimate the infrastructure that enables telecommuting, should be measured the availability of computers and Internet at home. In this case it is assumed and will be proposed other measures.

- INDICATORS:

  - SHARE OF EMPLOYEE WHO ARE INTERESTED IN TELE-WORK:

the measure is provided by surveys carried out on employees. It has been taken into account for one fundamental reason: if the employees are not generally interested in this kind of opportunity, there would be not an increase in productivity (The Green IT Report, 2008), and as a consequence cannot be guaranteed business value from its adoption. From a research by SIBIS (Statistical Indicators Benchmarking the Information Society), "the degree of interest in tele-work remains considerable: 40% of the EU workforce express interest in permanent tele-work (where practically all working time in spent at home), 52% in alternating tele-work (with at least one working day spent at home per week) and even 55% in centre-based tele-work (meaning workplaces provided by the employer in an office facility close to the employee's residence)". This measure can be more meaningful if the percentage is expressed in proportion to that employees whose job is suitable for tele working.

  - PERCENTAGE OF EMPLOYEES CONNECTED TO IT SYSTEMS THROUGH

NETWORKS:
this indicator aims to assess the coverage of the technology over the staff of the company taken into account. It considers tele-working and other forms of remote access. The indicator can be also disaggregated by size of the enterprise, industry and even business unit.

- SHARE OF EMPLOYEES WHO ARE TELE-WORKING:

it measures the effective utilization of tele-working across the overall company. A more specific alternative indicator might be the share of employees who spend at least a unit of time (depending on the feasibility, and then on the sector ,e.g. one full working day per week) tele-working. As usual, the optimal level depends on the company's sector. Some data are given another time by the SIBIS Institute. In fact they affirmed that "13% of the working population in the EU can be classified as tele-workers. This means that the share of tele workers in Europe is considerable lower than in the US: in the country where the tele-work idea was born, every fourth worker has some type of tele-workplace (25%)".

5.2.9 Server virtualization (reduce physical infrastructure):

it includes both data centres and end-users devices; it refers to the implementation of new virtualization technologies in order to reduce the number of physical devices and increase the level of utilization on the items deployed. Virtualization in data centres, as said before, will enable significant reduction in both servers and storage, while end-user devices can be integrated. The results are a significant reduction in the amount of energy demanded due to removal of base load requirements on under-utilized components, and a reduction of the investments on additional infrastructure refresh.
Using the virtualization techniques within the development and testing area, allows to reduce the demand for physical infrastructure. Some results might be identified in: agile test, and development environments while maintaining energy efficiency.
From a report by BT ("Result of a survey on its economic, environmental and social impacts", 2006), in Purdue University, Indiana US, the IT staff implement a great challenge of information growth and the attendant need for increased storage, servers, and systems. Storage virtualizaion technologies together with server virtualization software, reduced Purdue's administrative energy consumption by almost 20% (35 Kilowatts of power). They affirmed also that using virtualization technologies to reduce and consolidate the environment, EMC has been able to virtualize 1,357 of its servers to just 231 physical machines, resulting in infrastructure space, power and cooling saving 67% (more than $4.6 million) and eliminating about 3,159,726 pounds of CO_2 emissions over a three-year period.

- INDICATORS:

- VIRTUALIZATION RATE (VR):

this indicator aims to assess how the infrastructure is "virtualized". It can be conducted for servers, computers or other devices that may be the subject of virtualization. The indicator is very simple but also very significant.

$$VR = \frac{number\ of\ \ physical\ servers}{total\ number\ of\ \ servers}$$

Obviously the goal is to minimize it as much as possible.
Some optimistic value can be easily calculated from the utilization ratios of the components.

Here it is proposed a table from the World Economic Forum that shows the average utilization ratios of servers, computers, direct attached storage and network storage.

Component	Utilization ratio
Servers	5 – 15%
PCs	10 – 20%
Direct attached storage	20 – 40%
Network storage	60 - 80%

Table 2: Components' utilization ratio; source: World Economic forum;

- LEVEL OF VIRTUALIZATION MATURITY:

through the Architecture Journal, Kevin Francis (Solution Architect MVP, Australia) and Peter Richardson reported a Green Maturity Model for Virtualization. This model provides a number of different layers of abstraction at which virtualization can be applied. Here it is shown the four levels of maturity in this sense; obviously the higher level corresponds to lower energy consumption, and to a "greener" architecture.

Virtualization maturity	Name	Applications	Infrastructure	Location	Ownership
Level 0	Local	Dedicated	Fixed	Distributed	Internal
Level 1	Logical	Shared	Fixed	Centralized	Internal
Level 2	Data center	Shared	Virtual	Centralized	Internal
Level 3	Cloud	SaaS	Virtual	Virtual	Virtual

Table 3: Levels of virtualization maturity; source: Architecture Journal;

The "Level 0" means no virtualization at all, except for applications on individual PCs with no sharing of data. At the first level is introduced the idea of shared applications. "This first appeared in the mainstream as mainframe and then client/server technology, and later with more sophisticated N-tier structures" (Kevin Francis). At the "Level 2" the virtualization is referred to hardware and software infrastructure. The difference from the previous one is that the hardware and software infrastructure upon which servers and applications are run is itself virtualized. Finally the third level refers to the use of cloud computing, in which the virtual infrastructure is no longer tied to a physical location.

- LEVEL OF TECHNOLOGY MATURITY:

This assessment is an integration of the previous one. In fact considering those level of maturity can be identified some technological aspects of the computing platform that may be virtualized. The table presented in the next page, defines the virtualization layers as they map to the server, storage and network aspects, and is once again taken from the Kevin Francis' model. Hence through this standard assessment a company can evaluate its level of technological maturity towards a virtualized environment.

Virtualization maturity	Name	Server	Storage	Network
Level 0	Local	Standalone PC	Local disk	None
Level 1	Departmental	Client/server, N-tier	File server, DB server	LAN, shared services
Level 2	Data center	Server virtualization	SAN	WAN/VPN
Level 3	Cloud	Cloud platform	Cloud storage	Internet

Table 4: Levels of technological virtualization maturity; source: Architecture Journal;
where:

- LAN: Local Area Network.
- SAN: Storage Area Network.
- WAN: Wide Area Network.
- VPN: Virtual Private Network.

Then with these three indicators is possible to describe the goal's level of achievement. In summary can be said that energy consumption will be reduced at each increase in virtualization level, therefore organizations should be looking to move up the levels to reduce their energy footprint.

5.2.10 Comments:

In conclusion I have provided nine objectives for the infrastructure perspective. As described in the section on the approach used (see chapter 4), the goals are consistent with the initial overview of the topic, which is the base of the all Green IT BSC because it describes what needs to be evaluated. In fact all the aspects regarding the infrastructure in the “Greening of IT” and in the “Greening by IT” are included. Moreover should be noted that some indicators are not measures themselves. In fact, particularly in assessing the existence of a system (and not its effectiveness or efficiency) have been proposed such qualitative evaluations. Finally, as shown for the other examples of BSCs, is provided a general release. The effective use of the indicators is therefore subject to the requirements of the various companies. In this context the area where the company taken into account operates, is critical. For example, some companies may add more indicators to deepen goals that are considered essential. They can also add/remove entire objectives as needed.
Hence, this perspective is the core of a Green IT strategy and also its basement.
In the next page is proposed a summary table of the objectives, their indicators, and are provided also the unit of measures.

INFRASTRUCTURE PERSPECTIVE			
It is at the lowest level of the cause-effect chain, and it's the core of the model because considers the physical existence of IT. This perspective aims to identify the "greening of IT" level of achievement, and the capability requirements for the upper levels.			
OBJECTIVES	DESCRIPTION	INDICATORS	UNIT
Reduce energy consumption	It is one of the main objectives of the all balanced scorecard. Includes general measures and particulars ones, referring to the IT infrastructure. Performances must remain at least as now.	Total energy consumption	Gj $ (bills)
		PSUs efficiency	%
		PPW	FLOPS/Watt
		PM usage	%
		TDP	Watt
		ACP	Watt
		Watts per Active port	Watt/Port
		UPC supercomputer	Watt
Prevent amount of e-waste	Here is treated only the "prevent" issue. The procurement point of view is also considered.	Amount of e-waste	Tons
		EPEAT score of ICT products	Number
		Adherence to RoHS	Qualitative
		Depreciation time for ICT prod.	Time
		Incentives to suppliers	$
Generate knowledge	Aims to ensure the existence of an environmental knowledge management system providing quantitative and a qualitative measures	N° and quality of virtual communities	#
		Level of integration	Qualitative
		Staff contributing documents	%
		N° and quality of external links	#
		Portfolio of employee skills	Qualitative
		N° of internal centers of competence/excellence	#
Provide environmental decision supporting system	To ensure its effective existence, must be checked the presence of its physical and logical components. Is made of qualitative indicators due to a lack of standards.	Infrastructural evaluation (database, model base, DBMS, MBMS, DGMS, data mining, OLAP)	Qualitative
		Logical evaluation (Data gathering, Diagnosis, Decision support)	Qualitative
Provide environmental sensors and monitoring networks	The most issue is to ensure the availability of the technology, so the use of advanced sensors to improve monitoring and reporting	N° of physical flows sensed	# %
		N° of environmental variables sensed	# %
		Effectiveness of reporting	Qualitative

Reduce data centers environmental impact	Within this objectives there are indicators of data center efficiency and effectiveness to monitor in order to reduce its environmental impact.	PUE	Ratio (ideal 1)
		PPW (data center)	FLOPS/Watt
		SWaP	$\frac{operations}{RU * Watt}$
		DCiE	Ratio (ideal 1)
		CADE	%
Increase usage of green power	It is a cornerstone to become green. the evaluation take into account absolute and embedded values and also some contingent factors.	Consumption for source of electricity	% $
		Percentage ECRS	%
		GPUE	CO_2/KWh
		Amount of financial incentives	$
		N° of synergies (SMEs)	#
Enable tele-working	To estimate the infrastructure that enables telecommuting, should be measured the availability of computers and Internet “at home”	Share of employees interested in tele-working	%
		Percentage of employees connected to IT system	%
		Share of employees who are tele-working	%
Reduce physical infrastructure	It includes both data centres and end-users; it refers to the implementation of new virtualization technologies in order to reduce the number of physical devices and increase the level of utilization on the items deployed	Virtualization Rate (VR)	%
		Level of virtualization maturity	Score (qualitative)
		Level of technology maturity	Score (qualitative)

Table 5: Infrastructure Perspective;

5.3 STAKEHOLDER AND CULTURE PERSPECTIVE

The importance of stakeholders from a strategy development and service planning perspective is well acknowledged (Ackermann, Eden, 2001; Neely, 2001). However, the role of stakeholders and performance measurement has still been little discussed (Yee-Chin, 2004). The issue of who is seen as the end user of the performance measurement information generated, has received little attention and yet, particularly in the Green IT field, is of critical importance.
As an example the triple bottom line (TBL) concept (Elkington, 1997) was proposed as a tool for measuring organisational performance. The TBL takes a much wider perspective of who the stakeholders in the organisation are. “The theory behind the TBL is that an organisation should take account of its performance in relation to that wider group of stakeholders (such as communities and governments) who are affected by the organisation’s activities, rather than just the narrower group of stakeholders (such as employees, suppliers and customers) who are directly impacted through transactional relationships” (Elkington, 1997).
Stakeholder theory has also been applied related to information systems development. Pouloudi and Whitley (1997) found that “stakeholder analysis can highlight issues that other approaches would neglect related to the information requirements of different stakeholders and the evolution of requirements over time”. The International Institute of Sustainable Development said that "for the business enterprise, sustainable development means adopting business strategies and activities that meet the needs of the enterprise and its stakeholders while protecting, sustaining, and enhancing the human and natural resources that will be needed in the future."
So, after these considerations, the role of stakeholders' management is supporting an organization in achieving its strategic objectives through the interpretation and influence both internal and external environments and creating positive relationships with stakeholders through proper management of their expectations and agreed targets. Stakeholders' management is a process, and control must be planned and guided by basic principles.
Moving to the Green IT topic, it has been said too much about the growing interest of stakeholders in the environmental issue. Hence, consider a separate perspective is crucial, because they have, by definition, a central role both in the costs/revenues for the short term and in terms of corporate performance in the long run. This perspective is at the third level of the cause-effect relationship chain. But has to be said that this perspective is also a bit special because sometimes the IT may not have a direct passage through the people to manifest its benefits. For example comply the infrastructural objective “Reduce physical infrastructure” does not pass through this perspective for effectively achieve business value, because the role of stakeholders in this case is limited or even absent. However, it is clear that, for instance, IT users have an important role in solving problems about the negative environmental impact of IT, for example by using IT more efficiently, or retaining equipment for longer, or, again, replacing it with more efficient equipment. An interesting study would be to compare the socio-demographic characteristics of “high ICT users” with those whose views or attitudes indicate a concern or awareness for environmental issues. Such studies could help to understand the propensity to heavy ICT users to use ICT for purpose that are beneficial to the environment, or to use ICT in ways that add to or limit environmental damage.
Effective environmental strategy implementation requires the definition of a proactive stakeholder management process, which supports sustainable development and provide a sort of reconciliation of differing, and sometimes conflicting, stakeholder interests. Also behavioural factors are included. In fact provide ICT enabled solutions towards sustainability will only result in better outcomes if those solutions are effectively used, and users are aware of their options and obligations. So, the fundamental questions here are: how can people across the extended enterprise be encouraged to improve sustainability outcomes? And, which are the barriers?
Before analysing the measurements, it's important to identify:

- who are the key stakeholders: so, the goal is to identify interested parties either internal or external to the organization, that have an important role in the Green IT strategy. “A stakeholders map is helpful for identifying the stakeholders” (“Stakeholders Management Overview”, Rob Llewellyn, 2009). In particular the key stakeholders in this field are the ones who have a significant influence upon, or importance within the Green IT strategy.
  As an example of classification of the stakeholders is taken that one adopted by Anton G. Camarota in his paper: “Stakeholder Satisfaction: The Key to understanding ISO 14001”(1999). in particular he identified five different classes of stakeholders:
  - Financial stakeholders: “The parties who have a primary interest in the financial performance of any organization are shareholders, lenders, and insurers”.
  - Customers: they “are an essential component of any business, and are especially important in ensuring the ultimate success of any environmental strategy”.
  - Internal stakeholders: “The primary internal stakeholders for any organization are the management and the employees”. These have not only the need to have a say in developing and implementing a Green IT strategy, but the overall results of their efforts must be measured and communicated throughout the organization. Therefore indicators should take into consideration all these factors.
  - Communities and public policy: “The stakeholders in this area are the local and global communities of humans; the local, state, and federal regulatory agencies; and the community of competing firms”. For example, with the community of competing companies, mostly for the SMEs, an organization should look for possibilities of form joint ventures, share technologies, and develop integrated partnerships, for instance for the production of green power.
  - The biosphere: “The stakeholders in this area are all of the sentient beings of the earth, and the natural habitants that provide for their food and shelter”. This category will not be discussed in this perspective as it is impossible to find terms of satisfaction or compliance.

  It is clear how these categories may have different levels of importance in the function of many variables concerning the firm. For example, the classification may be different, or with different priorities, depending on the country where the company operates, according to its size, or the sector in which it operates.
  Moreover, what have to been identified are the following issues:
- what do they need: recognise and acknowledge stakeholders' needs, concerns, wants, authority, common relationships, interfaces. Then, this information should be aligned within a sort of strategic map, which positions key stakeholders according to the level of influence, and impact or enhancement they may provide to the Green IT strategy.
- which strategies processes and capabilities are needed to satisfy them. In this case, as the main capability refers to Information Technology, this issue is not included in this perspective, but has been already treated in the infrastructural one (see paragraph 5.2). For about what concerns the processes, this argument will be discussed in the next, “Sustainability Perspective” (see paragraph 5.4).

Below are presented the objectives, and the indicators for each of them.

5.3.1 Promote cultural change:

This objective relates to overcome the cultural barrier that exists within the organization. In other words, it can be defined as the struggle against stakeholders' resistance to change. The main goal here is to “define a common language to improve communication throughout the extended enterprise and establish activities to help embed sustainability principles across IT

and the wider enterprise" ("IT-CMF, SICT", IVI, 2010). Hence, a company must engage its key stakeholders shifting into a culture that integrates sustainability in the working day routine. In other words, the effective success of a Green IT strategy requires view IT sustainability as BAU (Business-As-Usual).

- INDICATORS

  - INCENTIVES:

The incentives are considered as a tool for promoting a cultural change within the extended enterprise. Across the various levels of an organization can be identified several examples, ranging from "awards and recognitions for new ideas and innovation, to a direct relationship to sustainable performance and rewards for senior executives" ("ITPRO", Donnellan, B. 2011).

  - % OF GREEN IT KPIs INCLUDED IN SLAs:

The SLAs (Service Level Agreement) are contractual tools through which are defined the metrics of service that must be followed by a service provider. They consist of performance indicators, of a reporting system, and finally undergo a phase of monitoring and periodic renegotiation of the threshold values. Inserting in this balanced measure of the service's performance some indicators related to Green IT, one who is subject to the assessment is pushed to get good results even in this sense, as he can enhance the level of his service. Then the definition of the SLA is not only based on the determination by the customer service level to guarantee an ideal of its business, but should include evaluation of the subject variables in terms of Green IT. "Being Green is a mindset that starts with the employees of a company and once this is achieved, can be easily transformed into Green IT policies" (Grey Matter Thinking report; this is a multidisciplinary financial and IT services firm, settled in South Africa).

5.3.2 Stakeholders satisfaction:

This goal is not released to demonstrate a particular environmental performance, nor demonstrate a very low impact, but rather that the organization has certified an appropriate management system to monitor the environmental impacts of its activities, and systematically seek improvement in a coherent, effective and, above all, sustainable way, and therefore meets the stakeholders of the Green IT strategy.
Especially in this case the metric indicators have some problems. In fact they can not evaluate the quality aspects related to the perceptions, actions and motivations of individuals.
It is here proposed a classification of the factors of satisfaction in line with the introduction of categories of key stakeholders, proposed in the initial part of the perspective.

- Financial stakeholders: all of them are concerned that the organization provides an adequate financial return on its assets employed, and that it maintains a positive cash flow to service current obligations and to provide adequate dividends. Insurers are concerned that the organization maintains low financial exposure, minimizing the risk or default or bankruptcy.
- Customers: their perceptions of a product or service are shaped not only by its specific environmental attributes, but also by the reputation of the organization as an environmental leader.
- Internal stakeholders: both the management and the employees "are concerned with

the degree of internal environmental excellence that a firm exhibits. The environmental focus of internal stakeholders is on the processes that create value for customers, produce acceptable financial results, and integrate the organization with the communities, public policy-making bodies, and ecosystems with which it interacts" ("Stakeholder Satisfaction: The Key to understanding ISO 14001", Anton G. Camarota, 1999).

- Communities and public policy: "These entities are external to the organization, and so pose a special challenge to management. The key question management must answer with regard to these stakeholders is this: Is my organization an environmentally responsible member of the communities in which it operates?" (Anton G. Camarota, 1999).

The classification was presented from a very high level and generalized. However, there are standard methods, mainly qualitative, for the periodic and continuous evaluation of this goal.

- INDICATORS:

  - SURVEYS:

in my opinion through surveys an organization could rise to three types of goal: the first is to provide measures that indicate how well the organization is delivering its service to the various stakeholder groups from an environmental point of view; then, it allows to identify specific actions that top management can take to improve the satisfaction levels of the company's stakeholders; and finally to provide benchmarks on which to evaluate actions the organization takes.
Gathering input from stakeholders is in itself an important activity that can help engender support for the Green IT mission. In fact a survey project is an important way for an organization to provide the stakeholders' views to those responsible for managing the company. To design an effective survey, the project manager should generate a short list of questions to gather input. Then he should provide a menu of choices, such as a satisfaction rating scale including the options "Completely Satisfied," "Satisfied," "No Opinion," Dissatisfied," and "Completely Dissatisfied." Then, the project manager must provide clear instructions on how to fill the survey, on when feedback is requested and on how the feedback will be used. Hence, the tool provides valuable research data. These data will be used to drive continuous improvement within the Green IT strategy and will be tracked in the Green IT Balanced Scorecard.

  - NUMBER OF STAKEHOLDER COMPLIANCES:

This is another indicator of the satisfaction of key stakeholders. Even in this case the measure is not relative but absolute. However, it can be related to some size to put it into a relative measure (for example, percentage). Moreover, should be stressed that it assumes great importance mainly for the governmental point of view. However, a broader discourse on regulatory compliance will be addressed in the next perspective as there are direct connections with aspects of infrastructure, connections that not explicitly concern the stakeholders' perspective (see paragraph 5.4.2). Anyway, here are considered also the other key stakeholders, as the situation is variable depending on the sector and the country in which the company operates and other structural factors.

5.3.3 Management of stakeholders needs:

"Companies need appropriate systems to measure and control their own behaviour in order

to assess whether they are responding to stakeholder concerns in an effective way and to communicate the results achieved" ("Sustainability and Stakeholder Management: the Need for New Corporate Performance Evaluation and Reporting Systems", Franco Perrini, 2006). Especially in a Green IT strategy it is essential that the needs of all stakeholders are met. To monitor these variables in a Green IT strategy were chosen three basic dimensions. The first concerns the level of involvement of stakeholders, the second deals with the services they provide and the third refers to assistance and aid in the use of technology.

- INDICATORS

  - NUMBER OF MEETINGS WITH KEY STAKEHOLDERS:

in this case what it's wanted to be measured is the propensity of top management (and even lower levels) to accommodate the wishes and demands of stakeholders. Additionally, must be said that it does not take into account actual communication (topic discussed later). This is considered a typical indicator even if it is not really "SMART". In fact it aims to be a qualitative measure more than a quantitative one. Relate the indicator to some parameter, for the purpose of any benchmark, is of little significance. The several different problems that can arise and the huge diversity of the various types of stakeholders are the major reasons. In conclusion, in order to satisfy the stakeholders' needs, ongoing meetings are necessary to understand any issues / requests and to report the progress of the strategy.
In this field may be also included the possibility of stakeholders' focus groups for running brainstorming sessions. Conducting an effective focus group usually involves comprehensive planning including setting an agenda, preparing specific questions to ask stakeholders, encouraging collaboration, and calling for action from participants. Green IT project managers should encourage all participants to provide candid input reflecting their perspective. This method allows to get timely input for all stakeholders at once, enabling the organization to avoid costly mistakes or rework later on.

  - NUMBER OF GREEN IT PROJECT WITH SLA:

including SLA in a Green IT project is also a crucial step because the person concerned has an accurate guide to follow providing his service and also helps to ensure that his contribution to the strategy is appropriately considered. It is for this reason that including SLA leads to greater effectiveness in managing the needs of stakeholders. Must be also underlined how in this field the SLA are offered by service providers as a service based agreement rather than a customer based agreement, as the most commons ones. Finally, the downside of SLAs in a Green IT strategy refers more to a management point of view. In fact it results difficult to determine the root causes for sudden changes in environmental performances taken into account due to the complex nature of the topic.

  - AVAILABILITY OF FORMAL ENVIRONMENTAL TECHNOLOGIES PROCEDURES:

this third indicator wants to measure the level of assistance and help in the use of environmental technologies introduced in the first perspective. Thus, this is also a process in the Green IT strategy with a view to meeting the needs of stakeholders. From a report by EEA (European Environmental Agency) "Environmentally sound technologies are not just individual technologies, but total systems which include know-how, procedures, goods and services, and equipment as well as organisational and managerial procedures". In this category is included the provision for users of a help desk service. It is a service that provides information and assistance with problems in the management or use of a technology. Particularly for the SMEs is enough to include environmental aspects into the

existing structure, while for large companies would be appropriate to set up a real Green IT help desk.

