

# DIGIT~Bio~TECH



## LO4 GREEN ENERGY & ICT: FROM SMART TO WISE STRATEGIES

*Advanced level*

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# Introduction

Nowadays, ICT plays an important role in the environment protection and fighting climate changes. It has attracted considerable attention of diverse types of international forums. Temperature and sea level rising, as well as the floods incidents and storms are undoubtedly impacting climate change, and influencing also the balance of the ecosystems, water and food supply, public health, industry, agriculture and infrastructure. The measures to combat climate change are focused on strategical aims like: i) energy efficiency enhancement; ii) increase the part of energy used from renewable sources and assure the trustworthiness of energy supplies; iii) ensure the supply of energy products and services, and sustainable production of green products.

The energy market today is undergoing serious reforms due to the introduction of new advanced energy technologies. They cause continuous environmental problems, rising needs for European and international cooperation. In this aspect, various intergovernmental agreements have been concluded to sharp and harmonize the organizational and legislative framework of the energy markets. Along the increasing attention for global climate change and related to the energy markets, the green Information and Communication Technologies (ICT) has been proposed as one, in which the environmental impact is taken into account in the design of new systems and technologies.

The topics of “Green informatics” and “Green ICT” are frequently discussed and the interest in ICT’s potential needs to be better appreciated and to focus the attention it deserves. The Green Informatics includes design, construction, and information diffusion techniques and offers optimization of environmental governance, in its efforts to save the natural environment. In this way, it contributes to successful management of the natural resources regarding sustainability, taking into account as well the energy requirements, in particular the alternative energy sources.

The web technology and broadband Internet along with web-based projects are penetrating in a great speed our society and a huge amount of information moves across the WWW worldwide. The Green Informatics are ICT tools, services and technologies deal with green practices and green manners either in the ICT industrial sector or with the ICT users. This can contribute also to the preservation and recovery of the environment as well as to the promotion of the quality of human life. Thus, the concept for “Green Informatics” has turned into a synonym to eco-friendly technology and software tools like Virtualization, Recycling and Telecommuting.

At present, ICT unifies the electronic services (e-services) - broadband network infrastructure - mobile services, and wireless technologies. This mergence led to the development of instruments, products, services and technologies with increased social network opportunities, available 24/7, worldwide in all sectors of human life.

Broadband has been the entrance to the networking economy. Its abilities to convert the daily processes into work and life opens new business prospects for development nowadays, when a lot of countries are fighting to save their economies during global economic crisis.

The services for stabile permanent access to Internet assure reliable delivery with a great speed of Internet of high quality almost all over the world. Part of the web-based products commonly used to assure e-services are e-learning, e-working, e-banking, e-voting, e-government, e-commerce, e-shop, e-



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research, e-medicine and e-payment. Recently, useful mobile broadband services (m-services) adapted to the needs of the people were set up. They combine elements of user-generated content with network-based promotion. Through modification of economic and social measures, the mobile technologies support the sustainable development through green banking, green commerce, green governance, green constructions, etc.

## The global trends in green ICT development

In order to understand the global green ICT trends, the current dynamics and directions of different sub-trends should be understood. The context of current green ICT trends should be explained, including the evolution of green trends and the background of ICT. From the perspective of green ICT, it is important to distinguish three different green trends, each of them alive today, but with different logic and history.

### LOCAL CONSERVATION

The first green movement (1860-1960) followed the idea that nature was static and should be protected against Industrialism. The main focus was on the creation of national parks, nature was primarily seen as an object of study and a place for recreation. Protecting nature just because it is beautiful and because it offers a place for recreational time spending is still a major part of the green agenda in many countries. This type of link to green ICT can be seen even today when companies plant trees to improve their image. There are still companies who think that a donation to a conservation project is a key part of their green work and many of the major environmental NGOs still approach ICT companies as a source of funding for conservation projects.

### POLLUTION CONTROL AND CORPORATE SOCIAL RESPONSIBILITY

During the period 1960-2000, a different trend is shaped, as instead of protecting individual natural areas, companies and policymakers considered the industrialization as on a collision course with the planet. This trend saw companies mainly as a source of environmental problems therefore, rules and regulations were created to minimize the negative impact of companies. The response of most companies was to establish environmental health and safety (EHS) staff and corporate social responsibility/public relations (CSR/PR) staff. Focus was on the end-of-pipe technologies and communication. Many companies, and especially business associations, considered environmental regulations as a threat to their business and this perspective still exists in many processes related to green issues. Several governments still define green or environmental technology as the end-of-pipe technology. The renewable energy is ever increasingly similarly regarded. But some include transformative low-carbon

