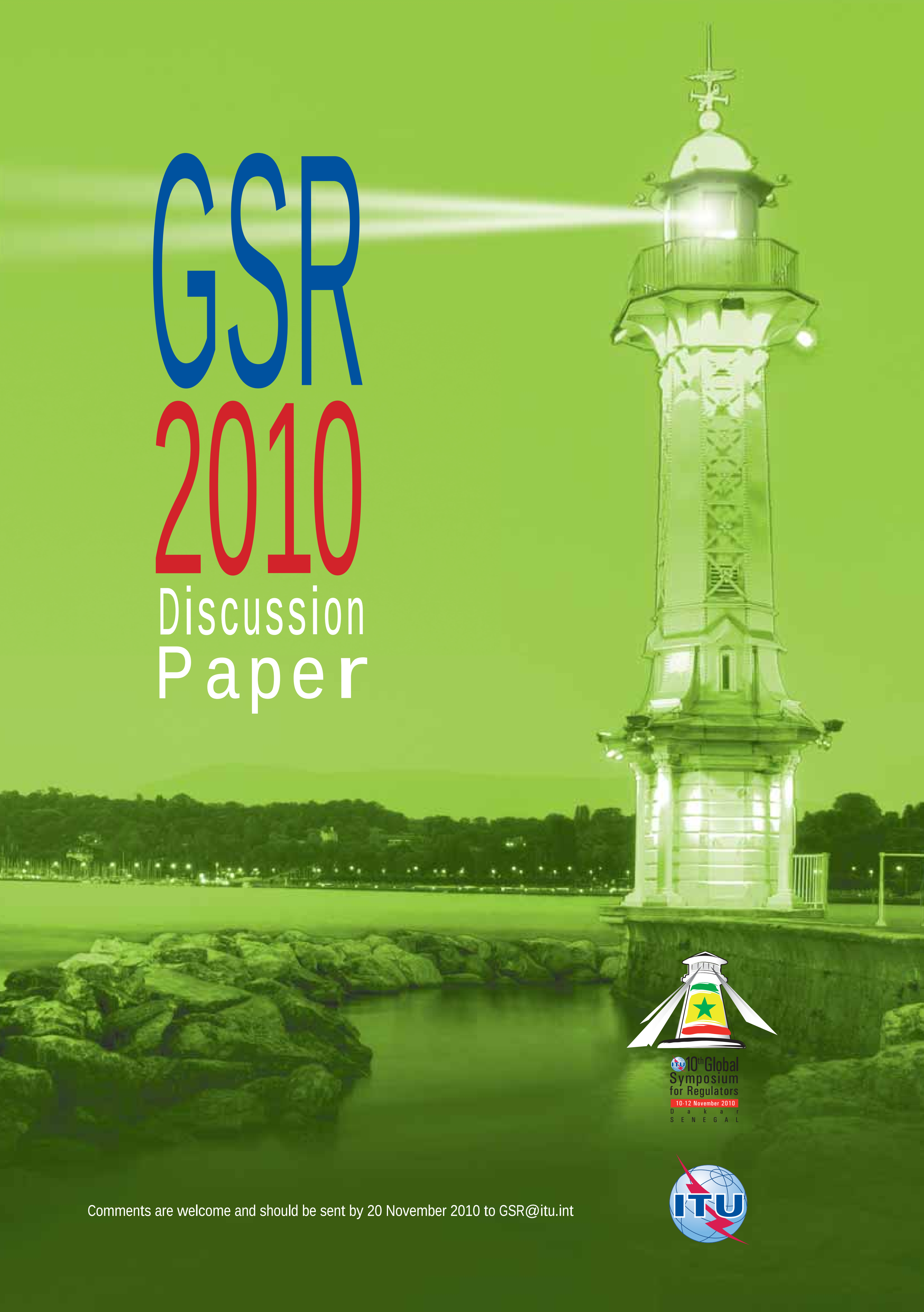
GSR 2010

Discussion Paper



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1.1 Executive Summary

1.1.1 Introduction

This paper discusses the relationship between climate change and the ICT sector, with a specific focus on telecommunications. The paper considers the special relationship between ICTs and climate change as the context for exploring whether the nature of the relationship ought to include a special role for regulators. Specifically, the paper considers whether the nature of the special position between ICT players and climate change suggests that ICT sector regulators, specifically those in charge of regulating telecommunications service providers (TSPs), should have a more active role in environmental protection and should consider climate change issues when making decisions concerning TSPs. The status quo ante represents the converse position, namely that decisions relating to climate change should be left to general laws and regulations that apply to other companies, organizations and individuals.

1.1.2 Main assumptions

The following assumptions underlie this paper and form the context for considering sector regulation relating to climate change:

- Like most industries, the ICT sector produces green house gases (GHGs),[1] but the ICT sector produces significantly less GHGs than many other sectors, and the levels of GHGs produced by the ICT sector represent a bargain in terms of tonnes of CO2 per USD of GDP.
- GHGs from ICTs are growing[2] and are likely to continue to grow for the foreseeable future, as devices and networks become ubiquitous and the applications and services based on ICTs continue to grow.
- ICT GHGs can be viewed as "business as usual" a natural consequence of the growth of the ICT industry worldwide – and like most other sectors, will need to be reduced, either as a result of self-imposed obligations, legislation, and/or the impact of increasing costs (especially long run fuel costs).
- ICTs have the potential to reduce GHGs created by other sectors (as evidenced in studies by Accenture/Vodafone, Association of European Telecoms Network Operators (ETNO), Global eSustainability Initiative (GeSI), ITU[3], Telstra and the European Commission[4]). These changes can come about from the wider diffusion and penetration of ICTs as a result of changes to industrial processes and changes to behaviour.
- Some estimates reckon that the impact of ICTs on other sectors could mean that, by 2020, ICT-enabled GHG reductions will be six times the size of GHGs produced by ICTs.[5]
- Reducing GHGs from other sectors is "business unusual," and represents a massive opportunity for ICT players. Deloitte estimates that by 2020, the overall market for environmental products and services will be worth USD 2.7 trillion.[6] In order to unlock new sources of revenues, TSPs will need to capitalize on opportunities to help other industries meet the demand for such services, including those that relate to reducing GHGs.
- Disruptive changes to markets and technologies in recent years have caused ICT sector regulators to focus their efforts on liberalizing markets, preventing the abuse of dominance, and ensuring effective and economically efficient relationships between service providers while protecting consumer interests.
- At present, except in a few limited cases, the objectives for ICT sector regulators do not include considerations relating to the environment in general, or climate change in particular.