5.3.4 develop a sustainable procurement:

in this objective it is wanted to assess the level of engagement within the supply chain. In fact, develop a sustainable procurement is a significant part of the Green IT strategy. It is indeed obvious how sharing knowledge on emerging technologies, business requirements for IT and procurement practices will realize higher degree of environmental and social sustainability. Some variables of environmentally sustainable procurement might be: the power efficiency of any procured device and its life span, the use of toxic compounds within devices, the use of packaging, as suggested by the Bristol City Council (2010), in its report "the working conditions for workers in the supply chain".
Organizations today 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" ("Return On Investment on Green IT", Dominique C. Brack, 2010).
Before introducing some indicators, it is needed to do some clarification. In a traditional context, there are standard methods for searching, qualifying and selecting suppliers. In particular, within the evaluation and qualification phases, is typically drawn up a list "favourites suppliers". Further insights of this process go beyond this discussion; however, is necessary for the company in question, to add to the evaluation criteria variables related to sustainability. In doing so the list of preferred suppliers will also consider "how much" they are green and which of them is best suited to pursue this objective.

- INDICATORS

  - ENERGY STAR RATING OF SUPPLIERS:

this indicator aims to answer at the question: "how much green are your suppliers?" In fact, as introduced before, within the U.S. EPA's Energy Star program have been developed energy performance rating systems for several commercial and institutional building types and manufacturing facilities. These ratings, on a scale of 1 to 100, provide a means for benchmarking the energy efficiency of specific buildings and industrial plants against the energy performance of similar facilities.
Devices carrying the Energy Star logo, such as computer products and peripherals, kitchen appliances, buildings and other products, "generally use 20%–30% less energy than required by federal standards" (Tugend, A. "If Your Appliances Are Avocado, They're Probably Not Green", 2008).

  - EPEAT SCORE/TIER OF SUPPLIERS:

this indicator is proposed as an alternative or supplement to the previous one. In fact, this also aims to assess how a supplier operates in a sustainable manner. So, the EPEAT registry provides a green-label by which computer companies can grade their products against some specific green criteria and score them as Bronze, Silver and Gold. Hence, products are ranked in EPEAT to these three tiers of environmental performance. All the products that are registered under this category must attain at least the lowest level (bronze) which correspond

to meet 23 required criteria. Manufacturers may then achieve a higher-level EPEAT rating for their products by meeting additional optional criteria, listed as follows:

- bronze: 23 required criteria;
- silver: meets bronze standard, plus at least 50% of optional criteria;
- gold: meets bronze standard, plus at least 75% of optional criteria.

Furthermore should be noted that there are significant differences between the Energy Star and the EPEAT programs. The first is a program "promoting energy efficiency and protecting the environment through products and practices" (EPA, 1992). In other words, it was established to identify products that reduce greenhouse gas and pollutants through more efficient use of energy, and to make it easy for buyers to identify and purchase energy efficient products. The symbol also recognizes energy efficient buildings, mainly from the 2007 with the "4.0" version. Instead the EPEAT is "used by purchasers to evaluate, compare and select electronics products, based on their environmental attributes" (Sylvia Tarin Brousseau, DEA Southwest Laboratory, 2010). It is also more recent. In fact, it was launched in 2006, and it's based on a standard that provides performance criteria for the design of products in order to reduce their environmental impact. The criteria (see paragraph 2.3.9), covers the product environmental performance within all its life cycle.

- % OF PROCUREMENT REQUESTS SATISFIED BY PREFERRED SUPPLIERS:

this indicator is intended to be a sort of measurement and estimation of the quality of the supply chain. In particular the term "preferred suppliers" refers to the list mentioned in the introduction to this goal. In fact, it is assumed that most supplies come from these suppliers and we are moving towards more "green procurement". Finally, it should be noted that is assumed that the list of suppliers is optimal and complete, and that, as mentioned above, take into due consideration the performances and the benefits from a sustainable point of view.

- NUMBER OF PARTNERSHIPS:

With a systematic process of communication (treated in paragraph 5.3.6), is possible to develop working partnership. It is significant to consider this possibility because it can ensure that the most appropriate sustainability criteria are applied to the procurement of ICT equipment and software. Develop partnerships means also reviewing continuously procurement's standards and practices, as new technologies and suppliers emerge. Also through partnerships with suppliers an organization could drive innovations and developments in sustainable technology.
Must be also underlined that developing partnerships meets some advantages for the recycling issue (see paragraphs 2.3.5 and 5.4.8). In fact, collaborate with suppliers helps considerably in the WEEE legislation compliance. The reason is explained in paragraph 2.3.5, particularly in the reflection on the extended producers responsibility derived by the WEEE directive compliance.

5.3.5 Create awareness:

Creating awareness and getting the employees and the all key stakeholders involved is one of the key success factors when implementing a Green IT strategy. In this part is considered the Green IT awareness within the organization. To get an assessment of this objective, I decided to separate this into three "sub-objectives". In particular, in order to create awareness about the Green IT issues, are considered three different process:

I. Steering committee towards Green IT: this part refers to the organization's strategic

commitment. Are then considered all aspects of training and policies from the top management or strategy group guiding the project of Green IT. As stressed several times, promote a common language in order to leverage a common understanding is a cornerstone to capture business value from the Green IT strategy. Policies in this field have been already included under the "Promote cultural change" objective which, as will be explained in the cause-effect relationship part later (see paragraph 5.6), is a direct cause of this goal. The same thing applies to the discourse concerning the awards and / or incentives. The indicators proposed in this section will be then to assess the training of stakeholders.

- INDICATORS

  – NUMBER OF INTERNAL STAKEHOLDERS TRAINED:

it is an indicator of about the depth of training. After identifying those who should really be subject to the courses, it is assessed whether it actually happens in reality.

$$st.\,trained = \frac{n^{\circ}\,trained}{n^{\circ}\,tobe\,trained}$$

It is a kind of evaluation of the effectiveness of the organizational training program, seeing if the project reaches properly the right people that really need awareness on the Green IT issues.

  – TOTAL HOURS OF TRAINING ON GREEN IT ISSUES (PER YEAR):

it's a general indicator that has little meaning in relative terms and for the benchmarks. However, it has been proposed to have an annual evaluation and a comparison with previous periods. The intent is to verify the total effort by the organization over the years, in providing training courses on various environmental issues such as how to use new technologies, or new environmentally friendly ways to use existing ones. Furthermore, should be noted that the measure may be affected by the phenomenon of recruitment. For example a decline in the number of total training hours could reflects the decrease in the number of hirings, rather than a less effort by the organization. This is because usually new hires are systematically provided with a substantial amount of initial training. Hence, this measure should be corrected (and compared) through a significant factor, related to the recruitment. In addition is proposed a further measure with more relative meaning and that is comparable with similar businesses:

  – HOURS OF TRAINING ON GREEN IT PER EMPLOYEE:

the reasons why the training hours are measured as an indicator of properly aware of the problems related to the environment, have already been exhaustively explained. It is provided just for a more accurate further analysis from the quantitative point of view.

  – NUMBER OF OTHER INTERNAL INITIATIVES:

in order to raise awareness there are several many initiatives that could be undertaken. Some examples might be: hold green team meetings to discuss what areas of the business are the least energy efficient and what can be done to make improvements; raise awareness throughout the office with emails, fliers and posters with information on how the business is going green and what they can do to help, or again, hold a green event in the office to get everyone excited and aware of the green team's efforts. The objective is therefore to create a real internal campaign to raise awareness towards the environment, in all the possible ways. Can be also included small things, such as for instance distribute brown bag lunches with a featured in-house.

II. The goal to improve the approachability of Green IT related knowledge from outside: this second source of knowledge, to improve awareness, comes from sources outside the firm. However, it is the responsibility of the organization to promote their integration and consolidation. The part of external knowledge integrated in the knowledge-base of the EKMS, has already been assessed in the infrastructural perspective (indicator "number and quality of external knowledge links", paragraph 5.2.3). In this part is provided a measure of the organization's effort in other external initiatives.

- NUMBER OF EXTERNAL INITIATIVES:

As said, another tool to encourage the growth of awareness is the possibility given by the organization to the key stakeholders (mainly internal stakeholders) to participate to external events about Green IT topic. In this part are included various initiatives such as participation in workshops, fairs, conferences etc. From these initiatives usually emerge experts opinions, new strategies by other companies, or even governments, and new ideas for move towards Green IT. In these presentations are also provided concrete data that prove the success of the various strategies, and this can even be a further essential benchmarking tool. It is therefore needed by the company an effort to forge relationships non-profit organizations to encourage this kind of information.

III. Part relating to the Environmental Knowledge Management System (EKMS): finally, as analysed from the technological point of view in the infrastructural perspective (see paragraph 5.2.3), and from the point of view of the benefits in the initial overview (see paragraph 2.4.6), a way to create awareness comes from the EKMS. It's true that it also incorporates external sources of knowledge, but, as noted above, the situation is different from that analysed in the preceding paragraph. Indicators to assess this part has already been provided in the infrastructural perspective. In fact are provided KPI to assess the organization's knowledge-base that describe the content of the EKMS in quantitative and qualitative terms.

5.3.6 Improve environmental communication:

environmental communication is the process of sharing information in order to build trust, credibility and partnerships, to raise awareness and support decision making. One way to build and monitor a communication program is aligning with ISO 14063 directive (2006). It is necessary to underline that the ISO 14063, unlike some other components of ISO 14000 (the group of issues concerning the environmental management), provides guidelines and not standards. Hence, there is no formal definition of compliance. However, it "utilizes proven and well-established approaches for communication, adapted to the specific conditions that exist in environmental communication. It is applicable to all organizations regardless of their size, type, location, structure, activities, products and services, and whether or not they have an environmental management system in place" (ISO 14063 Abstract, by ISO). In this guideline are identified two main forms of environmental communication: ad hoc and scheduled.

Moving ahead, this objective is very important to capture business value from the Green IT strategy implementation. In fact is mainly through communication that an organization can demonstrate its effort, towards a sustainable approach, to investors, customers and governments.

There are a huge amount of other benefits from an effective environmental communication.

First of all it allows to support stakeholders in understanding the commitments, policies and organizational performance. A high level of communication might also provide input and suggestions for improving the organization's performance in relation to its activities, products and services and progress towards sustainability. Resulted improved also the trust and dialogue between the organization and them, and exploit the credentials, the results, and the organization's environmental performance. Some other examples of benefits could be: raising the importance and the level of awareness to support the spread of culture and environmental values within the organization, and effectively address the concerns and grievances of stakeholders in relation to operational risks and environmental emergencies.
The main requirement is the existence of a policy about the environmental communication, by the top management. The policy must be promoted within and outside the organization, emphasizing the desire to engage in dialogue with stakeholders and a commitment to make public and disseminate information on their environmental performance.
In an optimal communication approach should also be developed an electronic register that keeps track of contacts with the key stakeholders. The objective of this register is for the ISO to:

- Reconstructing the history of communications with stakeholders (and their requests or concerns).
- Understand the changing nature of relationships and commitments entered into with the key stakeholders in time.
- Improving the effectiveness of the organization in responding to stakeholders and to give them a proper follow-up.

- INDICATORS:

  – LEVEL OF ENVIRONMENTAL COMMUNICATION MATURITY:

to introduce this issue, it is proposed an approach developed by the International Association for Public Participation. They have classified five different levels of involvement of stakeholders through communication, using two criteria: the exchange of information between the organization and its stakeholders, and the level of involvement of stakeholders and their active participation. The five level are represented in the following graphic:

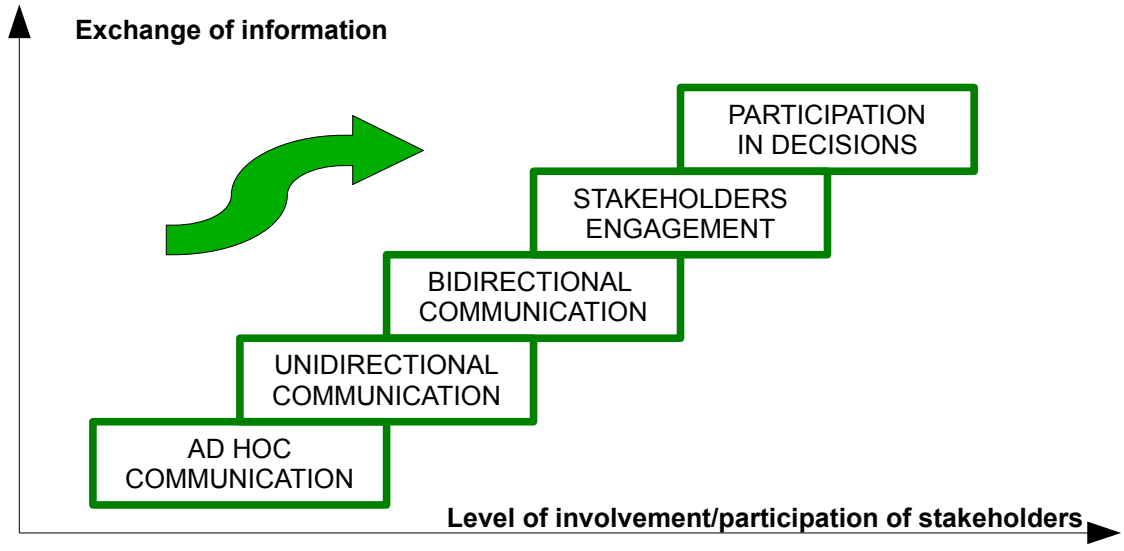


Figure 10: Levels of environmental communication maturity; source: International Association For Public Participation;

where:

- Ad hoc communication: it assumes a specific request by the group of stakeholders (e.g. local community) regarding a particular issue (e.g. system's environmental impact).
- Unidirectional communication: the organization communicates through brochures, letters or presentations without there being an interactive exchange with stakeholders.
- Bidirectional communication: is accomplished through an exchange of information between the organization and its stakeholders. From this interaction can emerge new ideas.
- Stakeholders engagement: the organization aims to identify and further the interests and problems of its stakeholders. The Communication has therefore the objective to deepen mutual understanding, through greater involvement of stakeholders and a more serious exchange of information.
- Participation in decisions: the involvement of stakeholders in the definition of certain decisions, although not always feasible, has the advantage of facilitating the acceptance of the choices and thus reduce the potential conflict.

– % OF KEY STAKEHOLDERS REACHED:

this indicator aims to assess the depth of the environmental communication. Using the different channels it is in fact desirable to reach as many key stakeholders as possible, of those listed above. Channels can be: websites, environmental or sustainability reports, public meetings, personal contact, focus group (to discuss a particular topic), sustainability agreement (for example to mutually commit to sustainable development), or cooperative projects.

– LEVEL OF TRANSPARENCY AND APPROPRIATENESS:

this indicator aims to assess the quality of the communication. A possible evaluation should come from both interview to stakeholders and from a continuous monitoring by the department in charge and the general direction. A transparent environmental communication makes available processes, procedures, methods, data sources, and assumptions used in it (assessable by the internal part). Must be also ensured (by interviews) that the approach and the language used are understandable. Instead, an appropriate environmental communication provides “relevant information to stakeholders, using formats, language and also” (sometimes) “media that meet their interests and needs, allowing for full participation” (ISO 14063). So, the environmental communication must be honest and fair, and must provide truthful, accurate, substantive, and mot misleading information.

– % OF KEY STAKEHOLDERS FROM WHICH IS OBTAINED A FEEDBACK:

by taking into account the feedbacks, an organization can see both if the key stakeholders were effectively reached and how the environmental communication was received. Hence, asking for feedbacks allows the company to demonstrate that it includes the point of view of the key stakeholders, that it is interested to know their opinions and that it definitely take them into consideration. Receive feedbacks provides also the possibility of a quick reaction by the company in case of failure of the communication. A possible solution could be for instance include a form in the published report. This measure could be also integrated with an internal indicator, as:

– N° OF FOLLOW-UP ON ISSUES RAISED BY KEY STAKEHOLDERS.

5.3.7 Comments:

In conclusion I have provided six objectives with which achieve the maximum performance in the stakeholders' management. In order to comply a continuous improvement in each objective are

provided throughout twenty-one indicators. As said in the introduction and in the infrastructural perspective their usage depends on the company and its parameters. For example, some companies may add more indicators to deepen goals that are considered essential. They can also add/remove entire objectives as needed. Most of the evaluation process, in this context, depends on the key stakeholders identified in the first phase. In fact, for any company, interested parties may be different and have different weights and priorities. For example for companies operating in European countries are of great importance the governments and/or the local communities for their strong community awareness towards the environment and a strong legislative commitment. The same thing does not happen for example in companies operating in African territory. Furthermore, the approach has remained consistent with the various balanced scorecards described above. In fact, from this perspective is judged solely the critical success factors of the stakeholders' management itself towards a Green IT strategy. Some statements may seem at first sight without a precise meaning within the model, but will be comprehensively linked with the other perspectives in the section of about the cause-effect relationship (see paragraph 5.6).
Moreover, in this stage are mostly considered qualitative measures or numerics ones but just in an absolute sense (not really relative). But it has also to be said that even in literature there is a lack of structured methods for the assessment of cultural and behavioural aspects of people and related to the satisfaction of the all parties concerned.
Finally, as done for the first perspective, in the next page is proposed a summary table of the objectives, their brief description, their indicators, and are provided also the unit of measures.

STAKEHOLDERS AND CULTURE PERSPECTIVE			
It is at the third level of the cause-effect chain, and consider the stakeholders' central role both in the costs/revenues for the short term and in terms of corporate performance in the long run. The importance of stakeholder management is to support an organization in achieving its strategic objectives through the interpretation and influence of both internal and external environments, and creating positive relationships with stakeholders through proper management of their expectations and agreed targets.			
OBJECTIVES	DESCRIPTION	INDICATORS	UNIT
Promote cultural change	Relates to overcome the cultural barrier that exists within the organization. It can be defined as the struggle against stakeholders' resistance to change.	Incentives	$
		% of Green KPIs included in SLAs	%
Stakeholders' satisfaction	To demonstrate that the organization has certified an appropriate management system to monitor the environmental impacts of its activities, and systematically seek improvement in a coherent, effective and above all sustainable way, and therefore meets the stakeholders of the Green IT strategy.	Surveys to Key Stakeholders	Qualitative Score
		N° of Stakeholders' compliance	# % Qualitative
Management of stakeholders will	It is essential that the needs of all stakeholders are met. Three basic dimensions: level of involvement, assistance, services.	N° of meetings with Key stakeholders	# Rate
		N° of Green IT projects with SLA	# %
		Availability of formal environmental technology procedures	# %
Develop a sustainable procurement	Is assessed the level of engagement within the supply chain. So, sharing knowledge on emerging technologies, business requirements for IT and procurement practices will realize higher degree of	N° of partnerships	# %
		% of procurement's requests satisfied by preferred suppliers	%
		Energy Star rating of suppliers	Score (from 1 to 100)

	environmental and social sustainability.	EPEAT score/tier of suppliers	Qualitative tier Score
Create awareness	Getting the employees and the all key stakeholders involved is one of the key success factors when implementing a Green IT strategy. Are considered steering committee, approachability of knowledge from outside, and EKMS.	N° of internal stakeholders trained	%
		Total hours of training on Green IT issues, per year	- H / Year - recruitment factor
		Hours of training per employee	H / employee (per year)
		Number of Internal initiatives	#
		Number of External initiatives	#
Improve environmental communication	Environmental communication is the process of sharing information in order to build trust, credibility and partnerships, to raise awareness and support decision making.	Level of environmental communication maturity	Score (qualitative)
		% of Key stakeholders reached	%
		Level of transparency and appropriateness	Qualitative
		% of Key stakeholders from which is obtained a feedback	%
		N° of follow-up on issues raised by Key stakeholders	# %

Table 6: Stakeholders and Culture Perspective;

5.4 SUSTAINABILITY PERSPECTIVE

This perspective is situated immediately below the “Business Value Perspective”. In short, after considering all aspects of infrastructure, cultural, and related stakeholders, we must introduce an additional layer to reach the ultimate goal of a Green IT strategy: to capture business value. The name of "sustainability perspective" seems a little vague. To be more clear, a complete description will be now provided. First of all, now is treated an organizational level. The elements that have to be assessed here, refer to the processes and the strategy. Within the Green IT BSC, this perspective can be explained as follows: an organisation, once it has developed a green infrastructure, and it has settled inside the correct cultural mechanisms, must pursue objectives at process and strategic level, to effectively capture business value from the Green IT strategy.

Before starting to present the objectives, are needed some clarifications. Taking a step back, in the infrastructural perspective have been introduced all the technological requirements to meet the needs of “optimizing, re-engineering, coordinating, auditing, monitoring”. These opportunities, although not evaluated numerically in the Green IT BSC, should be considered at this level also with the need of design for environmental sustainability. Retracing the latter, are identified needs of developing and promoting of green buildings (see again the definition provided by the USGBC in paragraph 2.3.1), green supply chain (already assessed in the stakeholder perspective), green products, smart grid, and smart logistic. Although apparently it may seem to the contrary, these issues have already been separated and measured in their elementary components in the previous perspectives, and will not be treated numerically in this part. However, it is true that at the aggregate level, consistent with the definition given to this perspective, may be included goals relating to these aspects. For completeness will add an indicator that summarizes many of these factors, inside the objective “reduce carbon footprint": the LEED rating, already introduced in the first part. In order to provide some data, the World Economic Forum in his report “Green Technology: Driving Economic and Environmental Benefits from ICT” of January 2009 affirms that a Smart Building Implementation program can lead to a “$334,628 saving on utility during the first year of implementation alone, $50,000 saving at pilot building, and $4 million estimated saving upon project completion”. In particular the energy consumption reductions would be about -12% for electricity, - 45% for steam, and - 10% in chilled water.

With regard to the solutions in order to optimize the internal processes, there are a huge amount of examples. An instance can be the development of a route or a fleet management system. In order to provide some data, a regional ambulance service (YAS: Yorkshire Ambulance Service Report, 2011) delivered an estimated 30% reduction in carbon footprint through the more effective distribution of ambulances across the region, , while also improving survivability by up to 23%.

Some words must be even spent about the possibility of application of rationalization and re-engineering, in order to decrease energy consumption through a reduction in infrastructure deployed to support the organization's processes. The first is supposed to enable a reduction in the quantity of underlying infrastructure (in the cause-effect relationship will not be proposed a link to the infrastructural objective “reduce physical infrastructure” for the lack of accurate data). Also re-cooling of existing application could be undertaken to increase processes' efficiency. Verizon Wireless, the largest mobile telecommunication network and wireless phone provider in the United States, is now saving $20 million annually by consolidating 13 billing systems into a single enterprise system. Moreover, again from the World Economic Forum (2009), through carbon network logistic optimization can be reach: 26% reduction in warehouse electricity consumption through site rationalization, 33% reduction in carbon emissions for vendor inbound activities through consolidation of movements, and 11% saving as part of a 3 year period change programme.

Some considerations may also be made about the process of auditing (as the others, already mentioned in chapter 2, paragraph 2.4.3). Its importance is demonstrated again by some data

provided by the World Economic Forum report, that in relation to a energy-efficiency program, says that “simply auditing the environment to identify these devices could lead to a reduction in infrastructure of over 10% together to power saving of between 10% - 20%”.
Instead, official data on the use of IT for monitoring, modelling and administration are unlikely to be available, but it could be argued even without data evidence that they would be vastly less efficient in the absence of ICT.
Therefore, this level is very broad, and thus meets all the strategic decisions that have been mentioned previously. For example, in the case in which there is not a self production of green power, a detailed analysis of energy utilization across the organization could enable negotiations with suppliers based on futures pricing rather than on spot energy prices (“Enterprise Demand Analysis to Support Future Pricing”, Green Technology report, 2009). Some advantages are identified in a long term reduction of energy costs and also in an improved budgeting for the organization. Hence, are proposed seven key objectives which, as mentioned, are the foundation for capture business value from the pursuit of technological sustainability.
Below are presented the objectives, and the indicators for each of them.