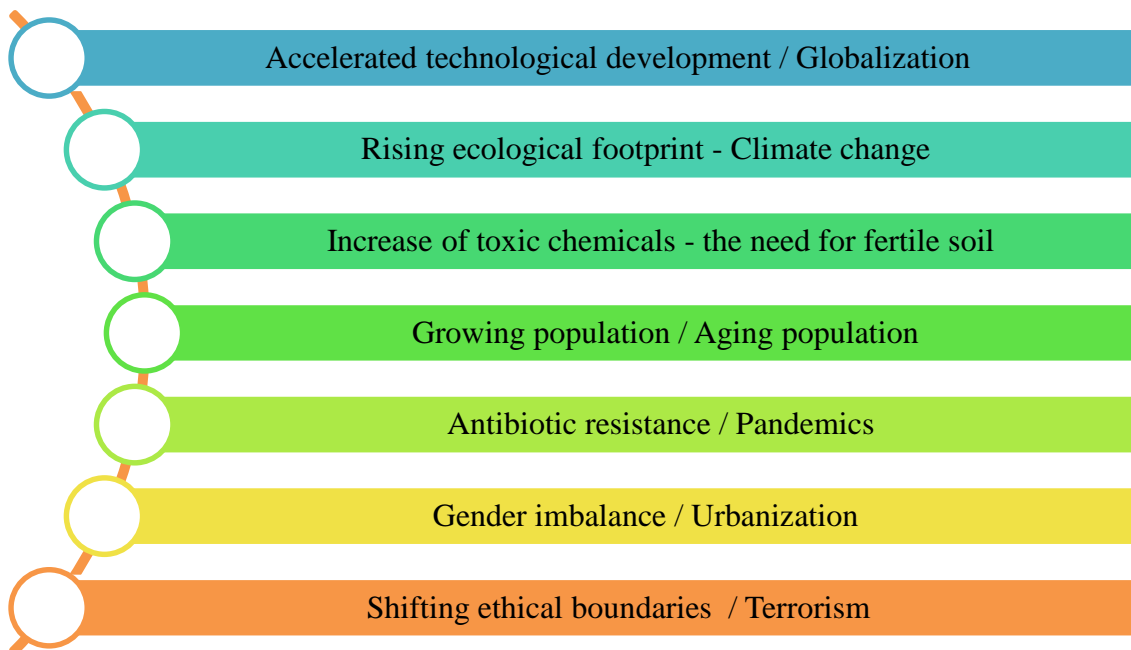


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ICT solutions, such as teleworking, e-books, smart control systems for buildings, even though these are of key importance to reduce emissions and the need for natural resources.

## SOLUTIONS, TRANSFORMATIVE CHANGE, AND PROFIT

At the early 21<sup>st</sup> century the need for transformative change and sustainability moved to a new phase. Instead of biologists and environmental organizations identifying problems, a new generation of stakeholders started to present solutions. This new trend of green thinking was the result of a number of converging trends (see Fig. 1). In addition, the new generation of entrepreneurs and business leaders see the opportunity to link the need for dramatic resource efficiency with the sales of new products and services. Instead of approaching green as a threat that only demands an incremental improvement in existing systems, these entrepreneurs have realized that new smart solutions, which challenge existing business models and ways of providing services, are ready. Underlying this shift is ICT development and its targeting of new areas. E-books, smart grids, electric cars, video conferencing and mobile applications are just a few examples of ICT driven solutions.



**Figure 1. Converging trends of green thinking**

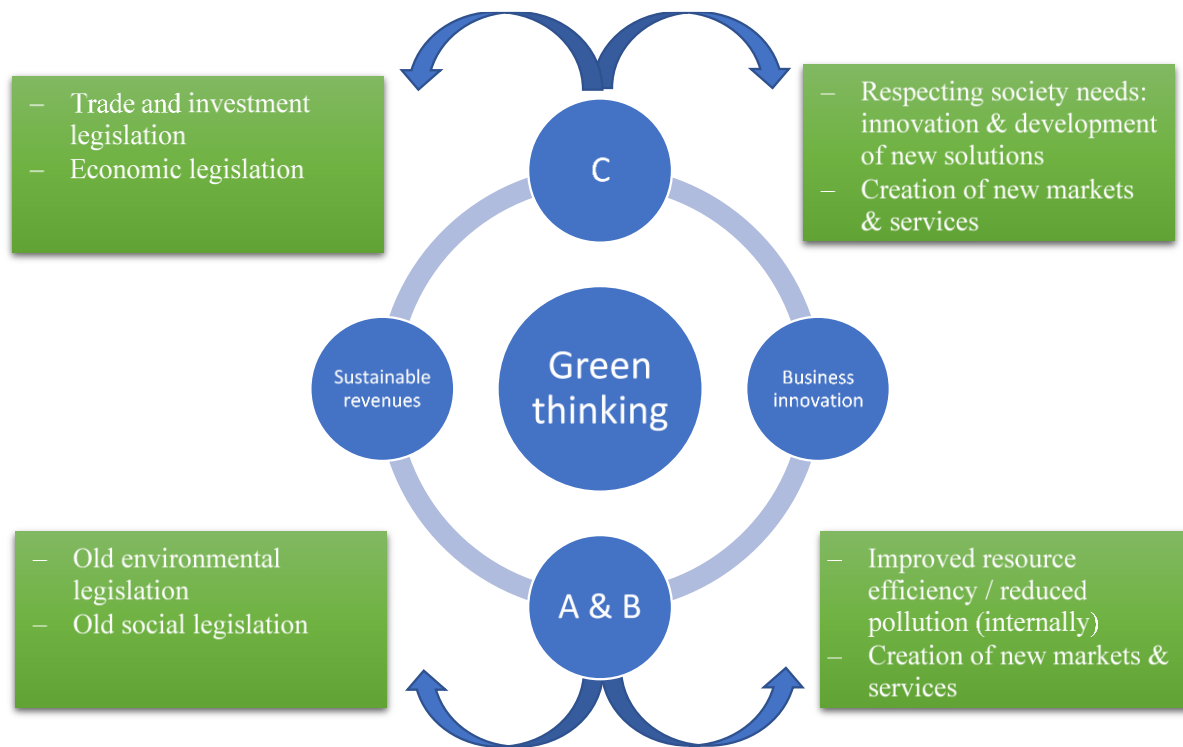
This trend of green thinking often creates significant pressure within existing structures in respect to the older trends on multiple levels. An overview of the different scopes and approaches related to



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business and policymakers is presented in Fig. 2. It is a matrix that illustrates the strains between the different institutions with different roles, as well as the pressure due to the discrepancy between the problem perspective and the solutions perspective.