1.1.3 Main questions

The overlap between climate change, ICTs, and sector regulators is a hitherto unexplored area. In order to develop discussion of this overlap, the paper throughout poses a number of questions. These questions are typically found at the end of each section and are organized as regulator's checklists. An integrated checklist is available at the end of the paper (in Annex 2).

The type of questions that are considered include:

- What is the relationship between ICTs and climate change?
- What is the role of ICT service providers, particularly, Telecommunication Service Providers (TSPs), in producing GHGs?
- Given the potential for ICT service providers, particularly TSPs, to reduce their own climate-changing GHG emissions, should the GHG production of TSPs be subjected to ICT sector regulation?
- Given the potential for ICT service providers, particularly TSPs, to reduce climate-changing GHG emissions in other sectors, are specific forms of regulatory intervention that relate to TSPs' ability to facilitate the reduction of GHGs necessary?
- Should the responsibilities of ICT sector regulators be broadened to encompass environmental objectives, particularly policies and interventions that relate to climate change?
- Which modes of regulation might be employed to bring about the desired outcomes?
- Should GHG reduction measures be incorporated into existing regulatory mechanisms, or is there a need to devise specific regulatory interventions?
- Should sector regulators have a role in encouraging ICTs using their networks and services to reduce GHGs in other sectors?
- If sector regulators are to have a role in policies that relate to climate change, how can these policies be designed so that they do not to stifle the processes of liberalization, increasing efficiency, and continuous innovation?[7]
- How can ICT sector regulators ensure that any actions which take account of environmental policies in general, and climate change interventions in particular, are effectively coordinated with other agencies and policy-making bodies?

This paper is a discussion document. As a relatively new and under-explored area, the objective is not to set out policy prescriptions, but to consider themes and raise questions as the prelude to a wider discussion.

1.1.4 Methodology

This paper was developed using a flexible methodology, combining qualitative research based on published resources, cross-cutting analysis, and synthesis of the two main topics (ICT regulation and climate change). This was augmented by informal discussions with some interested observers. The methodology used in this paper is based on defining the issues of relevance for the core topics and organizing them in a structured discussion in order to focus on the contact points between them. This provides the basis for illustrating how concrete climate change concerns could be integrated into ICT regulatory work, with the goal of stimulating environment-friendly industry practices and models of consumer behaviour.

The analysis has been used to build thematic checklists for regulators to help them position themselves vis-à-vis the emergence of regulatory issues relating to climate change and improved sustainability of ICT energy use. The checklists indicate a priority rank of those issues and the degree of regulatory involvement. The checklists also allow the identification of discrete areas of action within regulatory practice and can serve as a tool in the decision-making process. Most of the questions in the checklists can be answered in multiple ways: the possible ways forward are not limited to a predefined choice and can be tuned according to the regulator's status and circumstances.

The final goal of this exercise is not to provide a single solution to the issues identified, but rather to generate debate, raise awareness and commence a collaborative regulatory effort to curb carbon emissions in the ICT sector.

It may (accurately) be noted that this paper has a Euro/U.S.-centric orientation. This reflects the information that is currently available: there is some information about the impacts of climate change in, e.g., developing countries; there are also examples of innovative solutions to provide off-grid power to mobile base stations, typically in developing countries. In a sign that the balance is beginning to be redressed, in June 2010, China Mobile and the World Wildlife Fund (WWF) published a paper on the scope for low carbon telecommunications to reduce current and future emissions in China.[8] But the China Mobile-WWF paper is currently an exception: to date, most of the thinking and publishing by ICT players on climate change has happened in the "more developed" countries, and this paper reflects that situation.

1.1.5 Scope and focus of the analysis

This is not a paper about the totality of the relationship between the ICT sector and the natural environment. There are many points of contact between the ICT sector and the environment, which means that a paper on ICTs and the environment could result in a massive exercise. Instead, Table 1.1 sets out the actual coverage of this paper, which deals principally with TSPs and their impacts – both positive and negative – on climate changing GHGs.

The reasons for this segmentation are set out below.

1.1.5.1 Which market players?

ICT has been described as "*A fluid and ever changing ecosystem, (which includes) individuals….fixed and mobile network operators, Internet service providers, chipset design firms, device manufacturers, application developers, content owners and infrastructure providers*."[9] To this description, it is necessary to add broadcasters and satellite providers as well as government, businesses, and customers as additional key stakeholders.