5.4.1 Improve public image:

Good will and mutual understanding is essential for most of organization's operations to obtain planning permission and licences, to attract good quality employees and to sell their product. Also many companies operate in a world served by press and broadcast media who themselves survive on issue-driven stories aimed at generating public interest and concern in order to increase publication sales or viewer ratings. A good public image is often also viewed by stakeholders as an important desired status, as it usually directly affects the economic viability of the industry. Moreover, sustainability is undoubtedly a major issue contributing to public image and, as such, deserves consideration in any proposed communications strategy for the industry, as highlighted above.
Generally the public image evaluation is conducted through surveys on product quality, or from a higher level, even on the global demand for the output produced. Some examples of widely used indicators are: “demand for products”, “% of production covered by quality assurance”, “product quality and safety”, and so on. In the Green IT this assessment might be different. Consistent with what has been the development of the model so far, will be provided measures related to the Green IT field, even if most of them will be qualitative. However, before introducing the indicators have to be made some explications. First of all, the main cause of a good public perception, assuming prominent performances, is an efficient and an effective communication. A wide speech on this subject has already been made in the “Stakeholders Perspective” (see paragraph 5.3.6). Hence, will be proposed significant indicators referring on the analysis of the contents of the media about the organization and its works and activities, and public opinion surveys.

- INDICATORS

  - SOCIAL SURVEYS:

A survey is defined as a “method used to collect in a systematic way, information from a sample of individuals” (Wikipedia). What is wanted to collect in this case is an opinion on how a company behaves against the environment. As mentioned the views can be generated from many different sources. Some examples include the use of a product, the internal and external communication, or even simply unfounded opinion that comes from a personal perception. A psychological discourse on how a person can evaluate the performance of a

company from the mere perception goes beyond this discussion. Here the document is focused mainly on how to measure this quantity. Social survey techniques are well known and its application is quite easy. What is required for the effective implementation of this indicator is a constant and continuous research on market surveys techniques. Going ahead, a complementary implementation issue refers to the scientific facts, and mostly in the Green IT field it is a fundamental issue. Indeed, these concepts must be translated into non-specialised and in an "easy to understand" language, and then effectively communicated. For a guide on how to write good survey questions, Ten Brink in 1992 from the Department of Psychology of the University of Amsterdam, offered in a publication a list of rules for writing an effective survey. To allow an adequate analysis must be developed a standard questionnaire. After doing so is easier to gather data and synthesize them into a number that has meaning even if only qualitatively. Is essential to repeat the analysis on a sample continuously and at times set. So the company can analyse the improvements and above all provides adequate feedback to the actions taken in the lower levels perspectives.

- MEDIA CONTENT ANALYSIS:

This indicator is meaningful only relevant in the case of a large company with a strong media power. Precisely in this case, a qualitative assessment of all articles, services and publications provided by the media in general, can be considered an approximation of how the public sees the work of the company in terms of sustainability. The test should be conducted carefully and should cover every news channel, even if monitor the Internet is sometimes more expensive than the gains that can be achieved with it.

A particular part should be dedicated to the marketing opportunity. According to my personal interpretation, in fact, through marketing policies, an organization can reach a substantial improvement of its public image. Philip Kotler in its "Marketing Defined" (2009), said "it is an integrated process through which companies build strong customer relationships and create value for their customers and for themselves". It is true that the term marketing means much more than a process to improve public image, and it is equally true that in this context the term advertising is probably much closer to the objective in question. But this alone is not enough. To avoid wasting time on the etymology of words, marketing will be improperly used as the term to describe the process that, through political advertising, channels of communication choices, and market segmentation, aims to improve the public image of a company. Returning in the sustainability field, the same things are true for the term Green Marketing. "Unfortunately, a majority of people believe that green marketing refers solely to the promotion or advertising of products with environmental characteristics", says Wikipedia, and again "in general green marketing is a much broader concept". According to Dainora Grundey and Rodica Milena Zaharia Green Marketing consists of "all activities designed to generate and facilitate any exchanges intended to satisfy human needs or wants, such that the satisfaction of these needs and wants occurs, with minimal harmful impact on the natural environment" (Baltic Journal on sustainability, 2008). However what is important to understand here is that to assess this objective would be appropriate to include some indicators on the Green Marketing (a term used loosely) made by an organization. In particular there is definitely a positive relationship between effort and effectiveness of the Green Marketing and public image. But what can not be argued is a set of indicators to assess these benefits. In particular in the various sectors, the metrics can be completely different. The effort, defined as time and money, is highly dependent on exogenous variables. Therefore will not be included in this objective metrics to assess the contribution of this process. But, in any case should be carefully considered these aspects. Regarding this document, refer to the numerous citations of "marketing"

opportunity developed in chapter 2 (see "regulatory compliance" and "Eco-Labelling of IT products"), and in the analysis of communication strategies developed in the "Stakeholder Perspective" (see paragraph 5.3) .

5.4.2 Regulatory compliance:

For sure, there is no doubt that regulations and legislations will constitute a strong driver for change. As previously written in chapter 2 (see paragraph 2.3.6), the importance of this issue has been widely demonstrated by several researches. In particular has been estimated that " the financial penalties can reach a value of approximately 3% - 7% of the total energy spend". Evaluate this objective in a quantitative way is not difficult because developing indicators on fines/penalties, timing, number of laws to which it relates and many other variables, is immediate. In my opinion, what is more complicated here, is to give a full and whole assessment. For this reason are proposed some indicators and their use or waste depends on the context of the organization. For example, a company that works in the electronics industry will be much more sensitive to the WEEE legislation (introduced previously several times), and a purely industrial organization will focus more, for instance, on costs to be paid to satisfy the legal constraints (represented below by the indicator "Total legal spending" related to some variables). Before proceeding with the definition of the indicators, is necessary to dwell on the centrality of this objective within the Green IT BSC. In fact, as will be shown by the cause-effect chain part (see paragraph 5.6), the fulfilment of this goal is caused by many factors taken into consideration in the lower levels (especially in the "Infrastructure Perspective") and has consequences not only in purely monetary point of view, but also as a marketing tool. In other words, it causes not only the avoidance of financial penalties (or eventually the bonus for superior performances), but also, with its achievement, the organization goes towards the improvement of its public perception and in general of all stakeholders. Finally the "IT can play a significant role in streamlining how a company collects and processes the data that they need to be able to submit in order to show that they are in compliance" (Jim Anderson, Blue Elephant Consulting, 2011). A further example of the vast impact of EU directives (WEEE and RoHS in particular) refers to a study on the Chinese market, conducted in 2008, by West LB (an European commercial bank based in Düsseldorf). They affirm that "the European standards set by the WEEE and RoHS directives have a worldwide impact, which is reflected in Chinese trade statistics: the Electronics Imports & Exports Corp. indicates that products falling under the directives account for about 70% of the country's export to the EU market".

- INDICATORS

  - TOTAL AMOUNT OF FINANCIAL PENALTIES:

first, it is necessary to introduce a general indicator to assess the situation against all the rules in force concerning sustainability in general. Although not specified in the name should relate to the indicator parameters that indicate the size of the organization. So, as already done in other areas, it is estimated, for example, with the amount of penalties per employee, or in terms of revenues. Within this indicator is included a very general answer to the question: "how bad the company works against the environmental-related laws?" The particularity of this indicator is that it is not easy to identify how and where to act to improve it. As mentioned in the paragraph that introduces the objective, there is a lot under him. So it is a greatness that summarizes many of the environmental performance in terms of infrastructure, behaviour and culture, and also in terms of processes. From an high level

point of view, it is also interesting to include the financial bonus from governments, given to the company for eventual superior performances towards the environment. Hence could be useful to calculate the:

- NET BALANCE BETWEEN FINANCIAL PENALTIES AND BONUS:

in this way, the question that we try to answer becomes more general. In fact are also considered the positive actions implemented by the organization. It might be thought that it's enough this indicator for the overall assessment that there has set out to do. But in my opinion, it is preferable to emphasize the negative aspects, rather than what works well.

- FREQUENCY OF COMPLIANCE REVIEWS:

here it is assessed how much the organization pays attention the regulatory compliance. The indicator can be expressed in days or weeks depending on the context. But is obvious that to a continuous revision corresponds a better compliance of the laws in force, and greater sensitivity to the same.

- REGULATORY COMPLIANCES ON TIME:

it aims to calculate the percentage of regulations met by required date. Of course, this indicator has to be maximized. While the previous indicator was to assess the sensitivity of top management, this one aims to assess the internal efficiency against the law. A good percentage is synonymous of flexibility, a necessary feature for companies that pursue sustainability goals. This measure was introduced because many of the laws in this area set deadlines to achieve certain levels of performance. Sometimes are set up some milestones in a route, such as emission reduction, which can last even up to a few decades. Obviously the failure to meet these deadlines results in disadvantages for the company. The assessment of internal efficiency in this field can get a little more particular. It is interesting to integrate this measure with:

- AVERAGE TIME LAG BETWEEN NEW REGULATION AND INITIATION OF REVIEW:

it is represented by the time lag between the publication of a new law or regulation and initiation of compliance review. The unit, of course, is time and the direction of the indicator, obviously, goes towards its minimization.

- TOTAL LEGAL SPENDING AS % OF REVENUES:

it is the total legal spending expressed as a percentage of company's revenue. Here spending includes internal costs such as compensation and facilities as well as its external costs such as outside counsel and other service providers. As said, regulatory compliance is a critical concern for many organizations that pursue sustainability goals. However, implementing the proper security controls and demonstrating compliance can be very costly. Hence, the increasing compliance pressures and costs are a material concern for companies is reflected by the increased activity of industry initiatives. One example is “the recent teaming-up of the ‘Electronic Industries Alliance (EIA) and the ‘Electronic Components Certification Board’ (ECCB) to tackle the growing environmental compliance costs affecting the electronics industry in the US” (“Green ICT”, Hendrik Garz, 2008).
In order to provide some benchmarks, most law departments in U.S. companies of $500 million of revenue or more, run between 0.25 percent and 0.75 percent of revenue.

5.4.3 Reduce carbon footprint:

this issue refers to the reduction of the amount of technology greenhouse gas emission and

its carbon footprint for conducting the operational processes across the extended enterprise. It could be seen as the core of the Green IT strategy, together with the objective of "reduce power consumption" (see paragraph 5.2.1). In this measure are summarized most of the actions previously presented.

- INDICATORS

  - OVERALL GHG EMISSIONS:

this is often considered as the best approximative measure of the carbon footprint. As said in chapter 2, there are many points of view from which analyse this issue. Has been already provided a brief description of the two main instances: the organizational footprint and the product's one.
Anyway, calculating the GHG emission is not as simple as working out the gas and oil use, it covers all aspects and impacts of an organizations' operations, and also might be the first step in a program to reduce emissions.
Before introducing the unit, must specify that the ecological footprint refers to the six greenhouse gases defined under the Kyoto Protocol (adopted in 1997 and entered into force in 2005): Carbon dioxide (CO_2), Methane (CH_4), Nitrous oxide (N_2O), Hydro-fluorocarbons (HFCs), Per-fluorocarbons (PFCs) and Sulphur hexafluoride (SF_6). A carbon footprint is measured in tonnes of carbon dioxide equivalent (tCO_2e). The carbon dioxide equivalent (CO_2e) allows the different greenhouse gases to be compared on a like-for-like basis relative to one unit of CO_2. CO_2e is calculated by multiplying the emissions of each of the six greenhouse gases by its 100 year Global Warming Potential (GWP). In particular, the Carbon dioxide is the easiest gas to measure. For example, the Slate Magazine affirms that "when a unit of fossil fuel is combusted, it emits a predictable amount of CO2". In fact the poundage of carbon dioxide emitted depends in large part (in this instance) on the composition of the fuel.
Hence, GHGs can be measured by recording emissions at source by continuous emissions monitoring, but are also proposed other ways. The main example refers to the Department for Environmental Food and Rural Affairs (U.K.). They aim to measure the GHG emission by estimating the amount emitted by multiplying activity data (such as the amount of fuel used) by relevant emissions conversion factors. These conversion factors allow activity data (e.g. litres of fuel used, number of miles driven, tonnes of waste sent to landfill) to be converted into kilograms of carbon dioxide equivalent.
One way to effectively measure it could be involve a specialized company. An example could be the "Greenhouse Gas Protocol Initiative", born by the partnership between the World Resource Institute and the World Business Council for Sustainable Development, that is "is the most widely used international accounting tool for government and business leaders to understand, quantify, and manage greenhouse gas emissions".
As underlined several times, an appropriate measure of the carbon footprint allows an organization to set an effective communication to the various stakeholders, and it is needed because can provide a data (or multiples data) that summarizes the overall situation towards the environmental sustainability.
Finally with the advent of the Kyoto Protocol, is now mandatory for every nation (that adopted the protocol) to publish their emissions. Having these data available, can be derived other indicators, as the percentage, which indicates how much the company taken into account is "well behaved" if compared to its own country. An example might be:

  - COMPARED IMPROVEMENT:

in this case the idea is to relate the percentage improvement over the previous year (or the preceding two years) of the company with the entire nation. Obviously, if the indicator is

equal to 1 the company behaves exactly like the average, and more is greater than 1 and more the company is somehow "virtuous" in this way. This may also be useful for marketing policies as easily understood by all audiences. In order to provide a benchmark, the Netherlands Environmental Agency has published in 2005 the "GHG emissions of countries in 2005 and ranking f their per capita emissions". The best was China with 5.8 tons of GHG per capita, immediately followed by the U.S.; the reductions were respectively of 17% and 16%.

– CORPORATE REPORT:

here are included the majors standards for measuring the environmental impact of the overall enterprise takes into account. Hence are proposed three different corporate report; because of their breadth, they will be also used as indicators for the evaluation of other objectives within this perspective. Below is proposed a brief description of the three most important for completeness and prevalence. Later they will be cited again, and will refer to this description.

- ISO 14001: it is the most important; was launched by the International Organisation for Standardization in 2004. Normally is not mandatory, but is the result of a choice in order to improve the environmental management. In fact it is a standard that establishes requirements for environmental management for any organization. It should be noted that this provision does not validate nor does it show a low environmental impact. In fact, it is intended to prove that the organization has certified an appropriate management system to monitor the environmental impacts of its activities, and seek the continuous improvement in an efficient, effective and sustainable way. Are listed inside the specifications on the basis of which company will be assessed for the environmental certification. This standard is "based on the Plan-Do-Check-Act methodology" (PDCA), (Standards Australia/Standard New Zealand, 2004). The PDCA is "an iterative four-step management process" (Wikipedia) typically used in businesses and particularly for continuous improvement processes. Briefly it is a successive cycle, in which in the "Plan" phase are established the objectives consistently with the expected output, in the "Do" one is included the implementation of the new processes, preferably in a small scale in order to test the solutions and collect data for the next step; than in the "Check" step the new processes are measured and compared with the expected results. Finally in "Act" there is the analysis of the differences between the expected results and the effective ones, and are identified the causes; so, depending on the outputs are refined the main objectives (once again the "Plan" step).
- EMAS: the Eco Management and Audit Scheme (EMAS) is actually based on the previous one, but it has a huge degree of adoption too. It was first released by the European Community in 2001, and in 2009 was awarded its third version. Its goal is to encourage improvement of environmental performance of organizations by: introduction and activation of EMS (Environmental Management Systems); auditing, in sense of objective, periodic and systematic assessment of those systems; information on environmental performances and communication to stakeholders (already assessed in the "Stakeholders Perspective").

  Adhere to the EMAS certification means meeting the key indicators covering: energy efficiency, efficient use of materials, consumption and use of water, waste management, biodiversity and emissions. In the "Environmental Statement" for each key indicator should be specified the absolute value and a compared value. The latter is represented by the absolute value compared to a parameter that, according to the business, the size of the organisation, or the emission, can be: the size of the company expressed as the total number of the employees, the total annual gross value added, or for instance the total

annual physical output. The statement is evaluated annually by an accredited verifier, as well as the compliance of the EMS.

- GRI: the Green Reporting initiative was launched by the U.S. based non-profit CERES (Coalition for Environmentally Responsible Economies) and by the Tellus Institute with the support of the UNEP (United Nations Environment Program) in 1997. "GRI Guidelines are regarded to be widely used. As of January 2009, more than 1,500 organizations from 60 countries use the guidelines to produce their sustainability reports" (GRI official website). In fact it mainly produces standards for ecological footprint reporting. For this reason this measure will become fundamental in the objective that refers to "auditing, monitoring and reporting" (see paragraph 2.4.3). Hence, it seeks to make sustainability reporting by all organizations as routine as (and comparable to) financial reporting. Then it allows organizations to measure, track and improve their performances in the environmental issue, as well as helping them managing their impacts, their sustainability reporting, promoting transparency and accountability. The current framework in force the third generation of the GRI, called the "G3", launched in October, 2006. The Guidelines are applicable to every companies from the smallest ones, to the large multinationals and the public sector. Particularly, it includes two main components. First of all the principles, with which they aim to support the reporting process, defining its content, its quality and giving suggestions on how to set its boundary. Here are also included those such as materiality, stakeholders inclusiveness, comparability and timeliness. Finally the second main component refers to the items disclosure; so, it includes disclosures or management of issues, as well as performance indicators themselves.

These corporate reports proposed are a great way to assess and manage some objectives in this perspective. Their veracity is demonstrated in first place by the reliability of the issuers, and then by the large amount of accessions around the world by both small and medium enterprises and multinationals.

– HAZARDOUS WASTE RATING:

this indicator takes up a theme already treated in the first perspective of the Green IT BSC (Infrastructure), the problem of toxic wastes. In this case, however, the approach is quite different. Actually, wastes here are classified and separated into four different levels, and for each level is associated a kind of appropriate landfill. Hence, its continuous monitoring allows a better process of disposal at landfills. Indeed, there is available a standard classification for those landfills in terms of capability and facilities. Going on, it is definitely a method which differentiates between hazardous waste that is "fairly" or "moderately" hazardous, and others that are "very" or "extremely" hazardous. As said it also says the class of hazardous waste landfill in which that waste should be disposed. Levels are as follows:

Hazard rating	Risk	Type of landfill
1	Extreme	H:H
2	High	H:H
3	Moderate	H:h
4	Low	H:h / normal landfills

Table 7: Hazardous waste rating; source: Budget Waste;

In this tab a “H:H” landfill is more stringently designed, operated, and monitored than a “H:h” one. So, due to the extremely high design standard and permit conditions, “H:H” landfills are the only ones facilities that are allowed to accept high levels of hazardous wastes.

– LEED (LEADERSHIP in ENERGY and ENVIRONMENTAL DESIGN) RATING: as announced in the introductory part of this perspective, is here introduced this standard indicator that recognises Green Buildings to meet certain objectives. In particular, it provides a set of measurement standards for evaluating environmentally sustainable buildings. Since it was first drafted in 1998, LEED “has grown to include more than 14,000 construction projects in more than 50 U.S. states and other 30 countries covering 99 km ² of developing areas” (“Green Buildings by the Numbers”, USGBC, 2008). As said in chapter 2, “according to this standard, companies could achieve a lower overall impact on the environment and could also decrease the costs of the building owners. Hence Green Building leads to reduce costs and meet growing social demands”. Regarding the functioning of the evaluation are identified seven key areas: sustainability of the site, efficient water management, energy and atmosphere, materials and resources, indoor environmental quality, innovation in the design, and regional priorities. To each of these areas are associated subcategories, in the form of requirements to be met. Each of them has an associated score, and, for every requirement met, these scores are added together. Consequently, as indicated in the following first table, each macro-area has a maximum score. Finally adding the scores of the areas is obtained final score. There are 110 possible points and buildings can be classified into four different skill levels, as shown in the second table:

AREA	MAX SCORE
Sustainability of the site	26
Efficient water management	10
Energy and atmosphere	35
Materials and resources	14
Indoor environmental quality	14
Innovation in design	6
Regional priorities	4

LEVELS	POINT RANGE
Certified	40 – 49 points
Silver	50 – 59 points
Gold	60 – 79 points
Platinum	80 points and above

Table 8: Green Building by the Numbers; source: USGBC, 2008;

As a last clarification, must be said that the LEED protocol was presented for its completeness and its coverage. However, this protocol is used in mostly American countries

(USA, Brazil, Canada, Mexico, India), while in other states are used different standards. To provide a few examples there are: “Green Star” (in South Africa, New Zealand, Australia), “CASBEE” (in Japan), “HQE” (in France), “Protocollo Itaca” (in Italy), “BREEAM” (in the United Kingdom), and many other.

5.4.4 Future orientation and development:

This goal more than a single process assessment aims to impose a particular approach to innovation. To explain it, was taken a sentence written by S. Hart in 1995. Hence, it consists of “hardware and software innovations associated with green product or processes, including innovation in technologies involved in energy conservation, anergy alternative research, pollution prevention, waste recycling, green product design, and corporate environmental management” (S. Hart, “A Natural-Resource-Based View of the Firm”, 1995). So, as previously argued, organizations can increase the productivity of their resources via eco-innovations. In general innovations can be viewed as “repurposing, improving, or renewing existing ideas and practices that need to be understood, particularly the correspondence between new technology ideas and corresponding new practices” (F. Hewis, “Building Innovation for Sustainability”, 2004). According to this definition of innovation, eco-innovation has been broadly defined as “the process of developing new ideas, behaviours, products and processes that contribute to a reduction of environmental burdens or specified objectives of ecological sustainability” (K. Rennings, “Redefining Innovation – eco innovation research and the contribution from ecological economics”, 2000). Consistently with these definitions, this goal should be evaluated in several aspects. First of all, to pursue this approach, it is required a strong strategic commitment towards sustainability, and a great internal awareness on the Green IT issues. These aspects have already been discussed in the previous perspective, and their role in achieving this goal will be clearer in the section on the cause-effect relationship (see paragraph 5.6). In fact, both will be the direct cause of an orientation to the future, at this level. Here the indicators will be concentrated on the R&D (Research and Development) phase.

- INDICATORS

  – NUMBER OF ECO-INNOVATIONS:

a definition of what eco-innovations are has been provided in the introductory part of this objective. So, in other more general words, it can be seen as something that contribute to the sustainable development, or to reduce environmental impact. Thus, this measure aims to quantify the effort and the actual effectiveness of the department of research and development orienting towards the future. Should be also specified that it may be related to a product, to a service, but also to a process, or to a new way of working.

  – NUMBER OF GREEN PATENT:

I think there is a significant “promotional” statement by Gary Locke, the U.S. Commerce Secretary, which explain the general opinion on Green Patent. He said in fact that “American competitiveness depends on innovation, and innovation depends on creative Americans developing new technology. By ensuring that many new products will receive patent protection more quickly, we can encourage our brightest innovators to invest needed resources in developing new technologies and help bring those technologies to market more quickly”. To be eligible, patents must materially contribute to environmental quality, finding or developing renewable energy resources, improving energy efficiency or cutting GHG

emissions. It is quite obvious that a large number of green patent contributes to a greater future orientation, as well as to a greater effectiveness of the internal R&D.

- PERCENTAGE OF BUDGET ALLOCATED TO NEW R&D:

this is perhaps the indicator that best summarizes the organization's commitment in pursuing this objective. However, even here it is hard to find a comparison. In fact, there is not an optimal level in advance. For example some start-ups may have a larger budget for R&D initially, then for an extended period may keep that percentage and, as the company grows, so does their budget, meaning either the percentage itself can grow large. However, a term of comparison can be found on the previous years in the same company, but this time not as the percentage of budget but as the absolute amount. This is done to eliminate the element resulting from changes in the budget (even if in this case loses a bit of meaning why the indicator is calculated). Anyway, to provide a reference, Wallace Jackson, Multimedia Producer at MindTaffy Design, said “the figure could be around 8%”.