In the upper half of the matrix, companies focus on society needs and apply sustainability as a driver for innovation and profit. The actions within this part would be possible because of the unified efforts of entrepreneurs, business leaders and strategic players within the government. However, green alone is rarely the key driver due to the discrepancy among various stakeholders: governments, NGOs, media, etc. It is hard to implement greening with ICT solutions, since they require collaboration between multiple stakeholders. The result is a lot of green initiatives that focus only on ICT companies, as the source of emissions. Besides, companies that are solution providers implement a number of green solutions, but neither the solutions are called green nor the people using these solutions are aware of the green benefits from them. Thus, a shift from the traditional ‘problem’ approach to the new ‘solution approach’ is needed.



**Figure 2. Current and future green thinking trends. Legend: A – Local conservation; B – Pollution control and corporate social responsibility; C - Solutions, transformative change, and profit**



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## World directions in green ICT policies

An analysis of the global trends in green ICT has been performed with the purpose to find out what are the predominant trends in green ICT policies at global scale from medium- and long-term point of view. The analysis was carried out applying a desk research approach. First, relevant documentation related to green ICT was identified and, second, based on this documentation, the corresponding green ICT related policy trends at the EU and global level were outlined. The documentation set encompasses variety of EU and OECD strategy documents (e.g., OECD Green Growth Strategy, EU 2020 strategy, Digital Agenda etc.), as well as on researches and case studies performed before.

### GREEN ICT ADVANCEMENT: GLOBAL LEVEL POLICY

Both green ICT and greening with ICT comprise a new concept that has been on the economic and societal agenda since a decade. The area of greening with ICT is so new that it is hardly possible to launch a good practice for a single country to be securely followed. Most policymakers, major researches and business groups unambiguously declare that the greening with ICT is significantly important. However, the real programmes and policies at governmental level, NGOs' work, research at universities, business initiatives, etc. are rather concentrated on the direct effects then on the long-term impacts.

A number of studies have shown that the majority of the initiatives at both governmental and business level focus on greening of ICT not greening with ICT. A study, performed by the OECD, published in June 2009 showed that most *“Green ICT” initiatives concentrate on the direct effects of ICTs themselves rather than tackling climate change and environmental degradation through the use of ICTs as an enabling or “smart” technology*. The OECD analysis showed that the government programmes include initiatives to consider the enabling effects of ICTs. The ICT applications used for the dissemination of environmental information, for smart transportation, grids, and buildings are the most commonly promoted. However, software for energy optimization or smart engines have been less indorsed.



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There is a gap between the policymakers and ICT companies that want to support a good image in front of the society, who focus on greening of ICT, and the needs for implementation actions that will lead to greening with ICT. In this context, solutions are necessary to be implemented by the institutions and frameworks in the form of new rules and regulations to support greening with ICT.

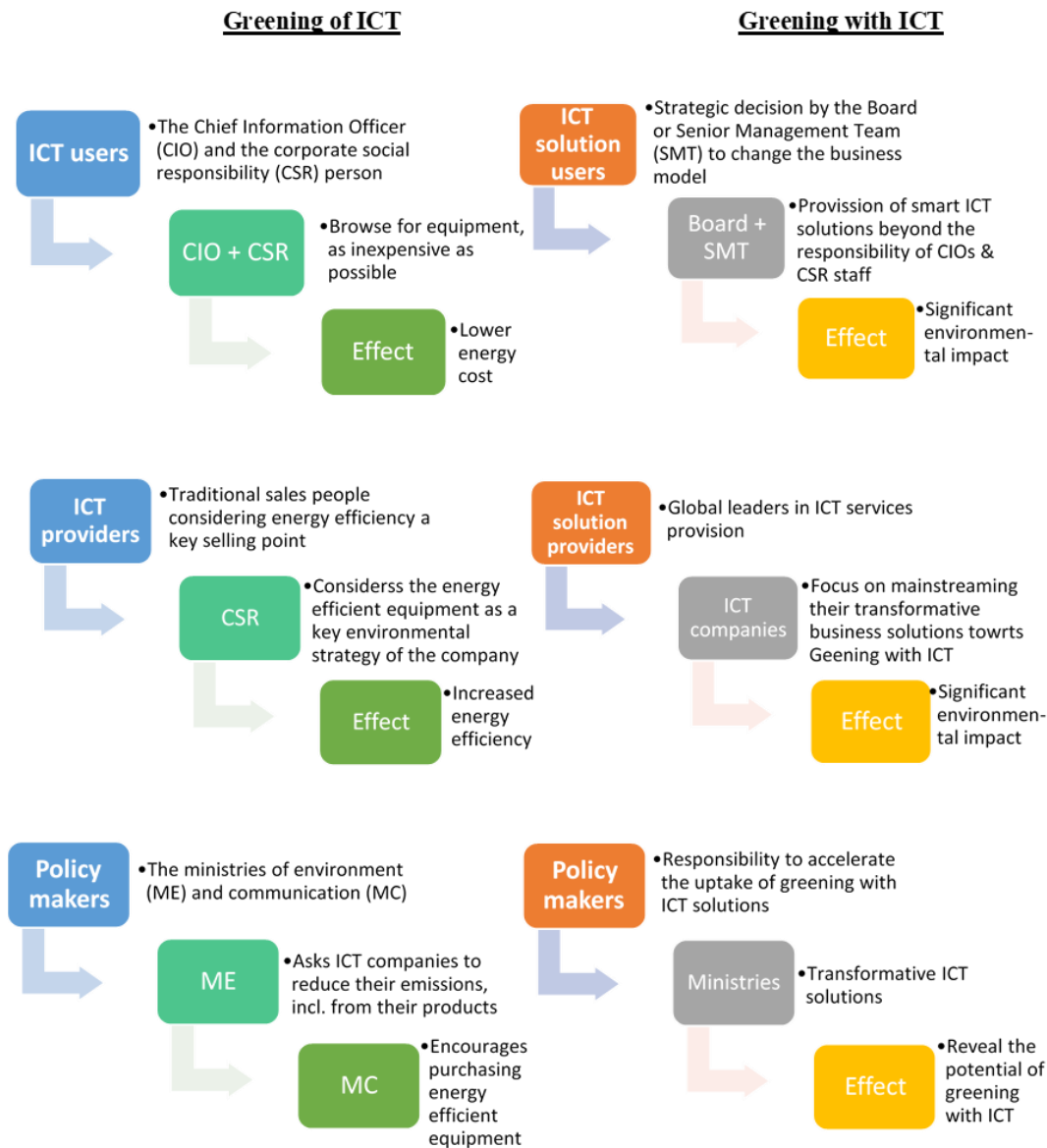
There is a variety of opportunities and challenges ahead the policy makers and businesses stakeholders along this implementation. To be best understand, these possibilities and challenges must be considered in respect to the main ICT players contributing to both greening of ICT and greening with ICT ideas. These interrelations are depicted in Fig. 3.