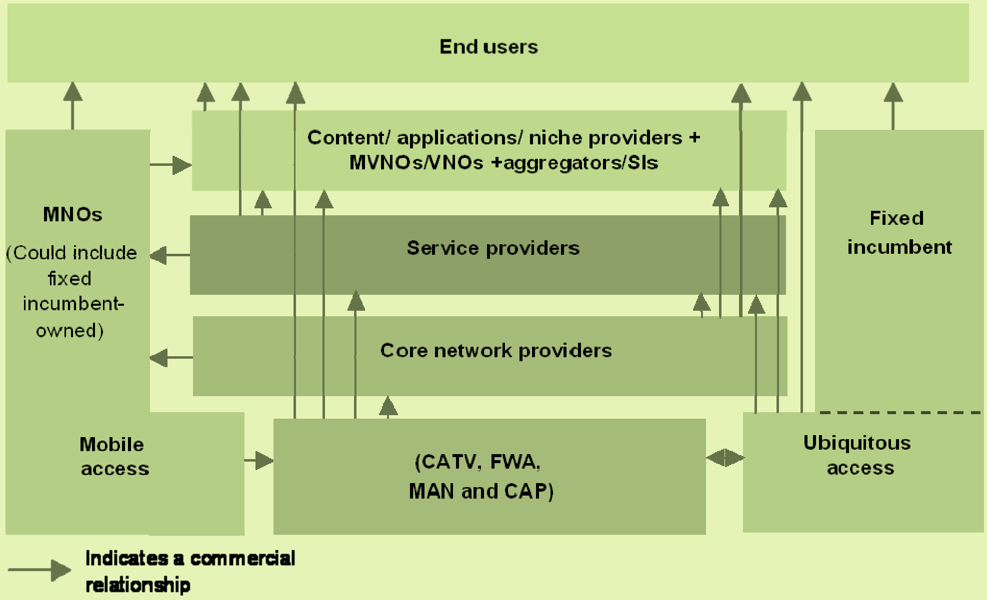
Using the model of the ICT ecosystem shown above, almost all of the entities depicted would be subject to TSP regulation, with the exception of service providers whose business is not primarily telecommunications and end users. But there are many players that are not covered in the scope of this paper notwithstanding the fact that they are part of the ICT ecosystem and despite convergence in ICT technologies and markets. This paper focuses on TSPs.

TSPs, whatever their individual differences, are more like each other than they are like the other organisms in the ICT ecosystem. It would be difficult to provide sufficient focus in a report of this kind without concentrating on a particular type of ICT player. For example, there are currently concerns about the energy used by computer data centres, which have demanding requirements for air-conditioning, electricity supply, and back-up.[10] Although data centres are now an integral part of TSP infrastructure, many data centres are provided by non-regulated market players for the provision of competitive services ranging from corporate back-up, disaster recovery, hosting and internet search. While the providers and users of data centres are subject to the general laws and rules, such as competition law, that apply to all companies within a particular country or region, they are unlikely to be the specific focus of an ICT regulator.

Table 1.1: Discussion paper on ICTs, climate change and regulation: scope and focus

Market Players	Regulatory coverage	Energy use	Environmental scope
Telecommunication Service Providers, or TSPs operating under general or specific authorizations – excludes service providers that use TSP networks, facilities or services, but are not primarily engaged in providing telecommunications services.	Sector specific regulation – agencies whose regulatory remit covers Telecommunication Service Providers operating under general or specific authorizations	Energy consumed in the provision of networks and services by TSPs and their customers	GHG emissions, mainly CO_2s, produced as a result of energy used to provide TSP networks and services
Examples	Examples	Examples	Examples
BT, DTAG, France Telecom, O2, Telkom South Africa, Vodafone	FCC (US), OFCOM (UK), OPTA (Hong Kong, China)	Electricity consumed by TSPs to power fixed and mobile Telecommunication networks. Energy used by TSP customers to power handsets, phones, broadband routers.	GHGs produced as a result of activities of TSPs and their customers.

Figure 1.1: The ICT ecosystem



Key:	CAP:	Competitive Access Provider
	CATV	Cable TV Operator
	FWA	Fixed Wireless Access
	MNO	Mobile Network Operator
	MNVO	Mobile Virtual Network Operator
	SI	Systems Integrators
	VNO	Virtual Network Operator

Source: Ovum

This paper is concerned with the players that operate under specific operating licences, or general authorizations, under the overview of an ICT sector-specific regulator. Licensing and general authorization regimes have historically emerged as part of the liberalization and privatization of the telecommunication sector.[11] The transition to an effective competitive environment in the ICT sector requires a regulatory framework that is able to *"resolve disputes, address anticompetitive abuses, protect consumers, and attain national goals such as universal access, industrial competitiveness or economic productivity and growth."*[12]

Thus, one of the main reasons that network-based TSPs are subject to the oversight of telecommunication/ICT regulators is their market power: they are dominant in their markets (and thus enjoy significant market power) or they control access to essential facilities such as local loops (normally needed by competitors to gain access to customers).

While companies such as Microsoft or Google are not only larger than many regulated TSPs, they may be more significant in terms of energy use, hence GHG emissions.[13] Although these relative newcomers may provide similar services as TSPs, they emerged from and exist in a competitive environment. As such, they are subject to general competition law or anti-trust legislation, unlike the TSPs which are regulated under telecommunication-specific measures.

The result is that sector players that provide similar services can be subject to different regulatory regimes. Such differences normally result from differences in the heritage, resource endowment, and market power of the players concerned. Players that are deemed to be dominant or that enjoy significant market power are generally subject to specific licence terms and conditions, while non-dominant TSPs are likely to operate under fewer licence conditions or under a form of general authorization. The former tend to be facilities-based while the latter often operate on a resale basis.

If obligations to reduce GHG emissions were to be included in the licences or general terms and conditions of dominant TSPs whilst not being similarly imposed on non-dominant players, such measures would no doubt be resisted by the dominant players.

1.1.5.2 Which regulators?

The ICT sector is undergoing convergence, but converged regulation remains relatively rare The ITU has found that a number of regulatory authorities have *"revised their organizational structures, expanded their staffs and developed new skills."* [14] But this does not mean that most ITU stakeholders with the responsibility for regulating TSPs have become converged ICT sector regulators. The ITU goes on to note, *"The liberalization of ICT markets has stimulated a global marketplace of interacting innovations in products, services and applications. Old distinctions among different industries are blurring, as platforms, products and services converge in an IP or Net-centric world."* [15]

Despite these developments, driven by markets and by technology, government in general, and ICT regulators in particular, remain important players in the ICT sector. Whilst privatization and liberalization have transformed the ICT ecosystem, the transition to a fully competitive environment is not guaranteed. As long as TSPs continue to enjoy dominance in their markets, the need for regulatory oversight will continue. This means a continuing role for ICT regulators, opening up the scope for the inclusion of environmental considerations in such regulation.

1.1.5.3 Which type of energy consumption: life cycle or in use?

GHGs arising from the activities of telecommunication players are produced both by:

- the energy embedded[16] in the physical elements used to provide telecommunication networks and services, and
- the energy used to operate networks and provide services.