5.4.5 Develop an environmental and social risk mitigation plan:

As introduced in chapter 2 (see paragraph 2.3.7), for a company, in order to develop a risk mitigation plan, is necessary to profile the sustainability risks in its organization through its value chain. Risks relating to the environment can be divided, by a first approximation, into two macro areas: environmental risks and social risks. The firsts refer to sustainable practices in production and procurement processes, and to the effective compliance of all stakeholders with sustainability norms. Instead, the social risks are identified on a sort of adherence to human rights in all business operations, and on the impact on stakeholder community. For assessing this objective are proposed three measures. Has not been entered on the statistical calculation of risk, but the measures provided, although qualitative, are standard and with a high level of usage in practice.

- INDICATORS

- CORPORATE REPORT:

as underlined in the first objective in this perspective, this indicator is useful in order to manage and assess various targets. As mentioned above the most important for completeness and prevalence are the ISO 14001 standard, EMAS and GRI. A brief description has already been provided (see paragraph 5.4.3).
A small deeper can be done in this case through the illustration presented in the next page;
As can be seen, the corporate environmental reporting includes two main categories, one referring the “production” (seen as the conduction of the overall operations), and another that considers the financial side. As written below the figure, the latter will be treated and analysed in the next and last perspective, while the sustainability one is responsible of considering issues coming from the “energy and material accounting”.

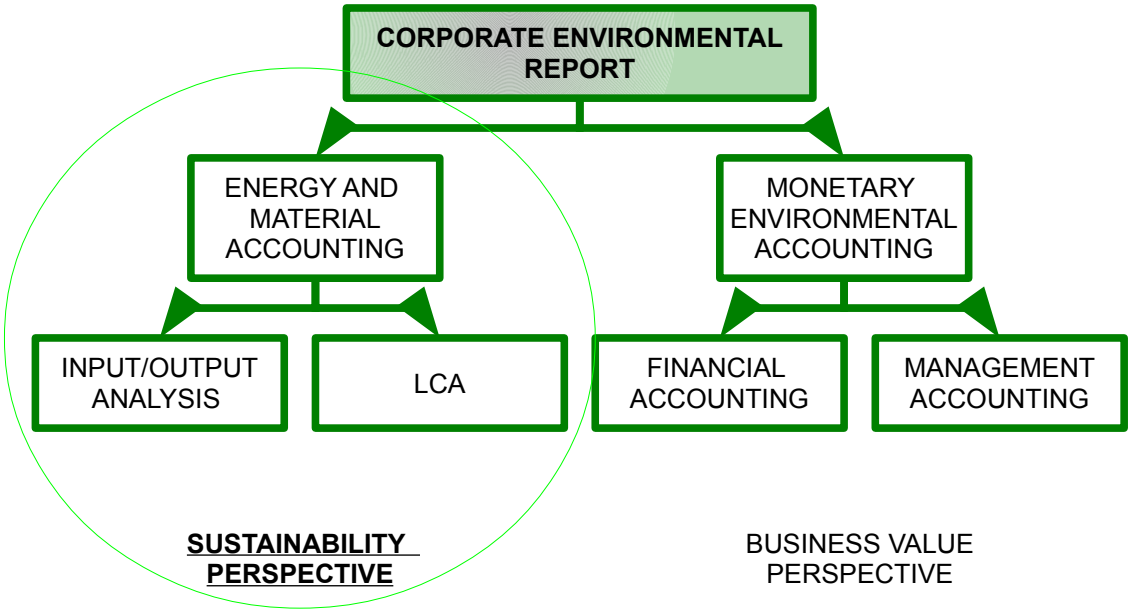


Figure 11: Corporate Environmental Report;

– ENVIRONMENTAL IMPACT ASSESSMENT (EIA):

the IAIA (International Association for Impact Assessment, U.S.), defines an environmental impact assessment as "the process of identifying, predicting, evaluating, and mitigating the biophysical, social, and other relevant effects of development proposal prior to major decisions being taken, and commitments made". It began to be used in 1960s, but Stephen J. (2006) said that it is practised today, but is being used as a decision aiding, rather than a decision making tool. The main objective of the EIA is to ensure that environmental aspects are effectively take into account and incorporated into the development decision making process, and "to promote development that is sustainable and optimizes resource use and management opportunities" ("Principles of Environmental Impact Assessment Best Practice", IAIA 1999). In particular it is made of basic principles, in which it has to be applied, and operating principles as best practice to follow in order to reach environmental sustainability and minimize the environmental risks. As done previously for other indicators, this is not a numerical measure, but a standard methodology. However, it has been included as a guide that is structured and consolidated towards the minimization and mitigation of environmental risks related to technology.

– RISK TECHNOLOGY ASSESSMENT:

in order to provide a complete evaluation of the IT risks, is interesting consider the GAIT (Guide to Assessment of IT risk), developed by the IIA (Institute of Internal Auditors). Its last version was delivered in January 2007. the GAIT methodology involves the following steps:

i. identify the critical IT functionality, the IT General Control (ITGC) process: change management, deployment, access security, operation, following a top-down and a risk-based approach;
ii. identify the significant application where ITGC need to be tested, that with a significant financial impact.
iii. identify ITGC process risk and related control objectives;
iv. identify the key ITGCs to test that meet the control objectives;

v. perform a reasonable personal review.

5.4.6 Customers and investors loyalty:

according to studies in behavioural finance, investors' predilection is to judge the companies as better investment opportunities because they are perceived as highly reputed might be a mistake. In current studies, corporate reputation is investigated as a determinant in the formation of risk and return expectations. “Investors tend to assume that good investment opportunities come from “good” companies, that is from companies with a high reputational rating” (Shefrin, H. “Behavioural Finance”, 1995). From the organizational point of view, it may be beneficial when individual investors keep their shares on a long-term basis, mostly if it is implementing investments with return deferred in the future, as the case of a Green IT strategy. Leaving detailed analyses to future research contributions, the investor loyalty leads to stable relationships that reduce the risk of a hostile (in the sense of unwanted) takeover, to less volatility in share prices, as mentioned, to the possibility of implementing long-term strategies instead of quarter-based activities, and to a reduction of costs induced by investor relations. Among others, “satisfaction with investment outcomes (for example the fulfilment of investor expectations) and corporate reputation are interpreted as determinants of investor loyalty” (Macmillan, P. “Corporate Reputation review”, 2004). Concerning the customers, a Gartner study (2004) found that “organizations with loyal customers had profits up to 60 percent higher than those of competitors and were twice a likely to exceed the forecasts of financial analysts”. Hence, in this field loyalty is represented by the percent of “current owners that repurchase the same brand. Those who don’t repurchase the same brand are defectors and they represent lost business” (“Customer Retention Rate, What does it mean?”, John Sevec, June 2011).

- INDICATORS

  – CUSTOMER LOYALTY:

In order to measure the customer loyalty is proposed the Apostle Model developed by th Harvard Business Review. The model is shown in the figure at the top of the following page. Consistently with the figure, to measure the attitudes that result in this model, customers are asked to rate their overall satisfaction on a scale of 1 to 10 (horizontal axis) and their likelihood to continue to do business with you on a scale of “Definitely Will” to “Definitely Will Not” (vertical axis). In this model, “Defectors” are defined as anyone who answers the satisfaction question with a score of 6 or less and reports that they definitely or probably will not continue to do business with you in the future. Clearly the goal is to have as much“loyalists” as possible.
Finally this model can also be used (and it is likely to be used) for a market segmentation. This topic is not covered in this discussion, but it has to be said that the model also helps to formulate strategies to customers. In order to provide some examples, the “loyalists” must be “understood, served, protected”, and the company should “focus on developing communities for (and with) them” (Wendy Close, Sales force). Furthermore, concerning the “hostages”, the management should “focuses on strategies that can turn them into loyalists by understanding and addressing their issues before they spread their dissatisfaction to others or abandon your company”. For the “mercenaries”, who are highly price-sensitive, again Wendy Close recommended to “focus on communicating the benefits of your product or service that show they’re getting good value overall from your company”. And finally for the “defectors” to “ Focus on strategies for releasing these customers with good will intact or

implement a well-designed customer win-back program".

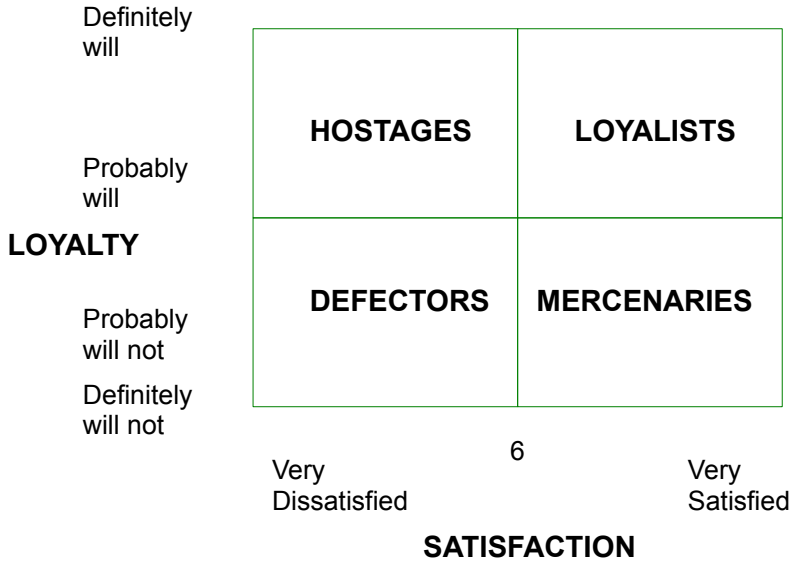


Figure 12: Apostle Model; source: Harvard Business Review;

- RETENTION RATE, and
- DEFECTION RATE:

in his book "The Loyalty Effect", Fredrick F. Reichheld (1996) puts forth the thesis that "the loyalty of customers and investors to a business are the essence of success". And again, "In order to keep track of their loyalty you must carefully measure the retention and defection rates". The advantages of these types of measurements are that they measure both the internal and external reality referred to the company. They offer an enormous ethical advantage and so are easy to communicate. They fit the criteria in that they are well within management's control and almost always subject to improvement. Furthermore, the links between loyalty and financial results are very well documented.
Entering in particular, the retention rate is used for determining the percentage of customers, or investors, who remain active in the period under review. The indicator is expressed as a percentage, and are not required special statistical calculations to arrive at the result. In fact, it is just needed to know the number of customers at the beginning of the period under review, the number of customers acquired during that period, and the number of customers at the end of the period. Must be said that from this data is also possible to calculate the CLV (Customer Lifetime Value), but it is not suitable for the model, as it is more a marketing measure.
The customer defection rate, contrariwise, is the rate at which customers defect or stop the usage of products of a company. Businesses with high defection rate, would be losing their existing customers. The measure is somehow complementary to the previous one. The calculation (also this time expressed as a percentage), however, is carried out on customers lost during the period under review, compared with customers at the beginning of the period. Must be also reminded that the calculation can be done also considering investors, for a more financial assessment.

- FINANCIAL RETENTION RATE:

this indicator differs from the previous one as it relates to investors, and has a purely financial perspective. In fact, it is defined as the proportion of net incomes that is not paid in

dividends. So, the Financial Retention Rate (FRR) is:

$$FRR = \frac{N.I. - DIV.}{N.I.}$$

Where:
N.I.: Net Incomes, earn after taxes;
DIV.: Dividends.

Hence, for examples a company earning $90 million after taxes and paying dividends of $15 million, it has a retention rate of $75 million / $90 million, or 83.3% (it is often expressed as percentage). A high retention rate makes it more likely a firm's income and dividends will grow in future. So, are privileged long-term investments, which are the essential features in order to obtain investors loyalty.

5.4.7 Improve de-materialisation:

as previously discussed, in a Green IT strategy particularly important is the de materialisation issue. The process is quite simple; as in most of the cases it is necessary to start from a careful analysis of the "as is" situation, hence of the activities with a high level of detail. From all of those activities must be then identified those on which action in this way can be potentially taken. So, with an evaluation of the current and potential impact of activities that can be dematerialised there are some best practices that can be followed, such as: use virtual rather than tangible products, reducing physical mail and paper use, use e government solutions as much as possible, and increase the use of video-conferencing and tele-working (topics analysed from the technological point of view in the infrastructural perspective, see paragraph 5.2).
There are some official statistics on de-materialisation because of its potential to improve productivity. For example, a possible "sub-objective" could refer to the change in paper production and physical mail because of the potential role that the IT can play in the reduction of the need of paper. In fact, the production and use of paper products is very high, despite the speedy growth of diffusion of the personal computer. In fact "the consumption more than doubled between 1983 and 2003, with most of the growth occurring during the first of the two decades. As the growth rate of consumption (139.3%) outstripped the rate of growth of the population (23.6%), per capita consumption increased by 93.6% to 91.4 kilograms in 2003. This is equivalent to almost 20,000 pages per individual, enough to cover an area of almost 1,200 square metres" ("Our Lives In Digital Times", 2006, G. Sciadas).
Some other interesting studies, mentioned above in this paper, are about the use of tele-working in businesses, use of video-conferencing, e-commerce, and trends in paper use and changes in the volume of physical mail.

- INDICATORS

  - NUMBER OF PAPERS PAGES USED PER EMPLOYEE:

This indicator has been introduced in order to measure effectively the paper consumption in an organization, and to allow management to set up a goal to reduce paper consumption as well. Connected to the problem of paper consumption, there are several tools and procedures that can be adopted by the company. To provide some examples, reference is made to print the paper on both sides, the utilisation of electronic means of storage, or the adoption of electronic means of sharing, such as FTP files, Power Point, electronic meeting minutes, and

so on. The time range for this indicator is supposed to be per year.

- PERCENTAGE OF INVOICES THAT ARE ELECTRONIC:

This opportunity, of electronic invoicing, has not yet been discussed in this document. “European companies exchanged between more than sixteen billion bills per year” (Campomori, F. “Electronic Invoicing and electronic storage”, 2005). And again, “the management of these huge all-electronic document flows in and out will have a significant impact on businesses in terms of cost savings, productivity gains, improved quality of information”. The complete de-materialisation of invoices is now finally possible thanks to new laws and regulations in force by early 2004: the European Directive on electronic invoicing and electronic storage of documents on the legislation relevant information for tax purposes have in fact completed the picture legal reference. In short, the process of electronic invoicing consists to manage the entire life cycle, completely de-materialised, of invoice document, from the issue through the transmission up to conservation. It goes without saying that it is also essential to become familiar with the tools necessary for the application of new digital processes. And that is crucial to understand what is the basic technical operation and, above all, know the value of legal tools such as computer documents, digital signature, the certified mail, and so on.

For completeness it is reported a current of thought in which is believed that a process like this brings very high costs, if compared to the benefits. In particular, it is proposed an example of an Italian Public Administration engaged in a project of re-engineering of recorded flows. The public body is medium in size (about 100,000 documents registered each year). The agency spends 80,000 € per year for the purchase of paper, 40,000 € for the delivery of postal mail and registered mail, and 20,000 € per year for internal mail. These are important numbers that are pushing the administration to see alternative routes. The de-materialisation process would allow, as seen, a workflow streamlined, fast, and also to see who does what and with what timing. However, legislative obligations are quite restrictive. In particular, concerning the certification of protocol systems, storage systems and digital signature and "have costs that can be depreciated only in different financial years”. An estimate of the costs that the agency will incur as a result of the proposal is:

- update software for logging incoming and outgoing calls and archive management: 30,000 €;
- 2 servers (one backup and disaster recovery) for the management and storage of document images: 100,000 €;
- 217 digital signatures (in Italy are valid for 3 years): 8,000 €;
- 20 network scanner for rent for 2 years, in order to allow a proper management of the transition phase: 43,200 €.

Then the total expenditure is 181,200 €, for this organization. Also must be considered that during the transitional phase is not possible to knock down the 100% of the traditional costs. So the payback time is estimated in this case more than 5 years.
The trick that can be drawn from this example is that there should be solid financial structure of the company to undertake an investment of this type. However, the advantages are obvious, even if deferred over time.

5.4.8 Facilitate recycle reuse and disposal at the end of the IT life cycle:

This objective aims at preventing the impact of IT, and toxic substances linked to it, at the

end of its cycle of life. For non recourse in unnecessary repetition, reference is made to read the overview part for further clarification and information (paragraph 2.3.5). It was presented "the 4RS approach"; it includes the processes of Reducing, Reusing, Refurbishing and Recycling, and it is clear how each component helps to decrease the quantity of material discarded.
Some data are available from Households and Environment Survey run by Statistic Canada in 2006. In this survey was examined the disposal of ICT with some response categories:

- put into the garbage;
- still had them in 2005 and did not know what to do with them;
- returned to depot or drop-off centre;
- returned to supplier;
- donated or gave away;

This survey was given as an example to indicate what is usually assessed in this way.
Anyway, in this part the goal is to assess the “4Rs Approach”, both from an environmental point of view and a financial evaluation, as well as the steering committee towards this issue.

- INDICATORS

  - DISPOSAL COSTS:

This measure seems quite general, but turns out to be a good indicator for two reasons. First of all, it gives the concrete idea of the impact of waste disposal, and secondly, especially when compared in different periods, can be used as a measure of the impact of new decisions and initiatives. For giving an idea, “in some Pennsylvania communities, the cost for disposal of municipal waste Exceeds $ 40.00 per ton. This does not include the cost for collection and transportation of the waste” (from Department of Environment Protection of Pennsylvania web page). Switching to the IT field, a Gartner research (2003) showed that a typical company “incur net disposal costs of between $85 and $136 per PC, depending on the disposal method”. Of course, to reduce this expense, the best way is to implement as much as possible the “4Rs” approach, presented earlier (see paragraph 2.3.5).

  - LIFE-CYCLE ASSESSMENT (LCA):

The UNEP (United Nations Environmental Program) in its 2004 report “Why take a life cycle approach?” said that “it helps us to find ways to generate the energy we need without depleting the source of that energy and without releasing greenhouse gases that contribute to climate change”. The main goal here is to optimize the utilisation of IT (already become green) during its life cycle, from its production through its usage to its disposal. Depending on the sectors in which it has been developed, the literature proposes several different stages of a product's life. To identify the critical areas, i.e. where are needed action plans for interventions, I have analysed numerous examples. The chart in the next page, is a general revision of those instances with a subsequent contextualization into the green IT topic.
In my opinion this chart are included the main IT's life stages to consider consistently with the definition given above and with the description of the “4 Rs” approach (see chapter 2).
The procedure in which the LCA is applied, follows the ISO 14040 (2006) series. The UNI EN ISO 14040 is the main standard and specifies the basic structure of the LCA, the principles and requirements for conducting the study and then reporting it, but not entering into the merits of specific details of assessment techniques. The definition of the objective of the LCA and its boundaries is discussed, together with the subsequent analysis phase of the inventory flows in and out of the system, in the UNI EN ISO 14041. It is at this stage, therefore, that embodies the LCA, going first to identify the reason for which the analysis is

conducted, identifying and then build the system around which the study is conducted and all the relevant data are analyzed.

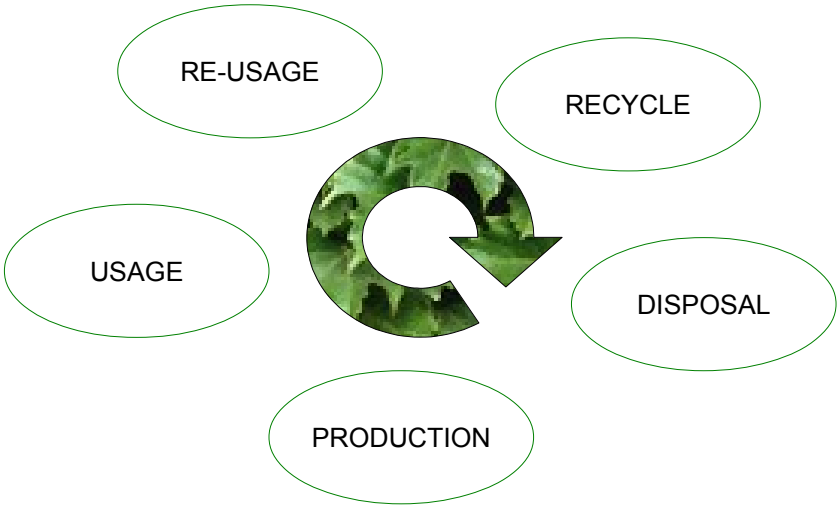


Figure 13: IT life cycle assessment;

Among the benefits of using this technique, there is a general improvement of the relations with the institutions, the possibility of immediate comparison between different products, and a more effective communication with the stakeholders.

- WASTE DISPOSED PER AMOUNT OF PRODUCT MANUFACTURED:

As suggested by its name, this quantity makes sense only for manufacturing enterprises. It can be a good basis for comparison with other companies, and with prior periods. Indeed, it is easy to measure and a reduction in value is certainly due to a program of reuse or recycling. Here wastes are expressed as weight (Kg or Tons) and product as number of items manufactured, that means that are included also discarded products.

- WEIGHT RECYCLED AS % OF PAST SALES:

Currently, there is no industry standard way to measure the effectiveness of a company's recycling programs. Dell has proposed a simple measure, assume a seven year product lifetime, and measure the percentage of the total weight you recycle each year compared to the total weight of what you sold seven years earlier. This makes sense to me, and has the added advantages of clarity and simplicity. The unit type is percentage, and the goal, obviously, is to maximize this rate.

5.4.9 Comments:

In conclusion I have provided eight objective with which achieve the maximum performances in the strategy and the internal processes, towards sustainability. In order to comply a continuous improvement in each objective are provided throughout 30 indicators. As underlined several times in the introduction to the model and in the previous perspectives, the usage of each indicator, and also focusing on some objectives rather than others, depends strictly from the company and its parameters. Also further entire objectives can be added if it is needed. In this perspective is included the fundamental (for the all Green IT strategy) objective of "Reduce Carbon footprint", which is considered the consequence of almost all the actions described at the lower levels. Finally, it is very

important because it is a sort of bridge between the infrastructure and the stakeholders, and the real business value, the ultimate goal of the Green IT strategy. Objectives as “Improve Public Image” and, most of all, “Investors and Customers Loyalty”, are the first prerequisite for financial success regardless.
Finally, consistently with the structure of this document, in the next page is proposed a summary table of the objectives, their brief description, their indicators, and are provided also the unit of measures.