It can be seen that the majority of policy makers, foremost researches and business groups definitely indicate that the greening with ICT is meaningfully more important than greening of ICT.

The new concept of greening with ICT most commonly does not require only business relations but policy makers that create a new legislative framework and relevant guidelines for its implementation. However, currently the real initiatives of the business and the actual policies still focus on greening of ICT, persuading the direct effects of it.



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**Figure 3. Main ICT players contributing to greening of ICT and greening with ICT ideas**

A global trends analysis has been performed to make an overview of the long-term tendencies in global policy making in respect to green ICT. A representative selection of the most relevant and comprehensive documents worldwide has been evaluated. It is assumed that within last two decades, greening with ICT has moved ahead from being an almost fiction idea into being an important subject. In the 1990s, greening with ICT matter has not been included in global strategy documents or policy



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making. The role of ICT in sustainable development had shaped clearly among thought leaders at the beginning of the new 21<sup>st</sup> century. However, it was still more or less overlooked by both the policy makers and the business. The reason for this underestimation was grounded on the fact that the executive power was given to leaders from ministries of environment, and their efforts, and solutions, were sector-focused.

However, at that time the changes in policies on strategy level has started to officially recognize the businesses as an active party in solutions development; the power of ICT in supporting a more environmentally sustainable development was also acknowledged. Most governments and organizers that had mainly focused on the building of ICT infrastructure and the standards and rules its operation requires, embarrassed the new idea that ICT could be used to support an environmentally sustainable development. Accordingly, the companies have started to be seen as solution-generators that contribute to accelerate sustainable development instead of pollution-makers, which should reduce their emissions.

Starting from 2007, first attempts to include governments and businesses in a discussion about greening with ICT were organized. A year later, the chair of G8 brought green ICT to the forefront of the discussions' agenda for the first time. The G8 leaders united around the immediate necessity the world to diminish carbon emissions, contributing strongly to global warming, by at least 50 percent by 2050. It was then the issue of green ICT was opened and OECD and EU confirmed the tendency through increased focus on greening with ICT.

In this way, greening with ICT has been acknowledged as a policy area. However, between the new ideas generated and their practical realization, there is still an "implementation gap. Since not all the ideas become reality and the shift from words to actions does not take place very smoothly, the businesses are facing serious challenge how and when to make their contribution to the greening with ICT trend.

Greening with ICT strategy is growing more stable to become a significant element in the mainstream policy making. The global climate meeting in Durban, 2011 and the Rio+20 conference in 2012 were the first forums that indicated this. More and more leading countries want greening with ICT to become a part of the global agenda for planet saving. They recognize competitive advantage in developing and exporting greening with ICT solutions, and the greening with ICT is already deeply integrated into their policy making.

## THE LEADERS IN GREENING WITH ICT

In general, all main international stakeholders are key players in the greening with ICT area. At present, however, there is no a single leader; by contrast, there are many players that are focused on the process of greening with ICT with varying intensity and success. Indisputably, OECD and the European Commission are very important stakeholders but many innovative ideas have been emerging from independent business coalitions. Thus, there is a tendency for greening with ICT by economic clusters that focus on implementation at a local level.

The modern industrial society is built through organization of the society around certain economic sectors. These sectors were created by establishing new clusters in the pre-industrial society,



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and nowadays are called industries, even though they are combinations of several different skills. Crossing the era of the post-industrial / knowledge-based economy, the society needs new clusters to guarantee the new supply chains with new materials and new productions methods, the to secure the new business models with fresh ideas.

An example for this transition and the advancement of the clusters to a leading position is the energy sector, in particular the renewable energy. In renewable energy sector traditional utilities failed to deliver solar and/or wind solutions. It is because a collaboration between construction companies and architecture one and new solutions are necessary, and they often require new business models.

Usually, the ICT companies are very often at the center of the new clusters. However, their largest customers most commonly are one of the biggest polluters. This is a great challenge to the ICT companies and they have to be transformative to issue new solutions that support the business clusters with innovative greening with ICT solutions.

## ALTERNATIVE APPROACHES TO GREENING WITH ICT

Traditional green strategies are hardly effective for generation of greening with ICT solutions. In fact, most greening with ICT solutions result from smart strategies that are in search of resource efficiency and innovation in diverse economic areas, e.g., construction, transport, power supply, etc. This requires an approach to greening with ICT subordinated to the global development, discarding synergies and old stakeholders / methods. This very approach is a non-green one, although it also targets greening with ICT. A good example for a non-green approach is the use of procurements, both public and done by companies. As a rule, the companies face “green” and “ICT” trough a one-sided and limited approach; they focus on greening of ICT. This is because ICT companies (those who are selling) have products to put on the market and make profit from them, and CIOs (those who purchase) are trapped by old-fashioned ways of thinking and are besides, are not responsible for solutions like teleworking, virtual meetings and development of new business models.