This paper deals with the second type of energy, notably where "use" refers to the TSPs and the customers that are connected to their networks and that use their services.

Embedded energy used in manufacturing ICT equipment, whether fibre optic cables, servers, mobile phones or chargers, is important. It can also produce contradictory outcomes: increasing churn rates of new end-user mobile devices due to technical advance will result in more cumulative embedded energy usage, but could produce lower consumption of energy in use, as new, more energy-efficient devices come to market. It is not possible to consider such issues in this paper for two reasons, which are related to problems of measurement and of jurisdiction:

- the manufacture and sale of ICT equipment is a global industry; measuring and specifying embedded energy for this type of manufacturing is extremely complex and uncertain;
- the products involved are internationally traded. It is therefore likely that sector regulators, which operate within national jurisdictions, will have limited scope to intervene. Furthermore, intervention in the market for internationally traded goods and services would likely conflict with world trade regulations (i.e., WTO[17]). Discussions about issues that are related to world trade would therefore need to take place at a supra-national level. In addition, there could be possible measures at the national level as well – for example, countries may introduce higher duty or quotas on ICT products. Again, these would need to be aligned with the requirements of international trade agreements.

Finally, consumption of energy in use overshadows that of embedded energy for most elements of the telecommunications system. For example, information from Nokia Siemens Networks indicates that about 90 per cent of their equipment's CO2 footprint comes from their equipment when it is in use.[18]

1.1.5.4 Which environmental impacts?

The activities of TSPs have many effects on the environment, ranging from resource depletion to waste generation.[19] Most of these activities, whilst important, are outside the scope of this report. This paper deals solely with the relationship between TSPs and their customers in terms of climate-changing GHGs, the most significant form of which is Carbon Dioxide, or CO2 (see Box 1.1). CO2 is one of the main products when fossil fuels undergo conversion, whether to power engines or to provide electricity. The electricity used by the ICT sector is its most significant contribution to GHGs.

Box 1.1: CO_2: The Main Greenhouse Gas

Carbon dioxide (CO_2), a gas at standard temperature and pressure, is probably the most important of the greenhouse gases as it accounts for the largest proportion of the 'trace gases' and is currently responsible for 60% of the 'enhanced greenhouse effect'. CO_2 is thought to have been in the atmosphere for over 4 billion of the Earth's 4.6 billion year geological history. The amount of carbon dioxide taken out of the atmosphere by plants is almost perfectly balanced with the amount put back into the atmosphere by respiration and decay, so small changes as a result of human activities can have a large impact on this delicate balance. Burning fossil fuels releases the carbon dioxide stored millions of years ago.

The concentration of carbon dioxide in the atmosphere has increased more in the northern hemisphere where more fossil fuel burning occurs at higher levels. Since the Industrial Revolution the global concentration of CO_2 has increased by about 40%, and at March 2010 CO_2 in the Earth's atmosphere was at a concentration of 391 parts per million (ppm) by volume[20] or even more (see also Box 1.2 below)

1.1.5.5 Defining the scope and focus of analysis

Drawing together the discussion above, it should be now be clear that the focus of this paper is on:

- Telecommunication Service Providers (TSPs)
- The agencies which regulate TSPs (referred herein as ICT regulators)
- The energy used by TSPs in providing networks and services, and the dedicated devices which are attached to them
- The greenhouse gas emissions generated by TSPs and their customers (including both resellers and end users) in using their services

The paper covers the GHG-producing activities of network-related ICT players that operate under specific or general authorizations, under the purview of sector-specific regulatory agencies. The paper considers, under a number of headings, the existence of, need for, and scope for, sector-specific regulatory interventions aimed at:

- curbing GHG emissions from TSPs, and
- facilitating the ability of TSPs to curb emissions from other industry sectors

1.1.6 Acknowledgements

I would like to acknowledge the following for their help with this paper: for their personal contributions to my early thinking, Robert Milne, David Lewin, Ajay Gambhir, Galit Zadok and Richard Cadman; for reading the first draft, Sue Uglow and Viv Caisey;. For guidance, comments, kind words, support and encouragement, Youlia Lozanova and Nancy Sundberg at ITU. For detailed comments, five additional ITU reviewers, namely Alexandre Vassiliev, Cristina Bueti, Hani Escander, Jose-Maria Diaz-Batanero and Martin Adolf as well as Theresa Miedema for editing the paper. Thanks also for support from the Brighton Business School at the Universi-University of Brighton, where, as Senior Lecturer in Economics, I teach behavioural economics to undergraduates and postgraduates. Any errors and omissions are those of the author.

1.2 What is climate change?

"The Earth's climate is changing. In most places, average temperatures are rising. Scientists have observed a warming trend beginning around the late 1800s. The most rapid warming has occurred in recent decades. Most of this recent warming is very likely the result of human activities."

United States Environmental Protection Agency [21]

1.2.1 Climate change: the causes

The subject of climate change, and the role of human beings in causing it, remains controversial, despite the fact that, as Rajendra Pachauri, Chairman of the Intergovernmental Panel on Climate Change (IPCC) has written, *"the reality is that our understanding of climate change is based on a vast and remarkably sound body of science…"* [22]

Greenhouse gas (GHG) emissions have been identified as a major driver of changes to the climate, and human activity has been identified as the probable cause of rising GHG emissions, particularly carbon dioxide (CO_2) emissions. If climate change results from rising greenhouse gas emissions that are mostly attributable to human activity, then cutting greenhouse gas emissions will require that humans make changes to these activities. [23]

Box 1.2: CO2, "Simple Physics" and Human Activity

Lord Rees, President of the Royal Society, said in March 2010, *"As regards the evidence, and the reason why we should be concerned… the most important evidence is uncontroversial, and that's that the carbon dioxide concentration in the atmosphere is going up at a rate that's unprecedented in the last half million years and that's due to the burning of fossil fuels. That fact alone plus very simple physics is, in my view, enough to motivate some kind of concern and action…"*.[24]