SUSTAINABILITY PERSPECTIVE			
It is at the third level of the cause-effect chain, and it considers the organizational level, from the process' and strategy's point of view. Within the Green IT BSC, this perspective can be explained as follows: an organisation, once it has developed a green infrastructure, and it has settled inside the correct cultural mechanisms, must pursue objectives at process and strategic level, to effectively capture business value from the Green IT strategy.			
OBJECTIVES	DESCRIPTION	INDICATORS	UNIT
Improve public image	Here it is considered the public perception and reputation of the company under review.	Social survey	score
		Media content analysis	qualitative
		Marketing assessment	analysis
Regulatory compliance	This objective constitutes a strong driver for change. It is assessed the overall organizational behaviour against regulations, and the internal efficiency and effectiveness from both timing and monetary point of view.	Amount of financial penalties	$ / year
		Net balance between penalties and bonus	$ $ / year
		Frequency of compliance reviews	Time
		Regulatory compliances on time	%
		Average time between regulation and initiation of review	Time
		Total legal spending as % of revenues	%
Reduce carbon footprint	It is the core of the model. So far, all the objectives considered into the model can be linked with this one in the cause-effect relationship chain.	Overall GHG emissions	tCO_2e
		Corporate report	Qualitative
		Compared emissions	%
		Hazardous waste rating	score
		LEED rating	score
Future orientation and development	This objective aims to impose a particular approach to innovation. The indicators are concentrated on the R&D, and focused on eco-innovations	Number of eco-innovations	#
		% of budget allocated to new R&D	%
		Number of green patent	#
Develop an environmental and social risk mitigation plan	Here are assessed the environmental and social risks, and the part of the corporate environmental report referring to energy and material accounting.	RTA: Risk Technology Assessment	Score /level
		EIA: Environmental Impact Assessment	Qualitative
		Corporate report	Qualitative
Investors and customers loyalty	The goal is to privilege long-term investments, which are the essential	Apostle Model	Qualitative
		FRR: Financial Retention Rate (investors)	%

	features in order to obtain investors loyalty, and a successful Green IT strategy.	Retention Rate	%
		Defection Rate	%
Improve de-materialisation	It aims to assess the trends in paper use and changes in the volume of physical mail (particularly promoting electronic invoicing).	Number of paper pages used per employee	# / employee
		% of invoices that are electronic	%
Facilitate recycle, reuse, and disposal at the end of the IT life cycle	The goal is to evaluate the steering committee, the internal efficiency, and the financial benefits, by the adoption of the “4Rs Approach.	LCA	Qualitative
		Disposal costs	$
		Weight recycled as % of past sales	%
		Waste disposed per amount of product manufactured	Kg / item

Table 9: Sustainability Perspective;

5.5 BUSINESS VALUE PERSPECTIVE

This is the forth and the last perspective of the Green IT BSC. For a first approximation of what business value is, can be used the definition provided by Wikipedia; it is there reported that the business value is "an informal term that includes all forms of value that determine the health and the well-being of the firm in the long-run". It is not even clear who was the first in history to introduce this concept. A historical analysis is very difficult, because the term "business value" has assumed very different meanings over the years, and still there is not an absolute and a formal definition.
Somebody recognizes Peter Ferdinand Drucker (1909 – 2005) as the first who mentioned this word. Actually he "was an early proponent of business value as the proper goal of a firm" ("Peter Drucker, the man who changed the world", Business Review Weekly, 1997). Nevertheless, the innovation that carries the term is that it frees itself from the common idea that the mission of a company is composed of purely economic and financial variables, but also, as shall be seen below, can be decomposed into several components. Going on with the history, the weak point of Drucker's theory was that "he was sceptical that the dynamics of business value could ever be formalized, at least not with current methods". In other words, his thinking was more philosophical than practical.
A few years later (1985), ran to his aid Michael Porter, with his publication of "Competitive Advantage: Creating and Sustaining Superior Performance". In this book he described for the first time the concept of Value Chain. Thus, he wanted to describe an organization. Indeed, for Value Chain is meant "a model that describes the structure of an organization as a limited set of processes", divided between internal and external.
Over the years dozens of definitions were provided. Roy Posner in his "The Power Of Business Value" affirms that "a value is a belief, a mission, or a philosophy that is really meaningful to the company. An example of business value is: customer satisfaction; another example of value is: being ethical and truthful", to demonstrate its huge pool of application.
In literature can be found different components of business value, and the most important are: customers value (conceived variously as utility, quality, benefits and customer satisfaction), employee value, channel partner value (this will not be considered in the analysis as it is a very particular factor; in fact it is represented by the eventual value that may exists with partners relationships in the same business, and on how a partner value can be critical to a firm's functioning), suppliers value, managerial value, societal value, and shareholders value, maybe the most important, that is defined, for a publicly company, as the part of capitalization that is equity as opposed to long-term debt.

5.5.1 "Financial Perspective" or "Business Value Perspective"?

An important point of this Green IT BSC, was the adoption of this perspective, rather than a purely financial one. I will try in the next paragraph to explain the reasons of this choice.
I incurred in a discussion with a student working on a PhD in IT enterprise architecture, and it was argued that IT was more a cost centre rather than a centre of value. Contextualizing the discussion to this Green IT BSC, the alternatives for the analysis were three: the first was to replace this level with a purely financial perspective; alternatively there was the idea to put this same "Business Value" perspective, and finally we talked about considering this outlook, but at a lower level. The latter option was rejected immediately. In fact can be argued whether the IT can be seen as a cost centre or as a factor of corporate contributor, but this is not the case of this framework. In fact the Green IT, as it has been defined here, is a strategy whose mission is to create value. Therefore, consistently with the definition of the structure of the Green IT BSC, at the highest level of the cause-effect chain there must be a perspective that aims to measure the value. Then the problem

shifted to the decision to adopt a purely financial assessment or, indeed, a perspective that considers the business value. A possible push towards the adoption of a financial perspective has come from the fact that many components of business value have been already considered and calculated in the lower levels. In order to provide an example, in the "Infrastructure Perspective" have been yet developed measures that are performances that constitute a part of the Green IT business value. This issues were treated in the indicators provided to assess the efficiency and effectiveness of the Green IT infrastructure. Performances that have been mentioned are usability, functionality, reliability, and availability. A second reason why I was willing to choose a financial point of view, came from a recent current of thought that can be found in the literature. According to this theory, the business value is just a "buzz word used by various consultants, analysts, executives, authors, and academics" (PaperCamp, "Workforce Diversity"). These people believe that measuring the shareholders value is sufficiently complete to guide decision-making, and all the other forms of value are intermediate to the ultimate goal of create profits.
Finally, the choice of the "Business Value Perspective" has been preferred because this level is affected by various components within the objectives, and not just financial ones (see as an example the indicator "ROM", or the evaluation of the intangible benefits), although sometimes they are more intuitive than quantitative. In other words, even if at first sight the objectives are of a financial nature, they contain additional measures that refer to the business value components previously defined.
Finally it is needed a good level of consistency. While the ultimate goal of a traditional business strategy can be considered "create value for shareholders" (a purely financial point of view), a Green IT strategy, as deliberately stressed several times in this document, aims to "create business value, without compromising the environment". Therefore, in correspondence of what was the definition of the Green IT BSC (see chapter 4), the mission has to be included into the last level, and thus the "Business Value Perspective".
Below are presented the objectives, and the indicators for each of them.

5.5.2 Financial credibility:

This goal will be treated in a little special way. In fact, a substantial part has already been taken into account, in the "Sustainability Perspective" in the objective "Increase Investors loyalty". Here are only provided purely financial information. The set of indicators is also structured in a particular manner. In fact, it is proposed a general indicator and four smaller ones. The general indicator will be a summary measure of the four components. These measures are however considered indicators, because they identify important issues that must be taken into account separately, rather than only, as mentioned, aggregately.

- INDICATORS:

  – COMPOSITE FINANCIAL INDEX (CFI):

the intent of the Composite Financial Index is to provide an accurate measure of the financial health of the company, in a certain instant of time. The name "Composite" is due to the nature of this measure. In fact, it is derived from other financial indexes. This method was first developed by KPMG, Prager, Sealy & Co. "Examining the trend of an institution's CFI score over an extended period offers a more stable long-term view of an institution's financial performance, given fluctuations in institutional conditions, and external circumstances, such as market performance" (Prager, F. J.; Cowen, C. J.; Beare, J.; Mezzina, L.; Salluzzo, R. E.; Lipnick, J.; Tahey, P. "Strategic Financial Analysis for Higher Education", 2005) . In particular the CFI includes four commonly used financial ratios:

- Primary Reserve Ratio (PRR): is a measure of the level of financial flexibility and strength. The measure is obtained by comparing expendable net assets to total expenses. Expendable net assets represent those assets that the institution can access relatively quickly and spend to satisfy its debt obligations. It indicates how long the institution could function using its expendable reserves without relying on additional net assets generated by operations. From a research conducted by the UTSA (University of Texas, San Antonio, U.S.), "a Primary Reserve Ratio of 0.40 or better is advisable to give institutions the flexibility to transform the enterprise. The implication of a 0.40 ratio is that the institution would have the ability to cover about five months of expenses. Generally institutions operating at this level are able to carry on a reasonable level of activities, and appear capable of managing modest unforeseen adverse financial events".
- Net Operating Revenues Ratio (NORR): this indicator represents the component of measure of the operating performance.
- Return On Net Assets Ratio (RONAR): this component aims instead to see the point of view of resources; in fact it is a measure of whether or not the institution's resources are growing. “This ratio, like all the ratios, is better applied over an extended period so that results of long term plans are measured. Long term returns are quite volatile and vary significantly based on the prevailing level of inflation. Therefore, establishing fixed nominal return targets is not possible. Rather, institutions should establish a real rate of return target in the range of 2 – 3%” (KPMG LLP and Prager, F. J.; Sealy, D. “Ratio Analysis in Higher Education-Measuring Past Performance to Chart Future Direction”, 1999). Once again from a UTSA report, it has been affirmed that “a Return On Net Assets Ratio determines whether the institution is financially better off than in previous years by measuring total economic return. A decline in this ratio may be appropriate and even warranted if it reflects a strategy to better fulfil the institution's mission. An improving trend in this ratio indicates that the institution is increasing its net assets and is likely to be able to set aside financial resources to strengthen its future financial flexibility”.
- Viability Ratio: this indicator measures one of the most basic determinants of clear financial health: the availability of expendable net assets to cover debt should the institution need to settle its obligations as of the balance sheet date. In short, is a measure of the ability of cover debt with available resources. In "Ratio Analysis in Higher Education-Measuring Past Performance to Chart Future Direction", also mentioned above, is reported that “A ratio in the range of 1.25 to 2.0 indicates a strong creditworthy institution. However, the level that is 'right' is institution-specific. The institution should develop a target for this ratio that balances its financial, operating and programmatic objectives.

Once each of the four ratios is calculated, the relative strength of the score, or strength factor, and its importance in the mix of creating a composite score, or weight, are computed. Hence, the sum of all these weighted values is the CFI. Usually, the strength factors and CFI score are standardized scores that fall along a scale of -1 to 10. “A CFI score of 3 is the threshold of institutional financial health. A score of less than 3 indicates a need for serious attention to the institution’s financial condition. A score of greater than 3 indicates an opportunity for strategic investment of institutional resources to optimize the achievement of institutional mission” (Council Of Independent Colleges website).

5.5.3 Increase profits:

The starting point of this evaluation must be a complete picture of all benefits and costs of the Green IT strategy. In other words, it is needed an analytical framework of the investments required for implementing the strategy, and the expected returns. How to obtain these data and this framework will be explained in the following two objectives. Anyway, here the focus is only on how to assess the profitability. Therefore we aim to achieve a comprehensive assessment of the strategy from a monetary point of view. It is easy to understand that it is not simple to achieve an accurate measure, even because many aspects are implicitly included, such as:

- technological and infrastructural aspects: is assessed whether the technologies are really effective and, at the same time, if the company has efficient management procedures.
- Organizational aspects: is seen if the whole organization reacts properly to the changes. In turn, are included here managerial, cultural, and coordination aspects.
- Economical aspects: is assessed how much and when the Green IT strategy is profitable for the company.

The indicators proposed are the standard ones. In particular, each of the indicators proposed below, takes into consideration the costs and the benefits, and provide an objective assessment of the economic value. In these measures a very important role is played by th time variable. In fact, like in any investment, returns are shifted in the time, compared to costs. It is therefore used the method of Net Cash Flow (NCF). It is a measure defined as the "balance remaining after deducting cash outflows from cash inflows" (Business Dictionary).

$NCF(t) = CI(t) - CO(t)$ Where: CO = Cash Outflow; CI = Cash Inflows; t = period.

NCF is calculated at each period ("t") of the project life ("t" usually represents a year). What is critical at this point is to make the various periods comparable with one another. Right here are distinguished the two major characteristics of indicators in this objective:

- Discounted cash flow indicators;
- Non-Discounted cash flow indicators.

These two kind of measures will be treated separately.

- INDICATORS:

Discounted cash flow indicators will be presented first. Such ones, have the characteristic to consider the timing of NCF. It is precisely for this reason that those are considered the most appropriate.
The most important are:

- NET PRESENT VALUE (NPV):

this method consists in evaluating the sum total of the NCF, discounted at the time when the analysis is conducted. It is considered the overall lifetime of the strategy, which is up to " t = T ". The formula is:

$$NPV = \sum_{t=0}^{T} \frac{NCF(t)}{(1+k)^t}$$

Of course, the strategy is profitable only if the NPV value is greater than zero. In the

formula “k” represents the discount rate. It is a fundamental rate which varies from company to company. It is the key in order to discount an amount of capital at the desired instant (in the case of NPV, the moment of decision). In particular:

$$k = i + d + f$$

where:

- i: risk-free interest rate. It is the theoretical rate of return of an investment with no risk of financial loss;
- d: risk-premium. It is the particular rate that induces an investor to hold the risky asset, rather than the risk-free. Its value depends on the risk associated with the investment;
- f: inflation-rate. It takes into account the effect of the natural loss of purchasing power of money.

Should be also noted that this indicator can be also used to compare different investment alternatives. In this case is tendency to privilege the most profitable, then the one with greater NPV value.

– INTERNAL RATE OF RETURN (IRR):

it is also called the Discounted Cash Flow Rate Of Return (DCFROR) or simply the Rate Of Return (ROR). It is defined as the percentage return on investment linked to the strategy under consideration. In other words, it allows to compare the return of the project with alternative investments, such as bonds, corporate bonds, or investment funds. In practice the IRR is defined as the rate that nullify the NPV value:

$$\sum_{t=0}^{T} \frac{NCF(t)}{(1+IRR)^t} = 0$$

The criteria required to compare the IRR with the company's cost of capital (k_e). A project is therefore considered profitable if and only if:

$$IRR \geq Ke$$

So, if the return of the project is at least equal to the return of the company required by its shareholders (k_e). Obviously, in comparison with more projects, has to be preferred the one with greater IRR.

– PROFITABILITY INDEX (PI):

it is also known as Profit Investment Ratio (PIR) or Value Investment Ratio (VIR). It allows to classify the attractiveness of alternative projects, with different initial investment. Hence, it is an index that attempts to identify the relationship between the costs and the benefits of a proposed project through the use of a ratio calculated as:

$$PI = \frac{PV\ of\ Future\ Cash\ flows}{Initial\ Investment}$$

Where:

– PV: Present Value, or Present Discounted Value;

A ratio of 1.0 is logically the lowest acceptable measure of the index. Any value lower than 1.0 would indicate that the present value of the project is less than the initial investment. Obviously, as the PI value increases, so does the financial attractiveness of the project.

The focus now is switched on the second category of indicators: Non-Discounted Cash Flow. As mentioned before, these indicators do not take into account the timing of cash flows. However, they offer very important and interesting measures.

- PAY BACK TIME (PBt):

it is defined as the time point in which the returns of the project outweigh the initial investment. Operationally the Pay Back Time os defined as:

$$\sum_{t=0}^{PBt} NCF(t) = 0$$

In short, it allows to quantify in how much time the project is able to cover the investment, but as mentioned, does not take into account the timing of cash flows. An organization should set a target, depending on its characteristics, with which compare the PBt.
It is very interesting, assessing a Green IT strategy, to consider a different application of this same concept:

- ENERGY PAY BACK TIME:

it is referred to energy consumption. In particular it can be defined as the period of time over which the energy savings of a project equal the amount of energy expended since project inception. It is therefore a time indicator that assesses the economic impact of energy-efficiency systems.

- ROM: RETURN ON MANAGEMENT:

in the past, in order to measure the benefits from the IT, was thought to be sufficient to use conventional economic indicators, such as ROI (Return On Investment) and ROE (Return On Equity). The empirical evidence, however, have generally denied this possibility. In fact no one has ever proved the existence of a direct positive correlation (or even negative) between IT investments and returns. From these concepts, E. Brynjolfsson in 1993 introduced the "Productivity Paradox", as "discrepancy between measures of investment in Information Technology and measures of output at the national level" (Brynjolfsson E., "The Productivity Paradox of Information Technology", 1993). A few years later, Paul A. Strassmann, with a career of Chief Corporate Information System Executive since the 70s, tried to deliver an answer to this paradox. In his opinion, the reasons for the lack of a correlation between these quantities are mainly two. First, the complexity in understanding the level of aggregation of costs and outcomes between the various divisions, or rather the difficulty in connecting to the correct spending to the corresponding result. The second reason, according to Strassmann, is that the use of technology is not always smooth. Is therefore interesting his proposal. In fact, he considered only those investments called "MIS" (Management Information System), (the investments are measured within the cost related objective). Thus, Strassmann defined the ROM (Return On Management). This indicator is based on the assumption that the enterprise can be seen as an information-based organization. This enterprise is therefore characterized by a specific productivity. Management is regarded as the scarce resource. Hence, the ROM is defined as the ratio between output and input of management (consistently with the definition of productivity). Then the formula is:

$$ROM = \frac{MVA}{MC}$$

Where:

- MVA: Management Value Added;
- MC: Management Costs.

The ratio is then represented by the value added offered by management compared to the costs that it entails. In his "Introduction to ROM Analysis: Linking Management Productivity and IT" (1996), Strassmann said: "Management Value Added (MVA) is that which remains after every contributor to a firm's input get paid. If MVA is greater than Management Costs (MC), you can say that managerial efforts are productive because the managerial outputs exceed managerial inputs". Should be noted that the management cost is different from the profit. In fact, MC is obtained by subtracting from the profit, the theoretical cost of capital.
Finally, he demonstrated and confirmed the existence of a positive correlation between ROM and investments in Management Information Systems (see IMIS indicator, within this perspective, in the "Reduce Costs" objective, paragraph 5.5.5).

5.5.4 Increase benefits:

Differently from other objectives seen so far in this Green IT BSC, this is not really characterized by a set of indicators. In fact, in this case it is proposed a process of identifying the overall benefits arising from the Green IT strategy. The process in practice can be very complex. First, to allow a subsequent proper analysis of profits, it is essential to give to each of them a monetary value. This is not always immediate. In particular, those benefits that are related to an increase of effectiveness are difficult to quantify, and sometimes even to be identified. For example, it is not easy to assign a monetary value resulting from the use of new auditing procedures, as well as coordination ones. However, this value must be calculated in some way, and is critical to give meaning to the strategy. The non-presence of standard indicators is therefore motivated by the complexity of the process of identifying these benefits. For example, suppose is being conducting a feasibility study of an EDSS (Environmental Decision Support System, see paragraph 5.2.4). In addition to the benefits already mentioned above, further benefits may also derive from investments that can be implemented in the future thanks to this technology. So once again, the assessment can not be standard or mechanical, but must be supplemented with additional components of analysis based on subjectivity and experience. Generally the process involves two basic steps. Thus, for each Green IT initiative, must be conducted the qualification of the benefits (are identified which are effectively the benefits), and then their quantification (it is given to each its monetary value).
A classification generally adopted by literature consists in the distinction between tangible and intangible benefits.
The tangible benefits are so called because of their visibility and (commonly) their easily measurability. The most common example refers to the reduction of costs. For instance, the reduction of energy consumption (directly linked to the reduction of costs) is tangible, and so easily quantifiable. A further example concerns the process performance improvement. In fact, again here, it is relatively easy, to observe these time and costs aspects, and to get a monetary value of them. Some others common examples include: cost reduction, cost avoidance, revenue gain, performance improvement (time and cost).
On the other hand, the intangible benefits related to the adoption of a Green IT strategy, are not visible and easily quantifiable. For many years researchers are looking for a standardized approach for their evaluation, but an optimal solution is still not present in literature. However, the importance of this kind of analysis is not negligible. Jack Keen, Value Analytics Leader at Infosys Technologies, affirmed in an article (2003) that "more than 25

percent of the value of enterprises is now based on intangible assets, such as brand image and investors loyalty".
Generally, the most common examples of intangible benefits are related to the medium or long term. For instance it is still included the process performance improvement, but from other points of view. In fact this time, the focus is on changes made in carrying out of operations, or different ways of management. A further example might be the better ability to predict future events, and the consequent risk reduction. Finally, considering the long term, is included the greater adaptability of a company which undertakes a Green IT strategy. In particular, these aspects are connected to the network improvement, to the supply chain, and to the achievement of competitive advantages.
To summarize this discussion has been taken inspiration from a graph developed by Strassmann in 1990 (see figure 14, next page). He related the general benefits that are derived from IT. Then, he classified them by difficulty of detection and measurement, and time in which the benefits effectively occur.

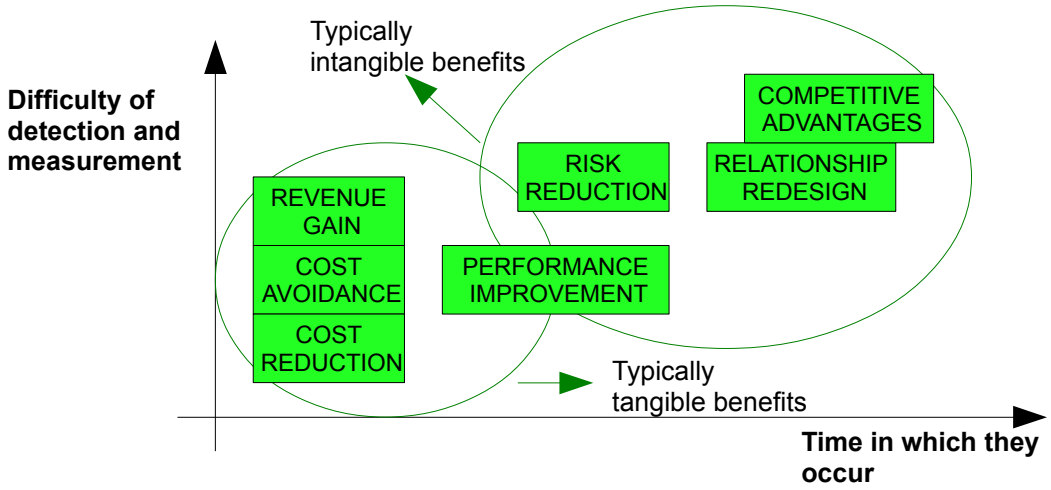


Figure 14: IT benefits classification; source: P. Strassmann;

As shown in the figure above, the discussion has been contextualized to the Green IT, and to the observations made earlier in this paragraph. Hence, demonstrating what has been said above, the left part of the graph is referred to the tangible benefits, and the right one, instead, is related to the intangible ones.
Finally, must to be highlighted how the benefits analysis proposed here is untied from a purely financial point of view. In fact, much broader aspects are included. So it is implicitly provided an additional reason the led to the choice of a Business Value perspective, rather than a purely financial one, as discussed above.

5.5.5 Reduce costs:

in a Green IT strategy, this is a fundamental objective. Since the introduction, in this document, have been identified the cost reduction as one of the final purposes for each Green IT initiative. In order to provide a complete and consistent cost analysis, reference is made to the approach presented by Bracchi, G.; Francalanci, C.; Motta, G. in their book " Sistemi Informativi d'Impresa" (2010). The following figure reflects partly the approach

described in this essay:

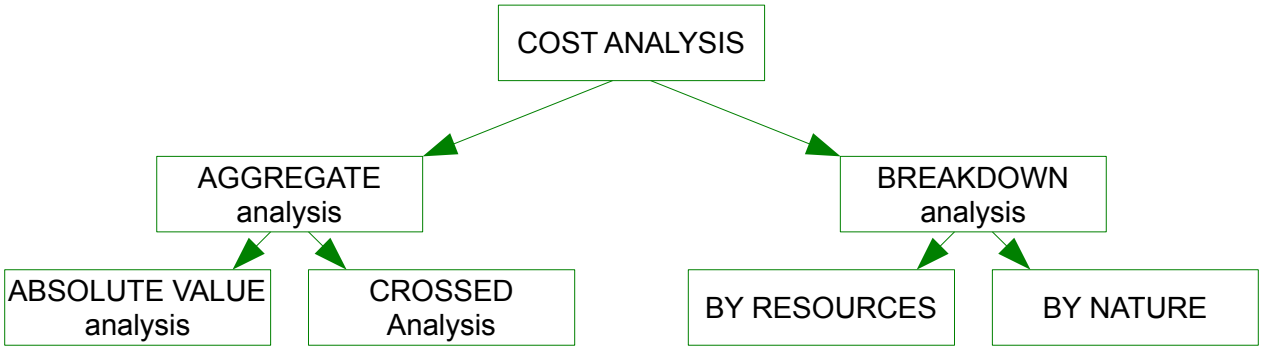


Figure 15: Cost Analysis approach;

The analysis will therefore follow this model of possible indicators. Every single part of this scheme will be explained below.