Both the providers and the requesters of “greening with ICT” solutions very often do so without knowing and/or taking care about the green benefits of the action. Two of the most typical examples of such lack of knowledge/care are Amazon and Apple. Bothe companies are great promoters of greening with ICT; Amazon has contributed largely to the dematerialization of world’s books and magazines, and Apple has dramatically changed world’s music industry and made it more resource efficient. In the same way, smaller companies like Skype and Viber have progressively transforming the business models and habits without regarding their green activities.

The lack of cooperation and understanding between those that know and value the ICT opportunities (ICT companies and CIOs) and those that make new products and services is a big challenge. The problems are multiplied by the lack of strategies and definitions of greening with ICT. Some innovative “smart” solutions are considered “green” regardless of the actual results of their performance. For instance, the development and exploitation of smart grids is a trend where the transformative potential of the new ICT solutions, such as smart grids, is jeopardized by the traditional



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stakeholders that rule the agenda: the power utilities label their solutions as “smart”, although they continue to use old business models and large-scale utility structures.

In brief, greening with ICT solutions is mainly directed by smart strategies not by green demand or green policies.

## The green informatics contribution to green energy

Green informatics contribute to the environment and environmental sustainability in the following areas:

- Reduction of energy consumption and carbon footprint along production and use;
- Diffusion of information, education, and training to rise environmental awareness;
- Environmental projects and networks promotion through communication;
- Sustainable environmental governance.

### REDUCTION OF ENERGY CONSUMPTION AND CARBON FOOTPRINT ALONG PRODUCTION AND USE

The massive introduction of ICTs in everyday life has resulted among others in the increase of greenhouse effect, due to the ‘carbon footprint’ increasing. As per definition, carbon footprint (CF), known as well as ‘Carbon profile’ comprises the overall amount of carbon dioxide (CO<sub>2</sub>) and other greenhouse gas (GHG) emissions (e.g., methane, laughing gas, etc.) associated with a product, along its supply-chain, end-life recovery and disposal. In respect to ICT, it refers to the energy needed, and the pollution generated in ICT production processes and within the ICTs use (Fig. 4). The total amount of CO<sub>2</sub> emissions from the ICT industry progressively counts upstream. At the same time, ICT applications are recognized to possess enormous potential in contributing to different performances across the economy and society. They are the right tool of the strategies for the global environmental protection.



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	2009	2015	2020
Data Centers	121.30	229.87	369.48
PCs	126.69	222.41	516.55
Mobiles	1.54	3.74	6.58
Gaming Consoles	11.23	26.04	40.22
Carbon Conversion Number (CCN)	1.3	1.265	1.23
Total	260.77	482.06	932.84

**Figure 4. Carbon footprint in megatonnes of CO<sub>2</sub> from ICT sectors. Source: Bronk et.al., 2010**

## DIFFUSION OF INFORMATION, EDUCATION, AND TRAINING TO RISE ENVIRONMENTAL AWARENESS

Diffusion of information, education, and training with the purpose to rise environmental awareness is an approach applied worldwide to help people be up-to-date and understand environmental issues and environmental policies.

The wireless/mobile) internet access is irreplaceable as a tool of information delivery for populations that are isolated or remoted and that lack an access to traditional channels, such as TV, radio, newspapers, magazines, etc.

There are numerous of internet sites, blogs, forums, social network groups, internet polls, etc. dedicated to delivery and sharing environmental information. These information sources are operating from local to international scale, and act as an open tribune for everyone to participate, to offer and share opinion.

Learning and training contribute to enhancement of people’s knowledge, skills, and awareness. Suitable learning/training software packages are those offering presentations and educational games, and educational e-services such as e-classrooms, e-learning, ODL, web-based learning, LLL, etc.

## PROJECTS PROMOTION THROUGH ENVIRONMENTAL NETWORKS COMMUNICATION

The application of ICT for communicating different projects within environmental networks can be a useful approach for their successful implementation at local, regional, national, and transnational level. The accomplishment of environmental projects requires as a prerequisite effective communication

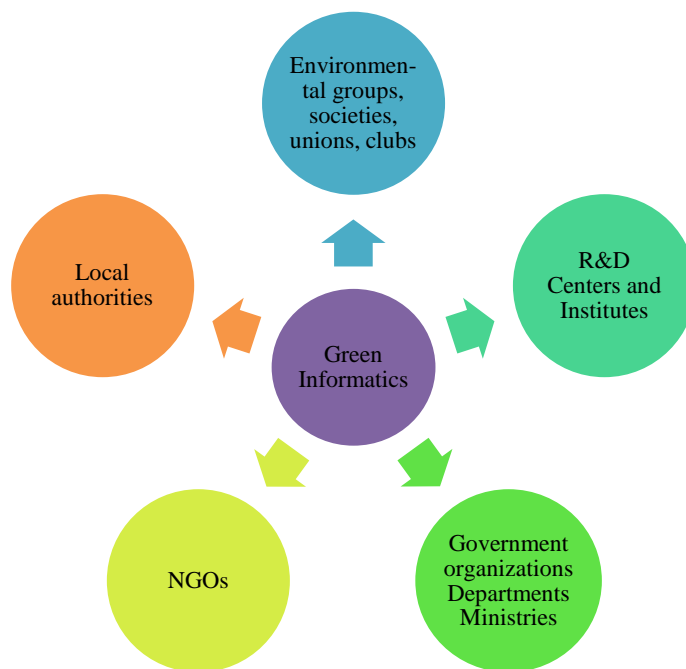


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among participants of various stakeholders, protected through innovative green informatics tools and services. Namely, green informatics makes safe information flow for the purposes of quick and reliable communication. Environmental networks comprise various stakeholders, all integrated through ICT-mediated communication (Fig. 5).