The Stern Review on the *Economics of Climate Change* stated this point more formally, *"The current level or stock of greenhouse gases in the atmosphere is equivalent to around 430 parts per million (ppm) CO2, compared with only 280ppm before the Industrial Revolution. These concentrations have already caused the world to warm by more than half a degree Celsius and will lead to at least a further half degree warming over the next few decades, because of the inertia in the climate system."*[25]

As to whether these changes have been produced by human activity, a meta review of 1,372 climate researchers and their publication and citation data published by the National Academy of Sciences of the United States of America in June 2010 showed that 97–98% of the climate researchers most actively publishing in the field support the tenets of Anthropogenic (man-made) Climate Change outlined by the Intergovernmental Panel on Climate Change (IPCC).[26]

The ultimate effects of a drastically changing climate are not known, but are likely to include loss of species, loss of habitat, and more violent extremes of unpredictable weather. Climate change is a serious threat to most species on earth, particularly humans.

Of course, the climate itself is indifferent to the controversy: it just keeps changing. In March 2010, the UK's Met Office published a review[27] of the latest climate research. The review studied developments in climate science since the last IPCC report (AR4) was published in 2007[28]. The Met Office used 'detection and attribution' methods to identify long-term changes in the climate, confirming that the planet is changing rapidly and that man-made GHG emissions are very likely to be the cause. The Met Office study noted that long-term changes in the climate system have been observed across the globe, from shifts in rainfall patterns to a decline in Arctic sea-ice. These changes follow the pattern of expected climate change and bear the 'fingerprint' of human influence, providing the clearest evidence yet that human activity is impacting the climate.

Box 1.3: Weather vs Climate

Changes noted in the review[29] published by the Met Office include:

- Temperature increase - global temperatures have increased by about 0.75 °C over the past century and 2000-2009 was the warmest decade on record. Human influence has been detected on every continent.
- Changes in rainfall patterns - wetter regions of the world (mid to high latitudes in the northern hemisphere and tropical regions) are generally getting increasing rainfall, and drier regions less rainfall.
- Humidity - surface and satellite observations show moisture in the atmosphere has increased over the last 20-30 years. This increases the amount of water that can fall in extreme rainfall, posing flooding risks.
- Warming oceans - temperature increases have been observed over the last 50 years in the Atlantic, Pacific and Indian Ocean basins. These cannot be attributed to changes in solar activity, volcanic eruptions or variations in ocean currents, such as El Niño.
- Salinity - the Atlantic Ocean is becoming saltier in sub-tropical latitudes. This is because of increasing ocean evaporation due to increased temperatures. In the long-term, ocean regions at higher latitudes are expected to become less salty due to melting of glaciers, ice sheets and increased rainfall.
- Sea-ice - summer minimum of Arctic sea-ice is declining at a rate of 600,000 km^2 per decade, an area approximately the size of Madagascar. While there has been variation from year to year, a long-term trend has been observed that can only be explained by human influences.
- Antarctic - there has been a small increase in Antarctic sea ice extent since the satellite record began in 1978. (although the increase in Antarctic sea ice is much smaller that the decrease of Arctic sea ice).This small change is consistent with the combined effects of GHG increases and reductions in the ozone layer which cause increases in some regions, such as the Ross Sea, and decreases in others, such as the Amundsen-Bellingshausen Sea.

1.2.2 Climate change: the consequences

The overall phenomena associated with climate change, as described above, may appear to be incremental and manageable, but events resulting from climate change are as likely to be severe, extreme and unpredictable. David Easterling from US National Climatic Data observes,

"Weather and climate extremes are major drivers of change in both natural and socioeconomic systems. Evidence points to substantial changes in many extremes with a warming world. These include increases in heat waves, droughts, warm days and nights. These increases in warm extremes have been and will be accompanied by decreases in cold extremes such as cold waves. Similarly changes in precipitation include increases in heavy precipitation events in many areas." [30]

In addition, the effects of climate change vary across different geographies. The UK's Royal Society noted that effective adaptation policy must be reinforced by a continuing effort in monitoring and understanding climate change in order to reduce uncertainty, particularly with respect to climate change.[31]

The World Bank has commented that not only are the effects of climate change uneven, but developing countries are more exposed and less resilient to climate hazards. It notes that the consequences of climate change will fall disproportionately on developing countries.[32]

There is consensus among scientists that emissions from fossil fuels are changing the climate. The biggest contributor to climate change is the increasing greenhouse effect created by carbon dioxide emissions, mostly from burning fossil fuels. The main reason for burning fossil fuels is to obtain energy. Accordingly, slowing the pace of climate change means either reducing energy use or developing new ways of producing energy.

Information and Communication Technologies (ICTs) are unlikely to be of much use for the latter (although ICTs are a component of the "smart grid" approach to distributed generation often based on renewable energy sources). But there is a significant role for ICTs in reducing energy use, both within the ICT sector itself and within those sectors that touch, and are touched by, ICTs – and it is becoming increasingly difficult to find any sector that now falls outside this category.

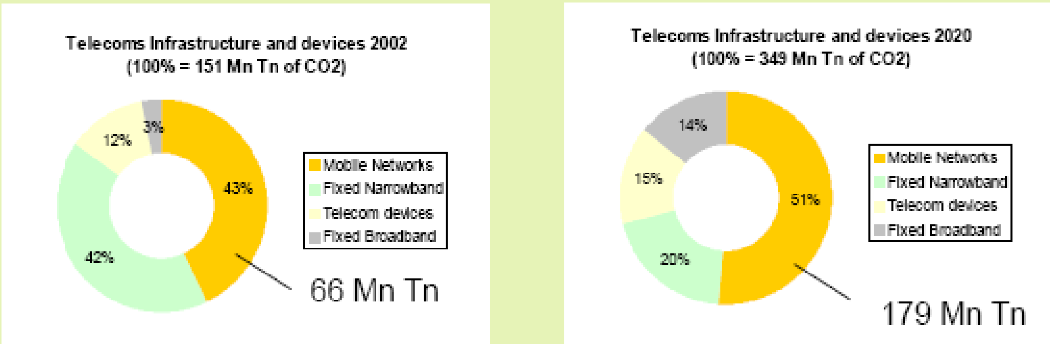
1.3 Points of contact: where ICTs meet climate change