- INDICATORS:

first, will be tackled the aggregate analysis. In this case the measures will take into account the total amount of spending on the project of Green IT. Indeed, here it is not mentioned where the spending have been addressed, and how these investments have been implemented. The ultimate goal of the calculation of the expenditures can be divided into two main parts: allow the real time analysis, and allow the construction of time series. In particular, the timely collection of data allows an ongoing management of all parameters. The second part, which refers to the time series, allows a company to construct cost curves, extremely significant in the assessment between different periods.

– OVERALL COSTS OF THE GREEN IT STRATEGY:

it represents the most immediate indicator of spending. By itself, this indicator does not make much sense, because it does not take into account too many contingent variables. However, an absolute measurement is always required. Moreover, in general, can be expected that with the growth of total spending, increase the variety and completeness of functional and strategic initiatives for Green IT. It shall include all costs for the technological infrastructure, but also those referring to the surrounding initiatives (for example incentives to employees, mentioned in the “Stakeholders and Culture Perspective”).

Consistent with the figure above, the next two indicators relate to the cross analysis. In particular is important to identify the parameter that better represents the size of the enterprise. Will be then discussed the two most common examples, with their strengths and weaknesses.

– COSTS ON REVENUES:

expenditures on sales is in general an indicator widely used. It is usually adopted both for high-level measures and for project evaluations. In particular it is appropriated to relate the spendings to a variable indicating the size of the organization. This is done in order to facilitate the analysis, as well as to provide a data that could also be comparable with other organizations. The strength is that the structure of this indicator by itself is not affected by the phenomenon of inflation. It also allows an accurate and consistent comparison with enterprises, but just in the same sector. In fact, a weakness of using this parameter in order to represent the size of the company, is that it changes a lot depending on the business in which the enterprise operates. For example, would be meaningless to compare the expenditure on a

Green IT project between a company operating in the IT sector, and a purely manufacturing one. Another, even greater, weakness is that a different approach to the Green IT strategy can lead to substantial discrepancies.

- COST PER EMPLOYEE:

to cope with the weaknesses described for the previous indicator this new parameter is introduced for the measurement of the company size. In particular it is, in part, solved the problem on the comparison between different sectors. It has been said "in part", because the comparison must to be significant anyway. There is, however, unlike the previous one, a problem with inflation. In fact, it affects the value just of the numerator of this indicator. Therefore it has an impact on the final value. Hence, should be introduced some special factors in order to deduct the impact of inflation. This factors allow the creation of time series as well.

The discussion will now proceed consistently with the right side of the figure above: the breakdown cost analysis. It allows a decomposition of the total spending, providing a more complete point of view. The main objective here is to identify two very important aspects: what it refers to each item of cost, and when and how these costs will be incurred. So, these measures will be carried out respectively through the splitting of costs for resources and for nature.

- COST BY RESOURCES:

First, it must be said that there is a prerequisite for a correct analysis. It is indeed necessary a detailed preliminary description of each item of cost. Anyway, the usefulness of this measure is given not only by its ease of comparability. Through such type of decomposition, in fact, is encouraged planning more effectively and efficiently, the use of such resources. Furthermore, know the cost associated with each resource, facilitates the calculation of its performance. Especially in a project of Green IT is fundamental to give an economic and financial meaning to all the performances related to each resource. Moreover, with this type of analysis can make a distinction (and a comparison) between spending on technology and personnel expenditure. As suggested again by Bracchi, Francalanci and Motta ("Sistemi Informativi d'Impresa", 2010) "the ratio of these two components provides a meaningful measure of productivity of "informatics personnel", in this case of the Green IT personnel. For example, "too low percentage of personnel expenditure could be a symptom of poor management of technology, resulting in a reduction in benefits" (Holsapple, Whinston, "Decision Support Systems: A Knowledge-Based Approach", 1996).
Finally, may be further broken down the analysis including the possible use of outsourcing. Is then inserted a new cost component related to external services, including technology and personnel. In fact a high level of external expenditures might be an indicator of a lack of internal knowledge. Therefore, for the reasons seen in the second perspective, it is important to keep this aspect also monitored.

- COST BY NATURE:

Which is carried out here is the distinction between: fixed costs, variable costs and semi-variable costs. Fixed costs are attributable to those expenses that do not vary depending on the variation of the level of such activity in the enterprise. Variable costs, instead, are those that vary depending on the use of a resource, or the level of an activity to which they are responsible. For example, costs related to electricity consumption of a server depend on its actual use, and therefore are variable costs. It also stresses that the dependencies spending-usage are not always linear. Finally, semi-variable costs are composed of a fixed and a variable component. A common example is a license fee whatsoever, which has a different

cost ranges depending on purchase volume.
This type of analysis is critical to Green IT strategy. In particular, has repeatedly stressed that a reduction in the use of IT resources may result in monetary and environmental benefits.
So, with this kind of analysis, can be seen where can be reduced costs by reducing the use (variable costs), and where it is possible only partially (semi-variable costs).

It must be also stressed that a complete analysis should include a section on the distinction between project costs and period costs as well. The first category includes construction costs and and expenses necessary for starting the project. Period costs instead are represented by those ongoing operational costs and those expenditures, not negligible, that refer to the overall maintenance. Nevertheless indicators have not been proposed for this particular distinction, because it is impossible to give a general point of view. In fact, it is only after a careful analysis of the situation "as-is" that can be known the values of these variables.

- IMIS: INVESTMENTS IN MANAGEMENT INFORMATION SYSTEMS:

As previously introduced, this is the measure proposed by Paul A. Strassmann for the calculation of the costs part in the ROM indicator. As this is an assessment concerning the costs, it is appropriated to treat it within this objective. The formula that Strassmann proposed is:

$$I_{MIS} = I_{TOT} - I_{EMB} - I_{MC}$$

Where:
- I_{TOT}: total investments in IT;
- I_{EMB}: embedded investments;
- I_{MC}: mission-critical investments.

Then the value is obtained by subtracting from the total investments in IT (I_{TOT}), them that he called “embedded”, i.e. that refer directly to the manufacturing process, and those called “mission-critical”, i.e. those essential for the generation of revenues.

5.5.6 Create business value:

In this framework, this is considered the ultimate goal. It is the overall Green IT strategy goal. In it is summarized the all Balanced Scorecard. Three indicators are proposed in this objective. Consistently with what have been said in the introduction of this perspective, are assessed the shareholder value, fundamental in all kinds of strategies, the sustainable value, as a synthesis of the benefits that come from the reduction of the environmental impact, and the overall returns of the all strategy. As noted previously, the other components of the business value seen in its definition, have already been assessed in the previous perspectives in this model.

- SHAREHOLDER VALUE:

The term "shareholders value" has assumed different meanings over the last thirty years. First, this term has assumed particular importance in the eighties. Was the General Electric CEO, Jack Welch, who focused on this analysis. Thirty years later, Welch himself, affirmed that, as has been used and defined, has become “the dumbest idea in the world” (Financial Times, 13th March 2009). In fact, during this period, shareholders value has been

interpreted in different ways and, sometimes, in misleading way. There are three basic interpretations. The term was first referred just to the market capitalization of the company. Then, was referred “to the concept that the primary goal for a company is to increase the wealth of its owners (shareholders) by paying dividends and/or causing the stock price to increase” (Wikipedia). The third interpretation, and that will be used in this document, there is the one introduced in 1986 by Alfred Rappaport (he is Leonard Spacek Professor Emeritus at J. L. Kellogg Graduate School of Management, North-western University). Basically, his idea is based on the fact that the returns to shareholders should outperform certain benchmarks such as the cost of capital concept. In essence, the idea that the money of shareholders' should be used to obtain a higher return than they could earn by investing in other activities that have the same amount of risk. The choice of his point of view, stemmed from my personal studies. Indeed the recent literature prompts to the focus towards the value based management. This theory, or even approach, states that management should first, and mostly, consider the interests of shareholders in the business strategies decisions.

- SUSTAINABLE VALUE:

It is an innovative way of measuring sustainability performances. Consistently with the introduction to this objective, it is a value based approach. This concept was first introduced by researches of the Euromed Management School (Marseille, France). As they said, “Sustainable Value integrates environmental and social dimensions into financial analysis and investment decision making”. The main advantage of its adoption is that it can be also expressed with a monetary unit. On the Sustainable Value website is reported that “financial market logic can inform thinking about sustainability. Financial markets value resources that come without a price tag. Sustainable Value builds on decades of this financial markets research to finally assess and manage environmental and social resources similar to economic resources. Using opportunity cost thinking it avoids most problems that have prevented us from truly integrating economic, environmental and social aspects in everyday decision-making”. This concept is based on the notion of opportunity costs, used in financial markets to calculate the cost of capital.
Entering into detail, it takes five consecutive steps for the calculation of this indicator:

1. “Calculate the environmental, social and economic efficiencies of the company using the resources”. Efficiencies here are meant as a sort of productivity measure. So it is calculated by calculating the return to the resource use.
2. “Calculate the environmental, social and economic efficiencies of the benchmark”. This step represents the identification of the opportunity costs.
3. “Calculate the value spreads by subtracting the efficiency of the benchmark (Step 2) from the efficiency of the entity (Step 1)”. So in this step is identified the position of the company, compared to the rest of the market of “comparables” enterprises.
4. “Calculate the value contributions by multiplying the amount of environmental, social and economic resources used with the corresponding value spread (Step 3), respectively”.
5. “Calculate sustainable value by adding up the value contributions (Step 4) and dividing by the number of resources considered”.

These steps, that represent the complete calculation of the Sustainable Value, were taken from Figge F. and Hahn T. in their book: "The Cost of Sustainability Capital and the Creation of Sustainable Value by Companies", 2005.

- TOTAL GREEN IT RETURNS (TGITR):

This indicator is introduced to a final calculation and overall returns of the Green IT strategy. Its definition is inspired by the TBR (Total Business Returns), developed by BCG

(Boston Consulting Group) in 1996. It consists in a measure of capital gains and dividend received by shareholders. The approach was explained as follows: “it measures the capital gain and dividend yield of a business unit or company plan as if the plan were known by the market or the business unit were publicly traded” (Boston Consulting Group, 1996). This approach was claimed in order to overcome the weaknesses of short term performance measures, such as EVA (Economic Value Added, see paragraph 3.2.1). In fact it incorporates the long term impact on the value of business decisions.
The formulation of the TGITR consists in combining the cash flow performances (calculated in the “increase profits” objective) coming from the Green IT strategy, with the change of value that occurred during a certain period of time.
Effectively, the TGITR represents an IRR (Internal Rate of Return) measure that equates the beginning value of a business with net free cash flows arising from the Green IT strategy in a certain period, plus the value of the business at the end of the period. It is precisely here that we find the greatest difficulties in applying the indicator. In fact, the determination of the value of the business can only be made through the managers' forecasts. So it definitely comes a high degree of subjectivity.

5.5.7 Comments:

In conclusion I have provided five objectives for correctly manage this perspective, and twenty-four indicators in order to develop a continuous assessment. The key step of this perspective, and perhaps of the whole Green IT strategy, is the correct identification of costs and benefits. In fact develop a complete costs-benefits analytical framework, as mentioned above, allows to understand the importance of these initiatives; reach this knowledge is critical in order to involve the top management, demonstrating the real value that could state behind an optimal implementation of a Green IT strategy. Moreover with such framework it is possible to predict the economical and financial impact of each initiative, and also it is possible to compare different alternatives, as stressed several times.
Furthermore are proposed the standard methods for calculating the profitability of those investments. In fact, it is not obvious irrespective that any strategy presented is profitable for any business. It is likely that some aspects are more appropriate to some sectors than others. Moreover everything could be different depending of each “as-is situation”. It is therefore important to assess all of the investment regardless on what has been done before by other companies.
Finally, as done for the previous perspectives, in the next page is proposed a summary table of the objectives, their brief description, their indicators, and are provided also the unit of measures.

BUSINESS VALUE PERSPECTIVE			
It is the last perspective in this Green IT BSC, and it's situated at the top of the cause-effect chain. Are included mainly economic and financial objectives, but not only. It can be considered as an evaluation summary of the all initiatives, assessing which projects are profitable and which are not, through a complete costs-benefits analysis.			
OBJECTIVES	DESCRIPTION	INDICATORS	UNIT
Financial Credibility	Have to be seen together with "increase investors loyalty". It aims to improve the financial reputation of the company.	CFI	Score (-1 to 10)
		PRR	Ratio
		NORR	Ratio
		RONAR	Ratio
		Viability Ratio	Ratio
Increase profits	Its indicators aim to assess the profitability of the Green IT strategy, from an analytical framework of the investments required for implementing the strategy, and the expected returns.	NPV	$
		IRR	Rate
		PI	Ratio
		PBt	Time
		Energy PBt	Time
		ROM	Ratio
Increase benefits	The benefits analysis proposed aims to be an analytical framework of the expected returns of the Green IT strategy.	Qualification of tangible benefits	List
		Quantification of tangible benefits	$
		Qualification of intangible benefits	List
		Quantification of intangible benefits	$
Reduce costs	The costs analysis proposed aims to be an analytical framework of the overall expenditures in order to implement the Green IT strategy.	Overall costs of Green IT strategy	$
		Costs on revenues	Ratio
		Costs per employee	$/employee
		Costs by resources	$
		Costs by nature	$
		IMIS	$
Create business value	It is the main objective of the overall Green IT strategy.	Shareholders value	$
		Sustainable value	$
		TGITR	$

Table 10: Business Value Perspective;

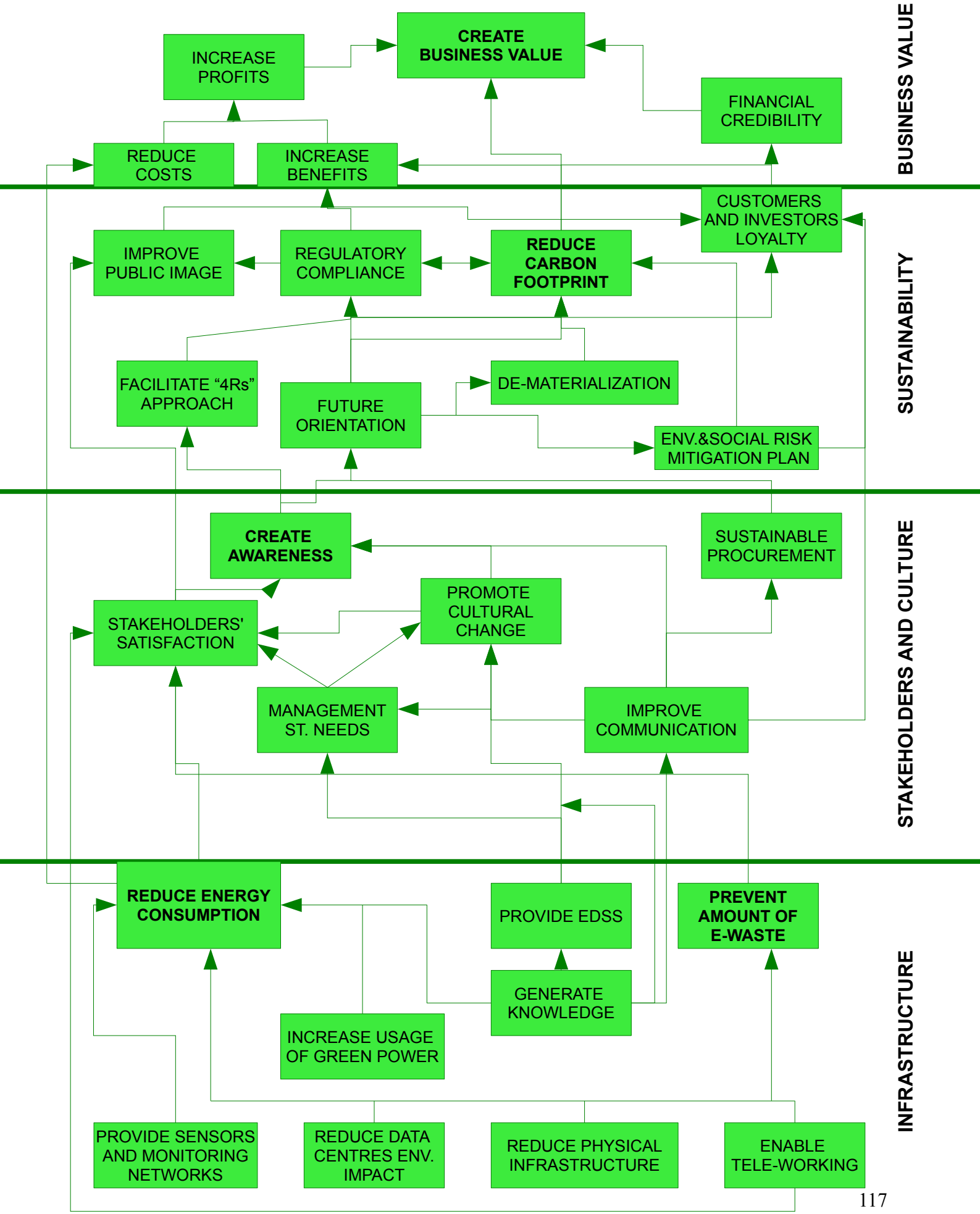
5.6 CAUSE-EFFECT RELATIONSHIP:

As for the other BSCs discussed earlier (Kaplan and Norton's BSC, IT BSC, etc.), also here the cause-effect relationship is the key for understanding the model. In fact it allows to give a meaning to it, and to insert the objectives previously defined in a coherent and meaningful context. It is also sometimes called strategic map, and any strategy shall need one.
Generally the strategy is defined as "a plan of actions designed to achieve a particular goal" (Wikipedia). Then, through a strategy is wanted to bring a company to a desired situation. But this situation is usually uncertain. To reach this goal, an organization needs a path to follow. As a consequence, it is needed a tool in order to describe this path. This tool is precisely the map of cause-effect relationship. In fact, to allow the implementation of the strategy, this must be properly communicated to those who must perform it. It is quite intuitive that can not be communicated what can not be described. Then the map of cause-effect relationship is that tool which describes the strategy. Generally the cause-effect relationship is argued to be "the feature that distinguishes a balanced scorecard from other kinds of scorecard, whether they are labelled stakeholder scorecards or KPI scorecards" (Kaplan, Norton, 2001, they termed KPI scorecards those that are "composed of a collection of indicators sorted in four dimensions without any attempts to map the relationships between the indicators"). From this point of view, a strategy can be seen as "a set of hypotheses about cause and effect" (Kaplan and Norton, 1991).
The four perspective of this Green IT BSC described so far, have been built and designed to be integral part of the organization and the strategy. In fact, as underlined in chapter 4, this issue has always been the guidance of the formulation of the objectives for each perspective. Each goal, indeed, before being finally placed in this BSC, should had a place and a clearly defined role in the cause-effect chain. Therefore, can be affirmed that each objective is part of the path of the Green IT strategy. It is then clear how this part is the structural key of this Green IT BSC. In fact, it provides a concrete, practical and real meaning to the model. Hence, with this part, the model turns out to be complete. Summarizing, have been provided four perspectives, consisting of objectives and indicators to assess their achievement. Now it is being provided a path and a meaning to those targets.
The cause-effect map could be basically built on two different levels of detail:

- from the perspectives' point of view;
- from the objectives' point of view.

The first part (perspective's layer) has been already discussed in the introduction of the Green IT BSC (see paragraph 5.1), in order to justify the choice of such perspectives. Shortly, this general level was defined by grouping together all the aspects that characterize a Green IT strategy in homogeneous categories, as long as these categories were not taking the meaning of a path leading to the mission. Concerning the objective's one, the discussion shifts into a deeper level of detail. The idea behind this level of cause-effect relationship, is that the objectives previously assigned to the perspectives, and then to the Green IT strategy, are not isolated goals, but they influence each other. In the next page is proposed the cause-effect map for this Green IT BSC (see Figure 16). Can be seen that the structure follows the one proposed for the perspectives, from the infrastructural one at the lowest level to the "Business Value Perspective" at the highest. For each perspective, have been placed the objectives that compose them. Are included all the twenty-eight goals previously provided. Then the target were connected to each other, according to the cause-effect relationship from which they are characterized. Because of a graphic reason, not every connections have been illustrated. In particular, the table had to be as clear as possible. For example, most of the objectives should have been linked to the "Reduce Costs" box, but the resulting drawing would have been incomprehensible.