## SUSTAINABLE ENVIRONMENTAL GOVERNANCE

Green ICTs have turn into a key factor for public sector’s performance because it promotes the advancement in the delivery of information and services and encourages the citizen participation in the decision-making process. In this way ICT helps the government to become transparent, responsible, and operative. The e-governance strategies, initiatives, and developments are grounded on the ICTs. In particular, the governance of natural ecosystems, natural resources and agriculture has to manage a wide range of connections between different environmental elements and decisions of local, regional, national, and international importance, and has to coordinate diverse administrative objects and players, and ICTs helps a lot for execution of these complex tasks.



**Figure 5. Impact of green informatics to environmental networks communication**

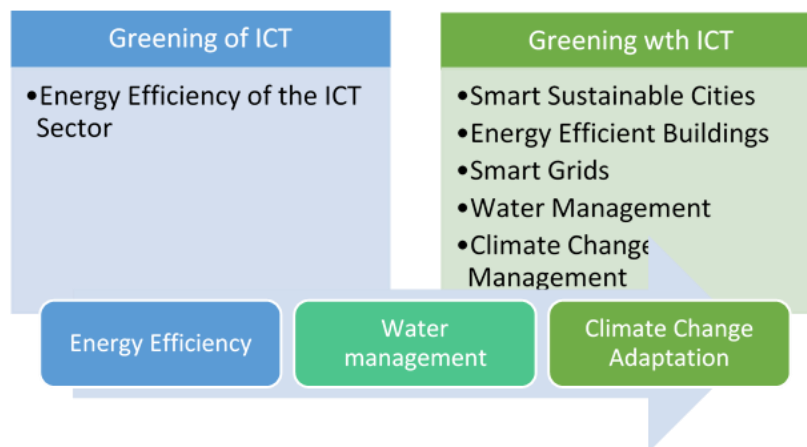


# Advanced cooperation for green ICT solutions

## ICT IMPACTS GREEN AND SUSTAINABILITY

EU has launched the initiative ‘ICT for sustainable growth’, a specific process that focuses on greening with ICT (in addition to greening of ICT). It has determined six policy areas of major priority that focus on Energy Efficiency, Water Management and Climate Change Adaptation (Fig. 6). Thus, it contributes to the development of a more sustainable Europe solving environmental problems and ensuring the sustainable environmental management.

The contribution of Green Informatics to the preservation and improvement of natural environment and resources is focused on the building of surveillance systems that aim to protect and restore natural ecosystems. In addition, it promotes ecosystems potential deployment and introduces prevention actions for its maintenance. For instance, forests and agricultural land are important to climate change mitigation because of the significance of their carbon stock and also for their exchange of greenhouse gases between the atmosphere, soil, and vegetation. The harvest of trees to supply book and newspaper industries leads to the emission of millions metric tons of CO<sub>2</sub> annually. Thus, the innovative tele-detection for forest fires, monitoring and alarm systems, GIS technology, etc., all contribute to sustainable forestry management.

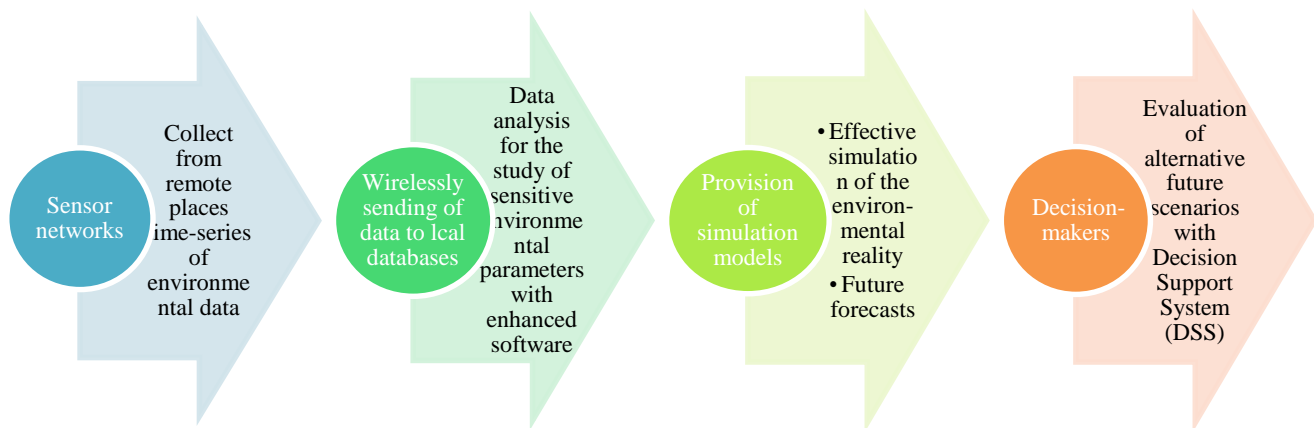


**Figure 6. ‘ICT for sustainable growth’ six policy areas**

The organization, access and management of the information in the environmental databases is an important factor within decision-making process. Since environmental projects have to manage huge multivariable data sets of interdisciplinary character (meteorological, geographic, biological, economic, etc. data), this has been successfully achieved through ICTs applications and is called environmental monitoring. The main procedure of environmental monitoring is presented in Fig.7. It is a useful tool

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that integrates geospatial technologies aiming to sustain agricultural and environmental observation networks and deploy agricultural and environmental applications



**Figure 7. Wise management to environmental sustainability – Green Informatics contribution**

**The DSSs use defined parameters to provide wise management aiming to environmental sustainability and helping decision making process towards sustainable environmental management. These are Environmental databases, GIS, time-series, multi-variant, and multi-criteria analysis, expert systems, etc.**

## ICT AND THE ECONOMY-DEFINING TECHNOLOGIES (EDTs): KBE/KBBE

The innovative technologies that constitute the principal technological basis of an economy, are called **Economy-Defining Technologies (EDTs)**. EDTs are always inherent to the corresponding economy, and ICTs are definitely such technology.