1.3.1 Climate change and ICTs

Climate change affects commerce and industry in general, and the ICT sector is no exception. But whilst some effects are common to all sectors, others are unique to ICTs, particularly Telecommunication Service Providers (TSPs):

1. Like other industries, particularly those that rely extensively on physical infrastructure, TSPs are likely to be adversely affected by the increasing number of severe weather events. Like other industries, TSPs are significant producers of climate changing emissions. Although generally considered "carbon-light" relative to their contribution to gross domestic product (GDP), TSPs are often among the largest electricity consumers in a country. Furthermore, their absolute energy consumption is rising (see figure 1.2 below). The Smart2020 study for Global eSustainability Initiative (GeSI), for example, showed that the sector's current contribution to GHG emissions of around 2 per cent of the global total is set to double (from 0.83 Gigatonnes of CO_2 equivalent (Gte) to 1.4 Gte).[33]
2. Unlike most other sectors, ICTs are in the unusual position of being able to do something to help reduce GHGs. ICT products and services can contribute to displacement or rationalisation of the movement of goods and reduction of travel; promote the development of more energy efficient devices, applications and networks; and encourage environmentally friendly design, to give just a few examples. The aforementioned GeSI study showed that enabling reductions in other sectors could cut 7.8 Gigatonnes (Gt) out of 52 Gt compared with business as usual in 2020 - 15 per cent of total emissions.[34]
3. ICT plays a unique role in climate monitoring and climate change forecasting systems (see Box 1.4). Radio-based remote sensing applications (terrestrial and satellite) and the related telecommunication infrastructure form the backbone of the Global Climate Observing System or GCOS.[35] GCOS helps all countries, especially developing countries, to adapt to climate change by predicting the negative effects of natural disasters caused by climate change, which in turn, allows countries to take measures to mitigate these negative effects.[36]

Figure 1.2: CO2 emissions from telecom infrastructure and devices, 2002 and projected in 2020



Source: McKinsey and the Climate Change Group

Box 1.4: Tracking and Responding to Climate Change with ICTs

Climate change tracking and responding services can represent a major business opportunity. ICTs are used in weather and climate change monitoring, for instance in predicting, detecting and mitigating the effects of typhoons, thunderstorms, earthquakes, tsunamis, etc. This includes radio technologies and equipment such as active and passive satellite-based sensors) for prediction, detection and mitigation of effects of hurricanes, typhoons, thunderstorms, climate changes, earthquakes, tsunamis, man-made disasters, etc. weather satellites that track the progress of hurricanes and typhoons; weather radars that track the progress of tornadoes, thunderstorms, and the effluent from volcanoes and major forest fires; radio-based meteorological aid systems that collect and process weather data, and broadcast sound and television systems and different mobile radiocommunication systems that warn the public of dangerous weather events, such as storms and turbulence; satellite systems that are used for dissemination of information concerning different natural and man-made disasters.

Examples include the World Meteorological Organization's (WMO) World Weather Watch (WWW), composed of three integrated core system components, with all three layers based on the use of different ICT components and applications:

- The Global Observing System, which provides observations of the atmosphere and the earth's surface (including the surface of the oceans) from all parts of the globe and from outer space, acting as a relay for remote sensing equipment placed on satellites, aircrafts, radiosondes (a type of weather probe), as well as meteorological radars on the earth and at sea.
- The Global Telecommunication System (GTS) which combines radio and telecommunication equipment capable of providing real time exchange of a huge volume of meteorological data and related information between international and national meteorological and hydrological centres.
- The Global Data Processing System (GDPS), based on thousands of linked mini, micro and supercomputers, which processes meteorological observational data and generates meteorological products such as analysis, warnings and forecasts.
- The ITU/WMO Handbook "Use of Radio Spectrum for Meteorology: Weather, Water and Climate Monitoring and Prediction".

As the steward of the global framework for spectrum, ITU provides for the necessary radio-frequency spectrum and orbit resources for the operation without interference of radiocommunication systems for climate monitoring, weather forecasting, remote sensing and disaster prediction and detection. ITU-R Study Group 7 (Science Services, online: www.itu.int/ITU-R/index.asp?category=study-groups&link=rsg7&lang=en) develops and approves standards applied for development and use of such systems.

Information from: ITU, ICTs and Climate Change: ITU background report, ITU/MIC Japan Symposium on ICTs and Climate Change, Kyoto, 15-16 April 2008, online: www.itu.int/dms_pub/itu-t/oth/06/0F/T060F0000070001PDFE.pdf.

ICTs have the potential to make a positive contribution to reducing the levels of GHGs; at the same time, ICTs could materially increase the rate of climate change, thereby contributing to the degradation of the natural environment. The potential of ICTs both to enhance and to hinder efforts to reduce GHGs and climate change is reflected in a report published by Forum for the Future in 2008. *"If we develop and apply ICT badly, it could add to the world's problems. It could devour energy and accelerate climate change, worsen inequality for those who do not have access and increase pollution and resource use by encouraging ever more frenetic consumerism. If we apply ICT well, the rewards could be enormous. It could help to enhance creativity and innovation to solve our problems, build communities, give more people access to goods and services and use precious resources much more efficiently. We have the capacity – through our decisions on how we produce, buy, use and apply ICT – to secure enormous social and economic benefits."*[37]

Whilst there is growing interest in applying ICTs to reduce GHGs, the role of regulators in facilitating, enabling and promoting measures that would capitalize on ICTs' ability to reduce GHGs is comparatively unexplored.