Figure 16 (next page): Green IT BSC cause-effect relationship;


BUSINESS VALUE
CREATE BUSINESS VALUE
INCREASE PROFITS
FINANCIAL CREDIBILITY
REDUCE COSTS
INCREASE BENEFITS
SUSTAINABILITY
CUSTOMERS AND INVESTORS LOYALTY
IMPROVE PUBLIC IMAGE
REGULATORY COMPLIANCE
REDUCE CARBON FOOTPRINT
FACILITATE "4Rs" APPROACH
DE-MATERIALIZATION
FUTURE ORIENTATION
ENV.&SOCIAL RISK MITIGATION PLAN
STAKEHOLDERS AND CULTURE
CREATE AWARENESS
SUSTAINABLE PROCUREMENT
PROMOTE CULTURAL CHANGE
STAKEHOLDERS' SATISFACTION
MANAGEMENT ST. NEEDS
IMPROVE COMMUNICATION
INFRASTRUCTURE
REDUCE ENERGY CONSUMPTION
PROVIDE EDSS
PREVENT AMOUNT OF E-WASTE
GENERATE KNOWLEDGE
INCREASE USAGE OF GREEN POWER
PROVIDE SENSORS AND MONITORING NETWORKS
REDUCE DATA CENTRES ENV. IMPACT
REDUCE PHYSICAL INFRASTRUCTURE
ENABLE TELE-WORKING

Now, what is necessary to focus on, is the demonstration of each connections. Collect empirical data for each process would be impossible (it will be the main challenge of the PhD on this BSC). The approach used is as follows. Foundations of what is implicitly stated in this chart, are mostly detectable in the section on the review of the literature (see chapter 2). In fact, should be reminded that all objectives have been defined and developed since the issues/initiatives of a typical Green IT strategy, identified in the first research phase. Then, taking a step back, the “Focus Areas” defined in chapter 2, are the basis from which everything started. In particular, in their description, were provided, for each area, detailed informations on their strengths and weaknesses. This was complemented by a deep analysis of the potential benefits and the competitive advantages attainable. So, this part was not affected by my personal opinion, nor were provided explanations derived by subjective interpretations. In fact, each benefit mentioned has been taken from surveys conducted by various organizations on that specific theme, or from publications on that topic, or from conferences on Green IT at which I have personally attended. Furthermore, have also been mentioned actual cases (see as an example the smart metering implementation by Enel S.p.a.), from studies and researches released by institution organizations, as well as by various consulting societies.
However, there are some connections between objectives in the cause-effect map, that were derived by fairly obvious reasons. For example, there is not need to prove that the initiatives and policies to promote cultural change, unambiguously lead to an increased awareness and sensitivity towards the Green IT. There are further examples in this sense. Indeed, for instance, it is not necessary to prove that to an effective reduction in energy consumption corresponds a costs reduction. Same applies for the connection “Improve Public Image” - “Increase Benefits”, and so on.
Generally, what has been observed was that uncertainty is greater at the lower levels of the cause-effect relationships map. In fact, at the “Business Value Perspective” level, connections are standards and hugely demonstrated by the literature. Contrariwise, infrastructural and technological aspects have been just recently introduced, and are therefore more difficult to assess and interpret. The main reason for this difficulty is in the fact that there still are not Green IT strategies that were fully implemented in the businesses. So far, the topic was taken into account mostly from the academic research field. The very first consequence refers to the lack of a huge amount of empirical data, as highlighted several times in this document. For this reasons, it was decided to add an additional analysis to further motivate what is stated in this graph and in these pages. This analysis was conducted through a survey distributed to experts, in the Green IT field, and to members of IT management of some companies (see chapter 6). Being the survey initiated after the development of this Green IT BSC, it was not a starting point (as was the review of the literature, chapter 2), but rather it was used as a further validation of what have been said. In general the investigation was focused on technological and cultural aspects, as are those characterized by a greater degree of uncertainty. However, the part relating to the collection and analysis of these data will be treated in the next chapter.
Going ahead, the cause-effect map is not just an illustration of the hypothesis that subsist behind the Green IT strategy. In fact, it allows also to make predictive assessments on the futures performances for instance. This can be accomplished through to the representation of the connections. Indeed they allow to verify with sufficient accuracy what impacts what, how and how much this issue under consideration is affected.
Furthermore the cause-effect map can be even considered as a post assessment tool. Indeed, it can be also seen as a graphic tool that helps identify, sort, and display possible causes of an effective result of an objective. In this sense it permits to understand where does one specific problem come from. In other word it helps optimize root causes analysis. In order to provide an example, let's image that there a general substantial lack of awareness, towards the Green IT issues, within the organization. This kind of anomaly, in accordance with what have been said so far, should be detected through indicators' values analysis, within the “Create Awareness” objective. Then, using

the cause-effect map, can be pinpointed the source of the problem, tracing back (or down) the connections with this same objective. For example could be a problem of ineffectiveness of the Environmental Knowledge Management System; otherwise may be that the Green IT policies were not promoted in the right way, or not correctly implemented; another possibility could be that more incentives to internal staff are needed, and so on. So, can be easily seen how this model allows a a focused, and most of all confined, analysis of those problems (or anomalies). As a consequence, the problem solving process results easier, more efficient and more effective.
Another important benefit of using this diagram, is that complicated relationships and mechanisms are translated into an "easy to read" format. The strategy is therefore easily understandable (and the tool results easily usable) by any kind of user.
It should also be noted that more this model is used and more result increased the user's experience and knowledge of the processes. Thus, it become easier to find the right areas to collect data for analysis, that is critical for a Green IT strategy.
Finally should not be underestimated the more possibilities offered by the map of cause-effect relationships, to find out new ways and Green IT initiatives to be undertaken. For example, suppose is being assessing the "Stakeholders Satisfaction" objective. The example has not been taken at random. In fact, from this objective is very difficult to understand how much value is given by, for instance, "Reduce Energy Consumption" or "Enable Tele-Working", using just the indicators provided. Hence, with the increase of data collected and the number of assessments made, it become possible to identify new objectives, or even new "intermediate" Green IT initiatives. So, if used in an appropriate way, the map of cause-effect relationships could also become a tool towards innovation.
After the conception of the BSC, many criticisms raised on what Kaplan and Norton intended with cause-effect relationship. A significant phrase was written by Norreklit, in her "The Balanced Scorecard: What is the score?", 2000. She reported that "the BSC makes invalid assumptions about causal relationships, leading to the anticipation of performance indicators which are faulty, thus resulting in dysfunctional organizational behaviour and sub-optimized performance". In my opinion, two points in her analysis require attention. First, a quest for generic relationships. In other words, should these relationships be assumed to hold universally, or in a certain organization at a certain point in time and in a certain setting? To answer this question must be done a step back. The basic belief behind of what has been proposed here, is not that there exists a generic cause-effect relationship between two measurement areas, or two measures, but rather that it would be possible to identify such measures in a particular organization, given all its contingencies, that reflect an organization's Green IT strategy and the improvement of which, will with high probability lead to a desired outcome in some other measures, consistent with the connections made.

With this part the Green IT Balanced Scorecard is complete. The tool is now fully defined.
The next chapter will discuss the collection of empirical feedbacks and opinions from domain experts.

Chapter 6: Demonstration and Evaluation

6.1 WHAT IS NEEDED TO DEMONSTRATE?

This is the last chapter of this master thesis. Here will be presented the "Demonstration" and "Evaluation" steps of the Deign Science Research Methodology (Peffers, 2007), introduced in chapter 4. Hence, once the problem to be solved (see chapter 1) and the objective for a solution (see chapter 2) have been introduced, was provided the tool in order to achieve those goals, the Green IT BSC (see chapter 5). Now, what is actually lacking is a demonstration of the validity and of the applicability of the model. Clearly, the best way would be its effective implementation in a real business. However, this process, in order to be properly deployed, would take several months. In fact, as stressed many times in these pages, the Green IT BSC is based on a holistic approach. This means that the assessment is not circumscribed just to the IT department, but it should be referred to the whole extended enterprise (one of the main objectives is to align the Green IT strategy to the overall business strategy). Thus, all the business' division should be included in the evaluation. Therefore, for the reasons listed above, it is believed that an assessment and a validation so deep go beyond the goals of this master thesis. This kind of action will be probably implemented during the three years PhD research program, which will follow this master thesis.
However, without the collection of empirical data, even this document would be incomplete.
First of all must be understood what is wanted to be demonstrated. The main goal of this chapter is to provide a convincing evidence of the effectiveness of the Green IT BSC. In other words, this next discussion aims to be able to affirm with certainty that the proper use of the Green IT BSC really leads to a situation in which is business value is effectively captured from a Green IT strategy implementation. It is clear that this objective should be broken down into smaller goals for this analysis.
First, it is important to motivate the choice of the BSC as the proper framework. In chapter 3 has been described how this model is structured and how it has to be used. In particular, starting from the Kaplan and Norton BSC, and through the IT BSC (Wim van Grembergen, 2005) and the Public-sector BSC (Fabrizio Bocci, 2005), has been explained how this tool can be used for several strategies in many business contexts. In fact, it has been defined as a "complete system of strategic management" and again, "it is a holistic approach from the strategy definition to its execution and verification, across the extended enterprise". Its "structural effectiveness", in the evaluation of any strategy, is very well documented by the literature, and by the very high degree of use in the business realities in the last twenty years. In fact, already in 1997, "64% of the companies questioned were measuring performance from a number of perspectives in a similar way to the Balanced Scorecard" (Kurtzman, J. "Is Your Company Off Course? Now You Can Find Out Why", 1997). Moreover, "Balanced Scorecards have been implemented by government agencies, military units, business units and corporations as a whole, non-profit organisations, and schools" (Kurtzman, 1997). Then, this is considered as the best way for implement and assess a strategy, and, as seen, the Green IT strategy is perfectly suitable for this model.
Then, what has to be verified is the effectively reachability of the benefits presented for each Green IT initiative. These benefits were the bases of the construction of the cause-effect map, the real key to understand the strategy and the BSC itself. In particular, it is needed to validate all the connections proposed for the cause-effect relationship (see Figure 16, paragraph 5.6). As underlined previously, this is the core of the model because the perspectives and the objectives take on the meaning of the strategic path to follow in order to achieve the ultimate goal of the Green IT strategy: capture business value. For doing this have been crossed two different ways:

- demonstration by references;

– Green IT survey:

6.2 DEMONSTRATION BY REFERENCES:

This part is found mainly in the overview of the literature, presented in the second chapter of this document. In particular, each "focus area" identified was translated in the Green IT BSC into a proper objective (or a part of it) in the subsequent strategy. While describing all the Green IT initiatives were proposed, for each of them, the possible benefits reachable and the potential competitive advantages achievable, from their proper implementation. These benefits have been afterwards the bases of the cause-effect relationship scheme. As an example can be taken the objective "enable tele-working" (see paragraph 5.2.8). Within the strategic path identified by the cause-effect map is stated that the achievement of this objective leads to two fundamental consequences (that are themselves intermediate goals of the Green IT strategic path): "reduce carbon footprint" and "stakeholders satisfaction". In order to provide a proof for the first statement was mentioned a research released by the World Economic Forum. Instead, for demonstrate the second connection were provided the results of a study conducted by the Statistical Indicators Benchmarking the Information Society (SIBIS), a project in the "Information Society Programme" of the European Commission. So, can be concluded that, considered the reliability of these organizations, what was affirmed can be regarded as true.
Here is proposed a table with examples of references taken into account in this document. In particular, are considered all of the Green IT initiatives (then became objectives in the BSC):

DEMONSTRATION BY REFERENCES		
GREEN IT INITIATIVE	**FIELD**	**BENEFITS / COMPETITIVE ADVANTAGES**
Design for environmental sustainability	Green buildings	- decrease "sick building symptoms", and enhance work performance (Lawrence Berkeley National Laboratory, 2000); - "using energy water and other resources more efficiently" and "reduce costs and meet growing social demands" (USGBC); - "increase productivity by between 6-16%" and "decrease absenteeism" (Rocky Mountain Institute); - "a Smart Building Implementation program can lead to a $334,628 saving on utility during the first year of implementation alone, $50,000 saving at pilot building, and $4 million estimated saving upon project completion. In particular the energy consumption reductions would be about -12% for electricity, - 45% for steam, and - 10% in chilled water" (World Economic Forum, 2009);
	Green IT products	- "decrease e-waste going to landfills" (Rocky Mountain Institute);
Enable power management features	PCs	- cost saving: "US companies alone waste $2.8 billion powering unused desktop PCs" (EPA, 2009); - "a centralized active power management

		software could save £175,000 a year for a business with 20,000 staff" (U.K. Parliamentary Office of Science and Technology, 2008);
Energy-efficient computing	Optimization problem	- "a 15% reduction in frequency (from dual-core to quad-core systems) could save up to 50% power consumption" (San Murugesan, 2008);
Server Virtualization	P2V transformation (Physical to Virtual)	- "the average usage on a dedicated stand alone server is less than 10% of its capability" and "less waste, less energy consumption, less real estate" (Angela Miller, 2007); - "storage virtualization technologies together with server virtualization software, reduced Purdue's administrative energy consumption by almost 20% (35 Kilowatts of power)". Again, "using virtualization technologies to reduce and consolidate the environment, EMC has been able to virtualize 1,357 of its servers to just 231 physical machines, resulting in infrastructure space, power and cooling saving 67% (more than $4.6 million) and eliminating about 3,159,726 pounds of CO_2 emissions over a three-year period" (Hopkinson, 2006);
"4 Rs" approach	Tackle and prevent e-waste	- "consider e-waste can provide both energy and cost savings" (UNEP, 2004);
Regulatory compliance	WEEE RoHS	- "financial penalties can reach a value of 7% of the total energy spend" (Eco Vadis, 2010); - "leverage regulatory compliance into marketing policies, and so increase public image" (Prakash, 2002);
Environmental-related risk mitigation	Develop a risk mitigation plan	- "investors are moving towards companies with regard to their carbon footprint. As a consequence markets are discounting share prices of companies that poorly address the environmental problem they create" (Kinaxis report, 2009);
Usage of green power	Block products Green tags Blended products Generation on-site	- environmental stewardship; - more secure energy supply; - public image; - financial incentives; - power portfolio management; - power reliability; (see paragraph 2.3.8);
Eco-labelling of IT products	Energy 4.0 standard EPEAT	- "this process would be critical for an organization and it's used to assess the brand position and seriousness towards the environment" (San Murugesan, 2008); - "devices carrying the Energy Star logo, […], generally use 20%–30% less energy than required

		by federal standards" (Tugend, 2008);
Reduce data centres environmental impact	Energy conservation; Eco-friendly design; Virtualization;	- " data centres in the U.S. consumed about 61 billion kilowatt-hour in 2006 […], similar to the amount electricity consumed by approximately 5.8 million average U.S. households" (HP eco-programme, 2008); - "capability of reducing the power consumption of in-room cooling devices by as much as 90%" (Novotny, 2010); - "50% of data centres' professionals have saved energy through server virtualization, 32% with underfloor air conditioning efficiency, 17.5% by power-down features on servers not in use, 11% by direct current power" (Sun Microsystem Australia, 2009);
Co-ordinating, re-engineering, optimizing	Internal processes;	- " ICT-based supply chain management could save 1.1% of total energy consumption in 2020" (European Commission report, 2006); - "through carbon network logistic optimization can be reach: 26% reduction in warehouse electricity consumption through site rationalization, 33% reduction in carbon emissions for vendor inbound activities through consolidation of movements, and 11% saving as part of a 3 year period change programme" (World Economic Forum, 2009);
Making business operations, buildings, and other systems energy-efficient	Design and simulation tools; Interoperability; Building automation; Smart metering; Users-awareness tools;	- "cost of the project at about € 2.1 billion and the savings they are receiving in operation of € 500 million per year, an astonishing 4 years pay back time" (Enel case study); - "the implementation of IT capabilities could lead to a reduction of approximately of 7% of total building emissions" (McKinsey report, 2004); - "reduction of between 5% and 15% of energy consumption could be achieved through the implementation of users-awareness tools" (Information Society Media, 2008); - the Yorkshire Ambulance Service "delivered an estimated 30% reduction in carbon footprint through the more effective distribution of ambulances across the region, while also improving survivability by up to 23%". (YAS report, 2011);
Auditing, monitoring and controlling	BEMS	- "Building Energy Management System (BEMS), could lead to energy savings of between 5% and 40%" (ClimateTechWiki report, 2011); - "simply auditing the environment to identify these devices could lead to a reduction in

		infrastructure of over 10% together to power saving of between 10% - 20%" (World Economic Forum, 2009);
Calculating and managing carbon footprint	Organizational footprint Product's footprint	- "it allows to save costs and emissions or prove environmental commitment to customers and stakeholders" and "to understand the level of carbon risk exposure" (San Murugesan, 2008);
Integrating data from environmental sensors and monitoring networks	Communication architecture and web portal	- " sensors enable accounting of invisible environmental variables, with great granularity and in real time […] with obvious benefits of quality, effectiveness and efficiency of data" (Zabico, 2010);
Offering environmental knowledge management systems	EKMS	- "improve corporate environmental performance by lowering information barrier that prevents organization from realizing environmental opportunities" (Iddo Wernick, 2003);
Offering environmental decision support systems	EDSS	- "ranging monitoring and data storage to prediction, decision analysis, control, planning, management, and improve communication with stakeholders and society" and it is also "a mechanism to make the entire process more open and transparent" (Cortés, 2001);
Creating awareness of environmental sustainability	Environmental knowledge portal KMS	- "define, communicate, and use common sustainability language and vocabulary across ICT and other business units, including the extended enterprise, to leverage a common understanding" (Donnellan, 2011);

Table 11: Demonstration by references;

6.3 GREEN IT SURVEY:

The survey proposed (Appendix 1) was built on Surveymonkey (http://www.surveymonkey.com) platform. This is an online program for constructing customized surveys. It automatically generates a web link in order to provide to respondents a modest interactivity and ease of response. The questionnaire is quite short and takes just no more than ten minutes to be properly filled. Otherwise is supposed that there wouldn't have been so many answers.
Anyway, it consisted of an introduction part and five questions on the topic. The objective was to send it (by email) to as many domain experts as possible. This was achievable taking advantage from IVI (Innovation Value Institute) and BIG (Business Informatics Group) networking and from their several contacts with companies and correspondent IT managers. Moreover, in order to enrich the collection of data, has been exploited the network of PhD researchers that work in my same office.

6.3.1 Survey questions and purpose:

1. Introduction: "*Short description: this survey is part of a master thesis in Green IT. My aim was also to introduce a management tool for managing and assessing a Green IT strategy in order to capture business value: a Green IT Balanced Scorecard. This survey will be very useful for validate*

my BSC with domain experts opinions. All the information you provide will be treated confidential and not spread to other persons. All questions are voluntary and if you do not want to answer some of the questions this is your choice to make".
So, it was provided a short description of why the survey was created. Immediately after this brief introduction, the respondent had to fill some basics personal informations: "name", "company", "size of the company", and "position" covered in such company. The size of the company could be: "big" (with more than 250 employees), "medium" (between 50 and 250 employees), "small" (between 10 and 50 employees), or "micro" (less than 10 employees). This aspect will be strongly considered in the subsequent data analysis. In fact, as stressed several times in this document, the size of the company is an important variable from which depends the feasibility of most of the Green IT initiatives previously presented. As a consequence, to the answers will be given a different meaning depending on the size of the enterprise.
Then, were provided my personal contacts (my name and my email address). This has been done hoping to get further opportunities to conduct some "face to face" interviews (or teleconferencing) or some further deeper discussion on the topic and on my Green IT BSC.
This part ended with the question *"Wish to be anonymous?"* followed by *"If you choose not to be anonymous, the company name and your name will be visible in my master thesis, but it will NOT be possible for readers to know whom of the respondents that answered what in the survey".*

2. Definition: *"In my master thesis the Green IT was defined as follows: Green IT is made of two processes: "Greening OF IT" and "Greening BY IT". So, it can be defined as the study and practice of designing, manufacturing, using and disposing of computers, servers and associated subsystems, efficiently and effectively, with minimal or no impact on the environment ("Greening OF IT"). Then, beside IT itself being green, the "Greening BY IT" refers to the usage of IT in several ways to improve environmental sustainability in business activities, and to its usage in innovative ways to create awareness and promote sustainability among employees, business partners, stakeholders and customers.*
Do you agree with this definition? Otherwise, how do you define and use it?"
This was the first question on Green IT. As the topic is new and because of the lack of consistent literature, there is not a standard definition of a Green IT strategy. So, in my opinion, the first thing to be checked had to be the definition that I provided for Green IT, in order to understand if it was intended in the same way. This was an open-ended question, in order to allow respondents to give their definitions, if disagreeing with mine one.

3. Importance of a Green IT strategy: *"In your opinion Green IT can be seen as".*
This was a multiple-choice question. There were given five possibilities:
a. "Focused on technology";
b. "A cost centre";
c. "A service centre";
d. "An investment centre";
e. "A value centre".
The aim of this question was to understand the effective opinion of experts on the strategical importance of Green IT initiatives. In particular at which level of the overall business strategy they think it should be. What was wanted to be proved, was what was stated on Green IT, i.e. it has to be integrated and align with the overall mission of the company taken under consideration.
To each answer corresponds a different point of view, and those can be seen as well as a "level of Green IT maturity". If the Green IT is considered focused on technology, can be concluded that there is no formal Green IT presence and users create themselves the policies. Going ahead, if its seen as a cost centre, a Green IT strategy would offer little or even no input for the business. Then, the third possibility, "a service centre", refers to the interpretation of Green IT as an initiative

established as a quality service. The answer "d" corresponds to a higher level and consideration of it, in which the strategy is discussed and used when overall strategic goals are set. Finally, the higher level of maturity is achieved when Green IT is considered as a core competency for the company.
What should be underlined here is that the optimal maturity level is not obligatorily the higher one, but it depends on the business in which the company operates. As a consequence, the analysis will take into account from which business the respondent comes from.
Finally, after the question was placed a box to be filled with further justifications and comments on the answer provided (open-ended box).

4. Green IT initiatives effectively implemented: *" For each of these processes listed in the following table, please indicate if, in your company, they are".*
Here was provided a table with the most important "focus areas" identified in the overview of the literature. For each Green IT initiative, were available six possible answers:
a. "It is considered";
b. "It is considered and measured";
c. "It is not relevant";
d. "The investment is considered greater than the actual gain";
e. "There is an absence of efficient measuring tools (and can not be managed what is not measured)";
f. "Should be considered".
The nine processes listed in this table were actually objectives of the Green IT BSC as well: "calculating and managing carbon footprint", "usage of renewable energy", "reduce data centres environmental impact", "prevent amount of hazardous waste", "reduce IT physical infrastructure (virtualization)", "recycling of IT products", "create awareness and promote internal cultural change", "environmental related risk mitigation", and "de-materialization".
The main objective with this question was to verify if the Green IT initiatives found in the literature are effectively measured, or at least taken into account, in the respondent's companies. In other words, it is assessed if the review of the literature was correct, and were perceived the major issues. Even in this case, are discriminant the sector in which the organization operates, as well as its size.
Furthermore, is included an analysis on, just in case, why such initiatives were not considered. In particular I thought that there are four different reasons for not considered one or more of the processes proposed in this question. First, an initiative could be not relevant for the organization. For example, it is believed that for a "micro" company is not always relevant to implement a strategy in order to reduce the amount of hazardous waste, in particular if it does not generate such kind of wastes (for example if it does not operate in IT sector). Then, there could be the possibility that a process wouldn't be convenient for the company ("the investment is considered greater than the actual gain"). As a further reason for do not implement one of these initiatives, was proposed the answer "e". Here would be the situation in which is impossible to demonstrate the added value (by measuring it) of such area, and then, as "can not be managed what is not measured", its implementation would be just a cost for the company. Finally there is the situation in which the respondent believes in the potential value that could be given by the initiative, but it is not actually implemented in his organization.
Then, was inserted a box in order to provide the possibility of make some comments on the answers given.

5. Benefits provided by Green IT internal aspects: *"In your opinion, how much these internal aspects can provide benefits for the company? (Enter a value from 0 to 5, where "0" represents the situation in which there are no possibilities to capture benefits from that variable)".* Also here, as in

the previous question, were provided some of the objectives of the Green IT BSC. The output wanted from this question is a quantitative measure of the real benefits of each of the most important internal Green IT initiatives. The seven objectives listed in the table were: “Reduce energy consumption”, “Prevent amount of e-waste”, “Usage of green power”, “Provide environmental knowledge management systems”, “Provide environmental decision support systems”, “Reduce data centres environmental impact”, and “Usage of server virtualization”.
The goal is then provide an effective measure of the benefits of these processes listed above. What is necessary to highlight here is that the answers are based on the domain experts' opinions, and not on the actual situation in their companies. Have been chosen this way in order to include all of their experiences, rather than only their current ones. So, as a consequence, the answer results more complete.

6. Competitive advantages achievable with Green IT initiatives: *“In you opinion, how much these other aspects can improve public image, customers and investor loyalty, and then contribute to the achievement of competitive advantages? (Enter a value from 0 to 5, where “0” represents the situation in which there are no possibilities to achieve competitive advantages from that variable)”.*
The structure and the general goal of this question is the same as the previous one. In fact it is wanted to collect a quantitative measure of the potential benefits of these other aspects. What is different are the nature of such initiatives and the benefits achievable. In particular are considered only higher levels of the cause-effect map of the Green IT BSC (“Stakeholders and Culture” and “Sustainability” perspectives), and the benefits are greater (“competitive advantages”).so, there were five objectives proposed in the table, and were: “Effectively reduce overall carbon footprint”, “Eco-labelling of IT products (e.g. Energy Star, EPEAT)”, ”Regulatory compliance”, “Improve environmental communication”, “Promote R&D for eco-innovations”.

6.3.2 Presentation of the respondents:

Here follows a brief presentation of the “most important” respondents of this Green IT survey. Between themselves there were also some PhD students in the IT field. Personally I considered their opinions important as well. In fact, even if they are not IT managers they are having the opportunity to be in touch with some companies. Finally an important source was provided by IVI (Innovation Value Institute), settled in Maynooth within the NUI (National University of Ireland). Furthermore, unfortunately a lot of IT managers from various companies have chosen to be anonymous, and because of it it is not possible to mention here their name and their companies as well.

- Prof. Piero Formica: he is Senior Research Fellow at the National University of Ireland and Intel Innovation Value Institute (IVI), Dublin. He is also Founder of International Entrepreneurship Academy in Nice, France. Then, he is Professor of the Chair of Human Resources Development and Entrepreneurship Research at King Saud University in Riyadh, Saudi Arabia.

- Prof. Brian Donnellan: he is Co-director of the Innovation Value Institute in Maynooth, Ireland. Before joining academia, Prof. Brian Donnellan spent 20 years working in the ICT industry. While in industry he was responsible for the provision of information systems to support New Product Development.