Knowledge has always played a central role in any economy. However, in the **Knowledge-Based Economy (KBE)** knowledge has been liberated from its temporal and spatial constraints because of the ICTs. This is what allows knowledge to unfold its powers as a universal resource, leading to the KBE.



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Grounded on this concept, OECD defines the KBE in the following way: “*The knowledge-based economy is an expression coined to describe trends in advanced economies towards greater dependence on knowledge, information and high skill levels, and the increasing need for ready access to all of these by the business and public sectors.*”

Knowledge takes predominance for both individuals and organizations in the KBE.

The **Knowledge-Bases Bio-Economy KBBE** presents a wide range of challenges to ICT. However, the area with potential highest impact of ICT for KBBE is the general and synthetic biology along the dimensions of education, research, and industry applications.

The needs of ICT-driven innovations, which are able to reduce energy and materials used while enhancing the efficiency of business systems, can generate wide opportunities for companies' businesses. The said innovations include software applications (e.g., virtualization technology to implement power savings), and hardware applications (e.g., server with energy-saving properties). In addition, essential industrial infrastructure must be active in order to capitalize on the expanding global market for ICT-based solutions planned for improving the energy efficiency as well as tackling the climate change concerns.

Besides the economic benefits, adopting Green ICT practices in business operations can easily deal with climate change issues that are associated with greenhouse gas emissions. Additionally, it also described that Green ICT can play a crucial role in helping to promote the low carbon economy around the world. The ICT industry can also produce a green image while behaving as a responsible global citizen.

## GREEN ICT AND EDUCATION

### Green ICT at Higher Education Institution

Currently global warming and climate change are in the front of societal agenda. They turned into a common subject of discussion globally. Climate change consequences arise huge environmental problems and impact energy and industrial policies worldwide.

Green ICT, as a system of initiatives and strategies that reduce the environmental footprint of technology, is able to respond to the needs for implementation of climate change adaptation and mitigation actions. Hence, Higher Education Institutions (HEI) are forced to implement more sustainable approaches to ICT use. This necessity is introduced by the government, stakeholders and society as a whole. Green ICT implementation at University level has developed as key factor to reach the cost-effective solutions and sustenance of ICT.

Moreover, the HEI have deep moral responsibility to increase knowledge, skill and awareness, with the aim to create a sustainable future. Their role in mainstreaming society towards sustainability is indisputable. However, at the same time, they are facing some barriers in Green ICT practical implementation. Therefore, Green ICT is a multifaceted subject, which importance is progressively increasing towards understanding the role of ICT is enabling sustainable practices. For instance, green research and development activities can contribute to reducing environment impact of society by dropping the impact of ICT installations in telecommunication and data-centers, customer offices, homes



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through greening of ICT. At the same time, the impact of society can be reduced by providing various kinds of ICT services through greening by ICT. Thus, HEI need to transform education within sustainability prospect to be able to educate undergraduates to become the ICT engineers our future needs.

### Green ICT practices in HEI

The SMART 2020 report stressed upon the capacity of ICT to monitor and maximize energy efficiency, not only within its own sector but also outside it, resulting in considerable emission and footprint reduction. Studies performed to analyze and review the evolution of Green ICT practices in different HEI have proven that the proper ICT deployment contributes to sufficient reduction of GHG emissions. HEI follow environmental sustainability (ES) practices to complete the strategic plans for environmental sustainability through organization of virtual classrooms, digitalization of paper documents, performance of video conference to reduce travel, use alternative clean sources of electrical power, etc.

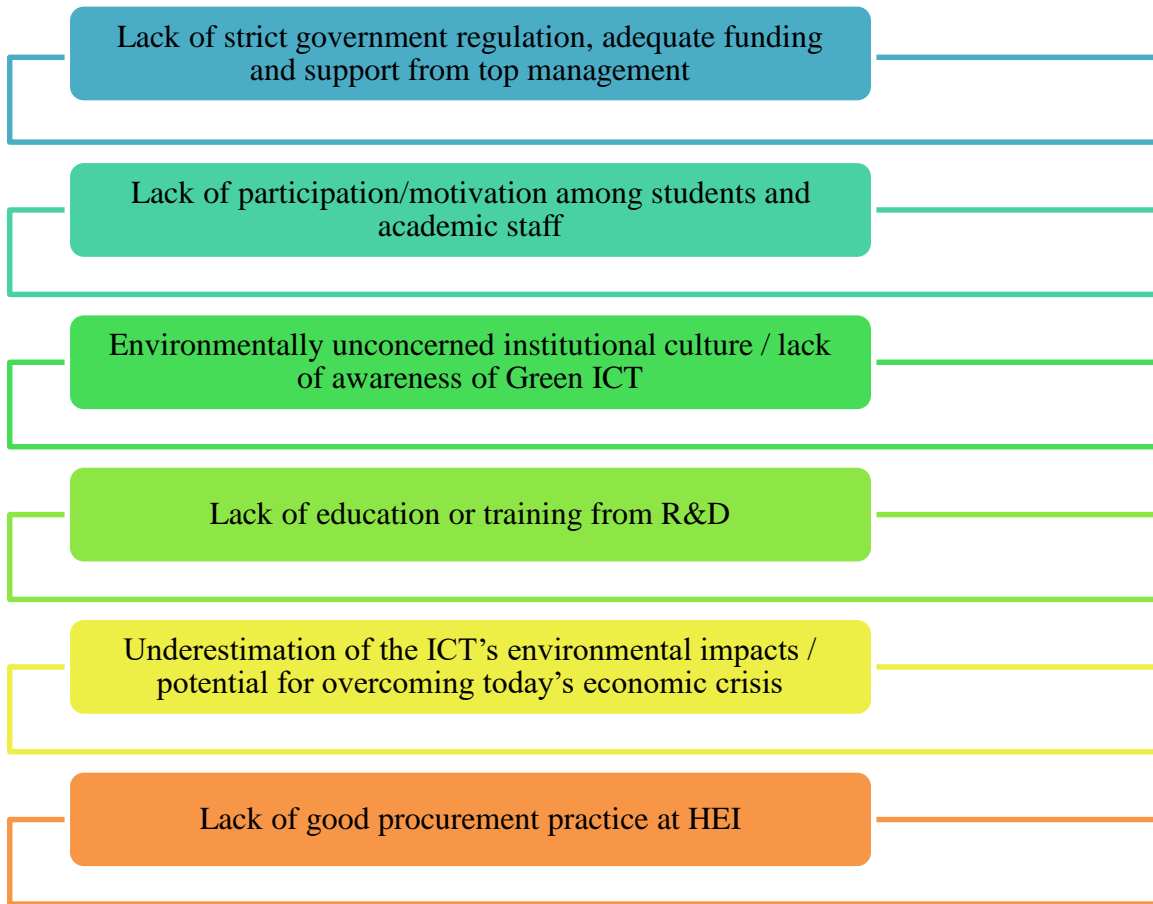
### Constraints for Green ICT Practices in HEI