1.3.2 Existing and potential points of contact

There are three *existing* points of contact between climate change and TSPs:

- Adaptation: the impact of climate change on TSPs as well as the changes in processes, practices, and structures to moderate potential damages or to benefit from opportunities associated with climate change[38];
- Mitigation: the contribution of TSP emissions to climate change; and
- Transformation: the role of TSPs in helping other sectors to reduce GHGs.

There is also one other, a *potential* point of contact, notably regulation. The main purpose of this paper is to ask whether regulation should be the fourth point of contact. The method of doing so is by asking a host of subsidiary questions in order to provide a check list for regulators to assess their role. The purpose is not to provide answers but to raise awareness of and draw attention to such questions.

Thus, the large question is: should there be a fourth point of contact between ICTs and climate change, notably, regulation? The subsidiary questions all fall under the three points of contact set out above. These questions are set out at the end of the relevant section throughout the rest of the paper. This section begins with a definition of First, Second and Third Order effects. (1.3.3 below). These terms are then used throughout the paper. Each of the points of contact is considered in turn, starting with the potential point of contact (regulation) in section 1.4, followed by the actual points of contact (adaptation, mitigation and transformation), in sections 1.5, 1.6 and 1.7.

1.3.3 First, Second and Third Order effects

Most academic research[39] on climate change refers to three orders of climate-changing effects resulting from the implementation and use of ICTs. Some effects are negative, some positive, but ICT is unusual among industry sectors in that it has the potential to generate more positive effects than other sectors. The three orders of climate change effects are:

- **First Order**: effects arising from the physical existence of ICT. These effects are normally negative and are caused by the manufacturing, assembly, installation, operation and disposal of a telecommunication system.
- **Second Order:** effects arising from the potential of ICT to change processes in other sectors (e.g. transport), resulting in changes to the environmental impacts related to those processes. These effects could be positive or negative.
- **Third Order:** effects arising due to collective medium or longer-term adaptation of behaviour (e.g. consumption patterns) or economic structures. Again, these effects could be positive or negative.

Second and Third Order categories also include 'indirect' effects that arise from the influence that a telecommunication system may have on other applications, processes or behaviours. These effects can be positive or negative and depend on complex sociological interactions. It is therefore difficult to identify Second and Third Order effects because they can involve changes to processes in other sectors. Perhaps even more importantly, Second and Third Order effects also depend on changes to human behaviour. This is covered in more detail below.

Coverage of the First, Second and Third order effects in this report is set out as shown in Table 1.2 below.

Table 1.2: First, Second and Third Order effects: coverage		
Section	**Title**	**Coverage of effects**
3	Regulation	First, Second and Third Order effects
4	Adaptation	N/A (although, see box 1.3 below)
5	Mitigation	First Order effects
6 and Annex 1	Transformation	Second Order effects Third Order effects

The following table indicates the order of magnitude of TSP emissions, using data reported by some of the leading telecommunication operators. Although these are not based on the same definitions and are, mostly, unaudited, the totals are shown in Table 3 below. Note that the inconsistencies in the data mean that the relative performances of operators cannot be derived from the table.[40]

In total the emissions shown above represent less than one fifth of the figure suggested by GeSI for the emissions of the global telecommunication industry.

1.4 Regulation: A Potential Point of Contact?

1.4.1 Introduction

Sections 1.5, 1.6 and 1.7 of this paper address the phenomena of adaptation, mitigation and transformation, respectively. All are *de facto* points of contact between climate change and the ICT sector, arising from the interaction between:

- the activities of ICT players as they provide services to their customers, and
- the natural laws that underlie the fluctuations of the climate.

The same cannot be said about regulation. This section considers whether there should be a fourth point of contact, one that is not yet in place and that would require active intervention to put into effect: ICT regulation, specifically regulation of TSPs relating to climate change. The section ends with a number of questions for discussion regarding the form, substance and content of such potential regulation.

Table 1.3: Total emissions stated by operators in 2007 (tonnes of CO_2 equivalent)

Operator	Stated emissions
AT&T California	108,760
BT	680,000
Cable & Wireless	113,157
China Mobile	7,000,000
Deutsche Telekom	1,885,318
Korea Telekom	714,869
NTT	3,776,000
Optus	257,075
SK Telecom	358,097
Telenor	604,767
Telstra	1,390,306
Verizon	7,600,000
Vodafone	1,350,000
Total	25,838,349

Source: ITU TSB Standardization Policy Division, ICT Corporate Statements on GHGs and recycling, 24 February 2009

1.4.2 Which ICT players are regulated?

It is estimated that since the late 1990s close to 200 new infrastructure sector regulators (including all network-based utilities, including energy, water, rail and telecommunications) have been created around the world.[41] In 2010, the figure is closer to 250 infrastructure regulators worldwide. The proliferation of regulators was the response of governments to far-reaching market reforms that saw the privatization of network utilities that had hitherto been vertically- and horizontally-integrated state monopolies under ministerial control. As part of this trend, countries introduced competition wherever possible and established utility regulators to enforce concession or licensing agreements and to regulate prices.[42]

In the ICT sector, as of June 2010, 156 countries had created a national regulatory authority.[43] These regulators are primarily focused on sector players that enjoy market dominance. These are the TSPs, normally former monopoly enterprises, that, in most countries, had been the sole providers of services, which they delivered using their own infrastructures. Such dominance created the need for regulation in order to:

- prevent the abuse of dominance;
- ensure a level playing field for new market entrants; and
- increase the likelihood that competition would flourish.

TSPs are regulated in order to generate outcomes that mirror those that would be produced in a competitive market, together with promoting public policy objectives that would likely not be met in a competitive market, such as universal access. The objective is to change the behaviour of the regulated entities so that they not only compete fairly but also advance designated public policy objectives (or support behaviour that is already producing these desired objectives).

This approach to regulating TSPs collides with an inconvenient truth when we consider the overall relationship between the ICT sector and its carbon footprint: many of the energy-intensive services and applications that are emerging in the new telecosm are not owned and operated by the regulated TSPs. In fact, these services and applications are mostly "outside" the scope of current telecommunication regulation, other than technical and commercial requirements that apply to any customer that is connected to a telecommunication network. Although these players are part of the telecosm, and require telecommunication connectivity so that their customers can access the desired functionality, they are not captured by telecommunication regulation. For example, as mentioned above, players like Google and YouTube are among the most significant energy users in the ICT sector, yet they are not typically subject to the jurisdiction of ICT regulators.