- IVI (Innovation Value Institute): some of the PhD students within IVI helped me in my analysis, answering this survey. In particular the institute “researches and develops unifying

frameworks and road-maps for IT and Business executives to create more value from IT and better deliver IT enabled innovation whilst validating that these frameworks/tools have a broad applicability across differing industries and contexts" ("http://www.ivi.ie"). They developed the IT-CMF (Information Technology – Capability and Maturity Framework), mentioned several times in this document. One of the research areas (that is one of the critical processes of the IT-CMF) is "Sustainable ICT". So, with the provision of opinions and case studies conducted by themselves (BP, Chevron, Intel are the ones I got from them), the value of this analysis resulted, in my opinion, increased.

- Green IT Observatory, RMIT University: the survey was also sent to them, that contribute to the collection of data with a couple of responses. RMIT has three campuses in Melbourne, Australia, and two in Vietnam. The School of Business IT & Logistics at RMIT has a world class capability in sustainable IT/IS. The group of academics and doctoral researchers in the school's Green IT team have between themselves some 30 years of accumulated experience in IT/IS management and in the transition to sustainable IT/IS. The Green IT research has a strong industry focus and work with and/or is supported by the Australian Information Industry Association (AIIA), Fujitsu Australia and Connection Research and is a member of the Centre for Sustainable Organisations and Work, RMIT University.

- Other whom have not chosen to be anonymous are: Brandner Christophe, from Interact Consulting; Jeremie Guy, Shuyan Xie, and Lucasz Ostrowski, all of them PhD researchers at the School of computing in DCU (Dublin City University), Ireland; Martin Meyer, involved with IVI and Intel for a research about IT enterprise architecture; Mouzhi Ge, researcher at the TUD (Technical University of Dortmund), Germany.

Totally have been collected 17 answers. All the respondents answered to almost all the questions, except the PhD researches that, obviously, they had no reason to answer to question number 2, because they do not aware of policies and initiatives implemented by their company.

6.3.3 Analysis and interpretation of the answers:

within this paragraph will be presented the results of the Green IT survey, previously introduced, and will be made some reflections on them. In particular, first will be tackled separately all the questions and then will be provided some general comments and a personal interpretation on the results. In order to simplify statistical and embedded analysis of the results I have used an excel file, which is proposed at the very end of this document (see Appendix 2).

Question 1:

fortunately, to this question were observed almost all positive responses. Through the comments was interesting to see how the respondents approve my definition of Green IT. In particular, what can be actually seen, is a stronger focus on the second part of the definition, that which refers to the "Greening BY IT". In fact, as underlined in chapter 2, the greater benefits, in quantitative terms, come from this second step of the Green IT strategy. Then in reminded the report released by McKinsey previously mentioned, in which is stated: "ICT can provide business solutions that can alleviate at least five times the GHG footprint of ICT itself" ("Smart 2020 Report", McKinsey 2007). Within the excel page (see Appendix 2), can be observed that "16,5" respondents agreed with my definition. The missing "0,5" refers to a particular comment that was as follow: "I agree, but please see Rick Watson's definitions of Green IT and Green IS (Information System) in his Open Source book on Energy Informatics". Reading those pages, he affirms that "green IT is the most important

technology for 2008"; and again, "IS has a central role in sustainability because of its cross functional view of the entire organization and its ability to understand, change and reinvent business processes" (Watson, R.; Boudreau, M. "Energy Informatics", 2009). From this words the definition is similar to the one given in this document. However, in those pages, Watson places particular attention to the cultural aspects of this kind of strategy. Therefore, this comment was not a motive of major concern for my pages because, even if these aspects are not formally included in the definition, they were considered as a cornerstone to capture business value from a Green IT strategy, within the BSC, as demonstrated in the "Stakeholders and Culture Perspective" (see paragraph 5.3).
Finally, I was satisfied by the answers collected for this question. In the case of serious disagreement with this definition, would have been useless an analysis like this, and all the work would have been upset.

Question 2:
being this question referred to an opinion, all of the respondents answered to this question. The aim of this second analysis was to understand the strategical importance of Green IT. Surprisingly nobody thought the Green IT simply as "focused on technology", nor as a "cost centre". So, can be captured from the experts' opinions that to a Green IT strategy might be reflected some benefits for who implement it. In other words, play out such initiatives does not only mean just spend some money in order to fall into constraints imposed from outside the company. Moving on, 35.3% of respondents see Green IT as established as a quality centre ("Service Centre"), the most part (41.2%) give it a significance in the strategic goals definition ("Investment Centre"). Finally, the remaining 23.5%, attach the greatest importance to the Green IT strategy. Between the latest I found interesting two particular comments: "extracting social value drives new economic value", reported one of the experts, and "for sustainable IT, Green IT needs to be reflected in the overall enterprise strategy", said a researcher involved in this field. What can be deducted from this second question, refers to the widespread emphasis on the strategic importance of Green IT. Was curious to observe how people from the academia field gave on average a higher level of importance to Green IT, sustaining the statement done in these pages about the importance of align the Green IT strategy with the overall business strategy. This result can be explained by the fact that the topic is new, and in this period of time is the research field that identified the real potential of Green IT. On the other side, companies, because of a lack of complete implementations, are still cautious in attributing too much importance to the Green IT.
So, is definitely proved that there is the possibility for a company to capture business value (or at least benefits for the third level) from these initiatives.

Question 3:
this question was treated in a little bit special way. In particular, only twelve responses were received, two of which came from PhD researchers. Despite their knowledge, I have chosen to discard these two answers from the analysis because of two main reasons: first, they are not completely aware on what are the initiatives undertaken by their Universities in this way, and secondly Universities themselves would deserve a separate analysis for their peculiarities (in particular is meaningless the strategic path identified with the perspectives because create business value might not be the primary goal for a Green IT strategy within an University).
So, the initiatives considered crucial for a Green IT strategy, were almost confirmed as important by domain experts. Only six answers fell in the box "not relevant". Nevertheless, contextualizing these responses in the context where they came from, can be seen that those initiatives ("prevent amount of e-waste", "recycling of IT products", "reduce data centre

environmental impact") are actually not fundamental for their businesses. In fact, was stressed several times in this document that different businesses have different priorities, and for example for a SME purely manufacturer it is not a cornerstone to become green consider the environmental impact of their data centre. On the other hand, responses from them showed how they are more concentrated in use renewable energy, promote cultural changes and de-materialising their internal processes. Anyway, generally for each initiative at least 70% of the responses affirm and state its relevance (so was chosen one of the possibilities between: "considered", "considered and measured" and "should be considered"). What is highlighted is that most of them are actually considered in the companies, and from the comments can be understood that what is missed is a holistic and embedded approach in implementing those initiatives. The only anomaly I found in these answers is in the "calculating and managing footprint" area. Here, despite the steady growth of standards methods for calculate the carbon footprint (as presented and documented in the paragraph 5.4.3), 60% of the respondents affirmed that there are not efficient measuring tools, and as can not be managed what can not be measured, this resulted not considered at all. Another surprising thing was that the initiatives properly considered and measured were generally scarce. This fact underlines again the lack of a proper approach by companies to the Green IT strategy. Finally can be identified that 20% of the respondents think that implement a virtualized architecture costs more than how much it gives back (the investment is more than the actual gain achievable), but this can be justified by the small size of those companies.
As a conclusion can be said that generally companies are aware about the initiatives to be undertaken, but there is a general lack of a embedded strategy, reason because I consider this document useful at this time.

Question 4:
within this question there were not many surprises. In fact, the respondents confirmed what was supposed in this document about the internal benefits achievable by the implementation of the Green IT initiatives taken into account within this question. What I want underline here, is that researchers' opinions and managers ones were aligned. So, there is a widespread awareness about the "goodness" of such goals to be reached. In Figure 17 is proposed a graph with the average score attributed to each aspect. A great emphasis from company refers to the effort put in order to reduce energy consumption and considering the environmental impact of data centre. On the other hand, it is quite low the score assigned to the issue "prevent amount of hazardous waste". Here a brief reflection is needed. In particular, has to be justified what have been said about the benefits achievable by preventing the impact of e-waste when they're going to landfills (see paragraph 2.3.5). I think that can be understood this low score as follow: considering hazardous wastes issues does not bring direct benefits, but can enable other mechanisms that allow to capture other indirect advantages (e.g. can be leverage into marketing policies the compliance of regulations in this field). So, I think that experts see at this issue as something to fulfil, rather than a direct opportunity to capture benefits, and then it is explained the low score attributed to it.
In the next figure is proposed a wide view of the answers and of the scores assigned to each aspect:

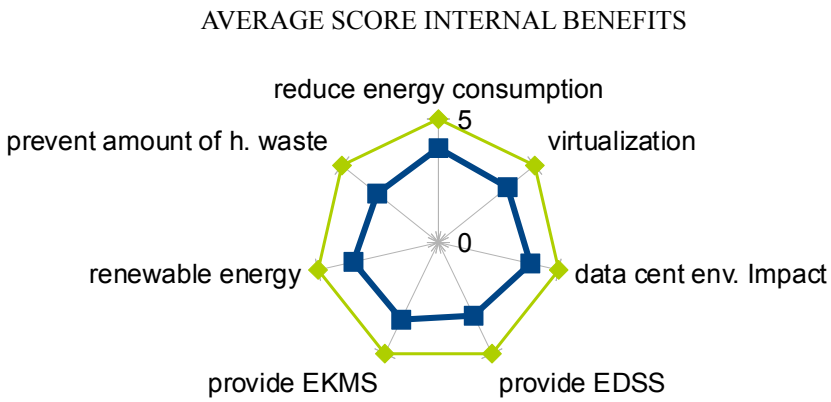


Figure 17: Average score internal benefits;

From the figure can be easily understand how all of these Green IT initiatives are considered as an opportunity to capture internal benefits for the company. As explained above, the aim of this question was to prove that the objectives proposed for the Green IT BSC are consistent with the companies' priorities in the Green IT area. The high scores detected demonstrate what was stated in this way.

Question 5:

in this last question of the survey, the aim was similar to the previous one. In particular, what I want to be sure was the effective possibility to capture competitive advantages by the implementation of the initiatives proposed as objectives for the Green IT strategy in the BSC. As done for the previous question is offered a figure that summarizes the opinions collected by the survey:

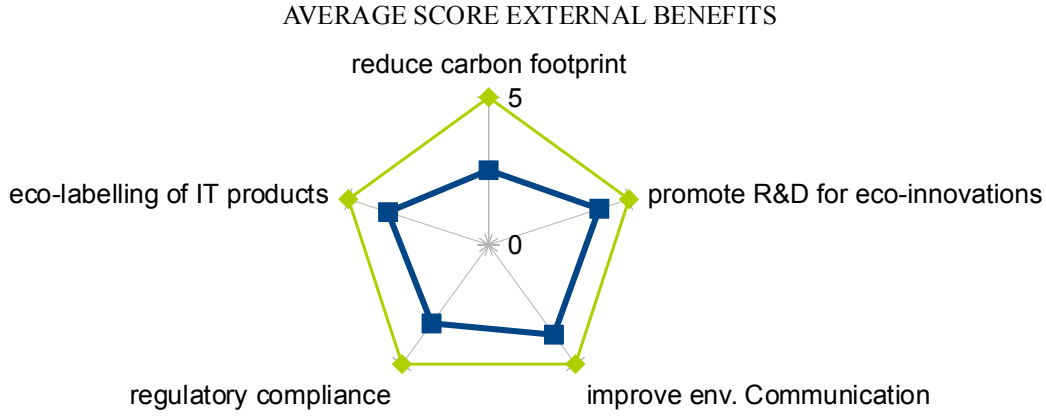


Figure 18: average score external benefits;

Even here, an anomaly can be detected in the initiative “reduce carbon footprint”. A possible reason for this low score can be found referring to the question 3. There, indeed, 60% of respondents affirmed that the aspect “calculating and managing carbon footprint” was not considered in their businesses because there are not available efficient measuring tools. A further 10% stated that it is not relevant for their company. However, at the same time implementing all the initiatives they considered relevant, leads to a situation in which the carbon footprint resulted actually reduced. Personally, I thought a lot about this result. The

only explanation I found, refers to the impossibility to communicate effectively a carbon reduction plan and its results, because of a lack of ways to measure the carbon footprint (in their opinion). So, without an effective communication, can't be captured competitive advantages.
Going on, as expected to the other initiatives was suggested a high score. Particularly are considered fundamental issues like "improve environmental communication" (average score: 3.77) and most of all "promote R&D for eco-innovations" (average score: 3.94). As a consequence, are proved those statements about that through an effective communication are achievable goals such as "investors and customers loyalty" (see paragraph 5.4.6) and "stakeholders satisfaction" (see paragraph5.3.2), that are direct linked to the achievement of competitive advantages. On the other hand, it is equally considered fundamental a "future orientation and development" (see paragraph 5.4.4) putting as much effort as possible for disruptive innovations.

6.4 SUMMARY AND CONCLUSIONS:

In this chapter were presented the "Demonstration" and "Evaluation" steps in the Design Science Research Methodology (Peffers, 2007). As stressed several times, a proper evaluation for this Green IT BSC would have been its application in a real case to be studied. However, it would have taken a long time to be correctly implemented (I guess around a couple of years) because of the holistic approach that stays behind this kind of strategy. In order to propose a sort of validation for what have been stated in this document, I mentioned the two steps: "demonstration by references" and the "Green IT survey". Summarizing I used the literature to build the BSC (and in particular the cause-effect relationships), and afterwards I collected data from domain experts in order to verify if I made the right choices in assessing a Green IT strategy that allow to capture business value. The survey analysis confirmed almost everything and where there were anomalies, I proposed some personal reflections and interpretations. Concluding, further programs for validate this Green IT BSC will be hopefully implemented in the subsequent PhD program.

Chapter 7: Conclusion

This final chapter will conclude this master thesis. Here will be provided a short summary on what have been done and stated in this document.
In few words, what has been provided is a holistic approach to the definition, execution and management of a Green IT strategy. I have started from the definition and motivation of the problem that had to be solved (see chapter 1). Generally, this referred to the environmental impact of Information and Communication Technology. Defining the issue, have been emphasized the benefits that may result from a solution, in the businesses. Another fundamental aspect that was underlined, refers to the actuality of the topic, demonstrated by the pressures that come from customers, investors and governments in this way. Then, the problem is relevant, and so, as a consequence, would be a solution. Going ahead, through a careful review of the (scarce) literature (see chapter 2), were identified the (single, "not-embedded") initiatives in this way. These were consistently divided in two main categories: initiatives in order to minimize or eliminate (where possible) the environmental impact of ICT itself, and initiatives referred to the usage of ICT in several ways in order to promote a sustainable approach in the overall business activities. For each aspect were presented and described the two main pillars of a Green IT strategy. In particular, was highlighted how each initiative could provide benefits for the company taken into account, and, in parallel, how and how much each one could contribute minimizing the carbon footprint created.
So, starting from the proper implementation of such initiatives, were defined the "objectives for the solution" (Peffers, 2007). In fact, what is needed, in order to solve (or minimize) or minimize the problem, is to deploy a Green IT strategy. For doing this, a company should provide a strategic path to be followed and, at the same time, a systematic framework for its proper management and its alignment with the overall strategy. This last aspect was considered fundamental in order to capture business value from Green IT, as the greater benefits come from the usage of IT in business activities, beside a "green" IT infrastructure itself.
Then, the artefact, or the solution in order to solve the problem and, at the same time, achieve the objectives, was designed and developed as a Green IT Balanced Scorecard. This is the core part of this document.
The choice of using a BSC, rather than another standard framework, came from its affirmed effectiveness (and its very high level of usage) in assessing different strategies in many business contexts. A BSC, indeed, being a holistic approach from the strategy definition to its execution and verification, satisfies all of the objectives for a solution previously defined. Then, after several attempts, were defined four perspectives that make up the structure of the framework.
In order to introduce those perspectives and the subsequent objectives, I imposed to myself two main constraints for this Green IT BSC: first, the model must take into consideration every single aspect that characterizes a Green IT strategy. In practical terms, it shall include all of the focus areas identified in the review of the literature (see chapter 2); on the other hand, it should provide a strategic path through which the mission is reached. In other words, the perspectives must have a precise strategic meaning, and it is not sufficient to provide homogenous assessment groups in order to formulate this BSC. In fact, just translate the initiatives into objectives for the strategy, and provide a set of indicators for each of them, was not enough in order to build a proper BSC. A framework at this step can be simply seen as a "KPI Scorecard" (Kaplan, Norton, 1991). Hence, has been given a meaning to this perspectives in terms of strategic path to be followed for achieve the final goal of a Green IT strategy: capture business value. In short, those perspectives can be explained in just one sentence, as follows: "with the proper technology infrastructure ("Infrastructure Perspective"), and an internal culture turned to green ("Stakeholders and Culture

Perspective"), through the organization and its internal processes ("Sustainability Perspective"), can be capture business value ("Business Value Perspective").
So, within these perspectives were totally provided 28 objectives to achieve, and 115 indicators. Then, the assessment is made through the calculation of these indicators (consistently with the size/core-business of the company) to verify the level of achievement of these objectives, within the four perspectives. As stressed several times, the consideration of each objective and each indicator, can completely change depending on the organization taken into account, its priorities, its "as-is situation", its size, and, mostly, its business.
Once defined the BSC itself, even the objectives were positioned into a strategic path towards the achievement of the mission. It was a graphical map of such objectives linked to each other, what commonly called Cause-effect Relationship. Thus, the Green IT BSC was completed.
Going on, the final challenge for this master thesis was to find a way to demonstrate what have been stated, consistently with a standard Design Science Research approach. Obviously, the best way to prove its utility and that it effectively solves the problem initially defined, would be a case study. However, its real implementation would have taken too much time and goes beyond the goals of this document. Hence, what have been done was to justify as much as possible what stated here, through the literature. This target was reached mentioning several researches, studies, surveys, and investigations in the field of Green IT. Furthermore, was deployed a survey, developed by myself, to some domain experts, both from the academia and business fields.
Future programs on this Green IT BSC will be implemented within a 3 years PhD program, which will follow my graduation. Then, I will focus mostly in the framework's utilisation within a company. Nevertheless, the main goal will be continuing keep this framework a flexible model, required prerogative having regard to the novelty of the topic, and to the turbulence of the underlying context.

APPENDIX 1:

Here is proposed a Word version of the online Green IT survey.

SURVEY GREEN IT

Short description: this survey is part of a master thesis in Green IT. My aim was also to introduce a management tool for managing and assessing a Green IT strategy in order to capture business value: a Green IT Balanced Scorecard. This survey will be very useful for validate my BSC with domain experts opinions. All the information you provide will be treated confidential and not spread to other persons.

All the questions are voluntary and if you do not want to answer some of the questions this is your choice to make.

- Please fill out the information below:

Name	
Company	
Position	

	YES	NO
Wish to be anonymous?		

If you choose not to be anonymous, the company name and your name will be visible in my master thesis, but it will NOT be possible for readers to know whom of the respondents that answered what in the survey.

Contact informations: if you have any questions, or are interested in deepening discussion on the subject, please do not hesitate to contact me:

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In my master thesis the Green IT was defined as follows. “Green IT is made of two processes: “Greening OF IT” and “Greening BY IT”. So, it can be defined as the study and practice of designing, manufacturing, using and disposing of computers, servers and associated subsystems, efficiently and effectively, with minimal or no impact on the environment (“Greening OF IT”). Then, beside IT itself being green, the “Greening BY IT” refers to the usage of IT in several ways to improve environmental sustainability in business activities, and to its usage in innovative ways to create awareness and promote sustainability among employees, business partners, stakeholders and customers”.

1. **Do you agree with these definition? Otherwise, how do you define and use it?**

2. **In your opinion, the Green IT can be seen as:**
   Please fill the correspondent box.

Focused on technology (no formal Green IT presence, users themselves create policies)	
A cost centre (Green IT offers little or no strategic inputs to the business)	
A service centre (Green IT established as a quality service)	
An investment centre (Green IT discussed and used when setting strategic goals)	
A value centre (Green IT considered as a core competency for the company)	

If you have any comments or want to justify your answer, please write them in the following box.

Comments:

3. **For each of the initiatives listed in the following table, please indicate if, in your company, they are:**

   A: considered;
   B: considered and measured;
   C: not relevant,
   D: the investment is considered greater than the actual gain;
   E: there is an absence of efficient measuring tools (and can not be managed what is not measured);
   F: should be considered.

PROCESS	A	B	C	D	E	F
Calculating and managing Carbon Footprint						
Usage of renewable energy						
Reduce data centres environmental impact						
Prevent amount of hazardous waste						
Reduce physical IT infrastructure (virtualization)						
Recycling of IT products						
Create awareness and promote internal cultural change						
Environmental-related risk mitigation						
De-materialization (e.g. decrease paper usage)						

Comments:

4. **In your opinion, how much these internal aspects can provide benefits for the company?**
   Enter a value from 0 to 5, where 0 represents the situation in which there are no possibility to capture benefits from that variable.

ASPECT	0	1	2	3	4	5
Reduce energy consumption						
Prevent amount of e-waste						
Usage of green power						
Provide environmental knowledge management systems						
Provide environmental decision supporting systems						
Reduce data centre environmental impact						
Usage of server virtualization						

Comments:

5. **In your opinion, how much these other aspects can improve public image, customers and investors loyalty, and then contribute to the achievement of competitive advantages?**
   Enter a value from 0 to 5, where 0 represents the situation in which there are no possibility to capture competitive advantages from that variable.

ASPECT	0	1	2	3	4	5
Effectively reduce overall carbon footprint						
Eco-labelling of IT products (e.g. Energy Star, EPEAT)						
Regulatory compliance						
Improve environmental communication						
Promote R&D for eco-innovations						

Comments:

Thank you very much for your kind collaboration!

Giovanni Maccani.

APPENDIX 2:

SURVEY ANALYSIS

QUESTION 1	**yes**	**no**	**tot**	**%yes**
definition agree:	16.5	0.5	17	97.0588235

QUESTION 2	**1**	**2**	**3**	**4**	**5**	**tot**
green IT seen as:			6	7	4	17
	%	**%**	**%**	**%**	**%**	
	0	0	35.29411765	41.1764706	23.52941176	

QUESTION 3	**cons**	**Cons. & meas.**	**not relevant**	**Inv. > gain**	**no meas tools should be c.**	**tot**
Green IT initiatives:						
calculating and managing carbon f.	2	1	1		6	10
renewable energy	6				2	2	10
data cent env. Impact	4	2	2			2	10
prevent amount of h. waste	4	1	1			4	10
virtualization	4	3		2		1	10
recycling of IT products	5		2		1	2	10
awareness and promote cultural c.	8			1		1	10
risk mitigation plan	3				2	5	10
De-materialisation	7	1		2			10
percentages	**%**	**%**	**%**	**%**	**%**	**%**
calculating and managing carbon f.	20	10	10	0	60	0
renewable energy	60	0	0	0	20	20
data cent env. Impact	40	20	20	0	0	20
prevent amount of h. waste	40	10	10	0	0	40
virtualization	40	30	0	20	0	10
recycling of IT products	50	0	20	0	10	20
awareness and promote cultural c.	80	0	0	10	0	10
risk mitigation plan	30	0	0	0	20	50
De-materialisation	70	10	0	20	0	0

QUESTION 4								
Benefits score	**0**	**1**	**2**	**3**	**4**	**5**	**tot**	**av.**
reduce energy consumption		1		3	10	3	17	3.824
prevent amount of h. waste			3	8	6		17	3.176
renewable energy		1	2	5	5	4	17	3.529
provide EKMS		1	1	6	7	2	17	3.471
provide EDSS		1	3	4	8	1	17	3.294
data cent env. Impact			2	3	8	4	17	3.824
virtualization			3	5	5	4	17	3.588

QUESTION 5								
competitive advantages score	**0**	**1**	**2**	**3**	**4**	**5**	**tot**	**av.**
reduce carbon footprint	1	3	4	4	5		17	2.529
eco-labelling of IT products			2	5	8	2	17	3.588
regulatory compliance		1	5	1	8	2	17	3.294
improve env. Communication		1		5	7	4	17	3.765
promote R&D for eco-innovations			1	4	7	5	17	3.941

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