There are various factors that obstruct the implementation of sustainability initiatives of HEI, associated mainly with institutional barriers. These constraints are complex: from old-fashioned contracts of educators, to shortage of equipment, finance and trained tutors, to inadequate environmental teaching methods, lack of motivation towards ‘green behavior’ of teaching staff and students in their approach of using ICT (e.g., by reducing print volumes, using conference calls to reduce unnecessary travel, etc.).

The main constraints that act as barriers in implementation of Green ICT at HEI are listed in Fig. 8.



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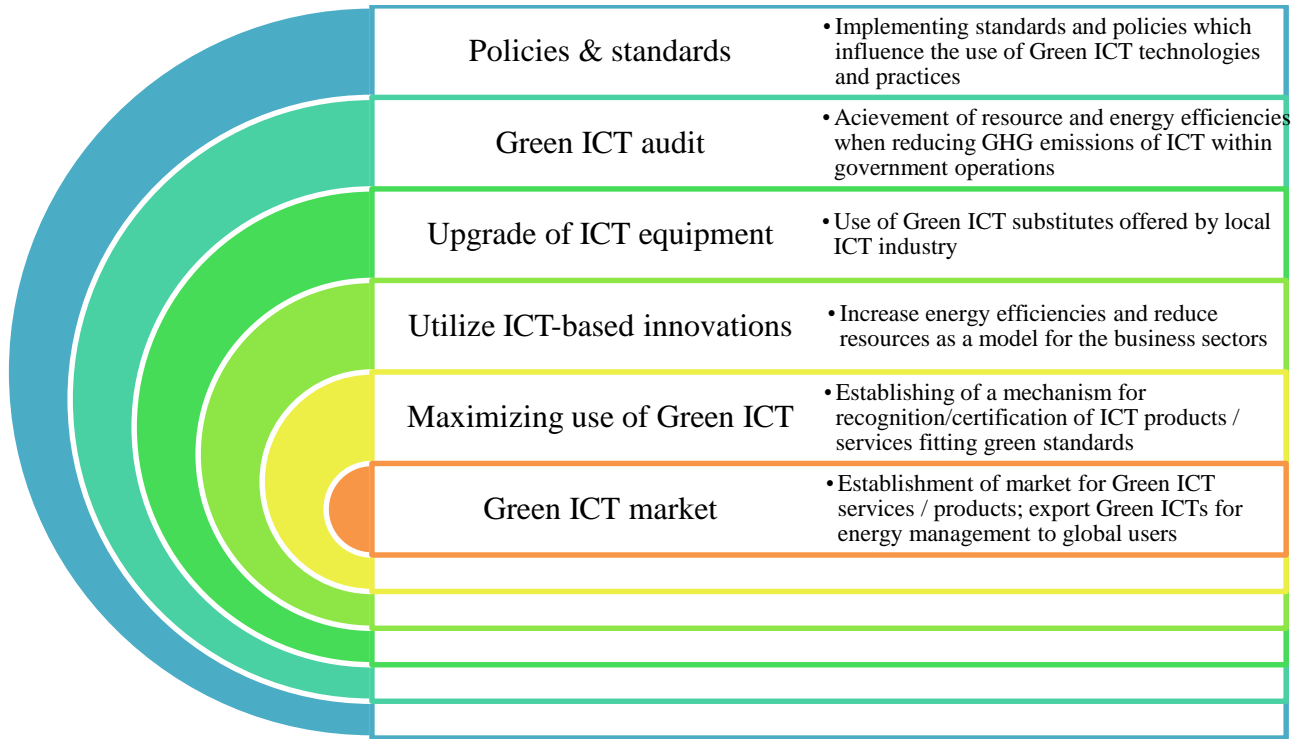
**Figure 8. Constrains for Green ICT implementation at HEI**

## GREEN ICT IMPACT AT GOVERNMENTAL LEVEL

Governments are one of the primary users of ICT and impact substantially the ICT industry. Due to its potent influencing power, the governments must play a leading role in acceptance of Green ICT technologies, improving its operational efficiency, and encouraging societal environmentally-aware and sustainable culture. Thus, it is essential for the governments to establish close collaboration with the ICT industry, and there are several areas that the governments have to seek for better opportunities for the Green ICT implementation. These are outlined in Fig. 9.



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**Figure 9. Areas for governmental collaboration with the ICT industry and Green ICT implementation**



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