Some argue that the new ICT players should be subject to regulation comparable to that of TSPs. For example Google's Gmail has 175 million active users,[44] and the Financial Times has posed the question *"Is Google now a monopoly?"*[45] But technology and markets move rapidly in ICT. Soon after the Financial Times posed the "monopoly" question, the Guardian reported that, for the first time, Facebook had passed Google as the most-viewed US site during one week.[46]

Moreover, the fact that a company has become large, as measured by turnover, number of users or internet hits, does not automatically bring it within the jurisdiction of sector regulators. Although such factors might render large companies liable to interventions by general competition regulators and the requirements of anti-trust law[47], this does not bring them within the scope of TSP regulation. Normally, ICT companies only fall within the scope of sector-specific regulation if they control access to essential facilities (the American approach) or need to be subjected to measures that prevent the abuse of dominance that arises from their market power (the European approach). At present, in many countries, there is no legal basis for ICT regulators to regulate the activities of the new type of ICT companies, whether software companies, application and service providers, or equipment manufacturers. Although equipment manufacturing has long been subject to regulation through type approval, in some cases this is overseen by ICT regulators, whereas in other cases, a different agency or Ministry has authority over this matter. (In some countries (typically developing countries), ICT regulators do have authority over application providers).

Smartphones and Mobile Internet Devices that use a 3G connection place heavier demands on their battery than previous mobile technologies. This is compounded by the rapidly growing market for applications and services: devices like Apple's iPhone or those based on Google's Android operating system also have a significant impact on bandwidth requirements, hence energy demand. For example, in April 2010, Apple announced that it had sold 50 million iPhones and 35 million iPod Touch players (which include WiFi functionality), with shipments due to reach 100 million by summer 2010. It also announced that more than 4 billion applications had been downloaded.[48] As one study[49] has pointed out, 3G services such as those provided on Apple's iPhone *"greatly reduce battery time, by 43 per cent for the iPhone 3G and 60 per cent for the iPhone 3GS."*

It is true that Apple and other providers have been adapting the firmware so as to improve energy efficiency, providing energy saving by better software design. And there are applications that will help customers use their smartphones in a more energy-efficient manner.[50] But the trends are clear: GHG emissions will increase due to increasing power consumption of devices, more frequent recharging (4 per cent of total mobile emissions) and more use of networks, data centres, and other key infrastructure (71 per cent of mobile emissions).[51] Such concerns would not generally be addressed by regulations that relate to network operators and service providers. Addressing these concerns would mean regulating the manufacturers of such devices: this may be possible for some regulators, who do have the authority to regulate type approval, but it will not be an option for many sector regulators.

To continue with the example of Apple, the company has risen from 71st place on the Fortune 500 list to 56th, it has a current market value in excess of USD 200 billion[52], and it is now a significant player in the telecosm. But Apple does not, and is unlikely to be, the subject of TSP regulation. Thus, measures that are designed to affect the climate-changing activities of regulated TSPs would not apply to Apple, despite Apple's contribution to such climate-changing activities.

1.4.2.1 Questions

- Given the twin forces of liberalization and technological innovation, and the consequent proliferation of new services and applications, which elements of the ICT sector should be subject to climate change related regulation?
- How do sector regulators ensure that a level playing field is maintained between their traditional subjects of regulation (fixed and mobile network operators) and new ICT service providers, which may be responsible for more significant GHG emissions?

1.4.3 Which ICT activities are regulated?

The core activities of ICT regulators typically focus on ensuring fair market entry and competition, promoting investment and universal access to ICT services, and protecting customers. Regulators seek to provide a balance of incentives and sanctions to bring about the desired outcomes without becoming involved in the micro-management of the sector. Some regulators are also concerned with shaping behaviours of sector actors, which may go beyond the regulated players to include their customers or their customer's customers.

Many regulators have responsibilities that go beyond merely maximizing the economic efficiency of the sector. Examples include the delivery of universal service, the notion of any-to-any interconnection for companies offering service to the public, and network coverage and quality of service obligations, which are frequently set out in the terms and conditions of licences or authorizations.

The prospect of extending regulatory responsibilities to capture wider public policy goals – which might include policy for ICTs relating to climate change - was also recognized by all ITU Elected officials (the General Secretary and the Deputy-Secretary General, and the Directors of ITU Radiocommunication (BR), Telecommunication Standardization (TSB) and Telecommunication Development (BDT) Bureaus). For example, the BDT Director, noted the need to *provide "regulators and policy makers with the insights and guidance they need to make key decisions for the constituencies they serve including proper consideration of challenges related to issues such as privacy, online protection and climate change."* [53]

Box 1.5: Mobile: Absolutes and Relatives

According to mobile operators, the overall energy consumption of mobile networks is decreasing due to technological innovation and network optimisation, such that in recent years, the energy efficiency of mobile network equipment has improved markedly. The GSMA quotes figures from Ericsson that show that annual carbon dioxide equivalent (CO_2e) emissions per subscriber have declined over the past 20 years, at the same time as the data throughput of mobile communication technologies has increased dramatically.

Source: GSMA, in collaboration with The Climate Group, Mobile's Green Manifesto, November 2009, online: www.gsmworld.com/documents/mobiles_green_manifesto_11_09.pdf.

Such *"key decisions"* would be designed to factor in all the social costs and benefits of transactions within the sector. Many social costs and benefits are not captured in market prices, resulting in market failure. The consequences of market failure can range from relative trivialities like the annoyance caused by a ringing mobile phone in a cinema to the disastrous, such as the effects of the Bhopal chemical plant explosion.

Considering such externalities is a reminder that ICT sector regulators are tasked with serving a wider public purpose than the simple focus on economic efficiency. Policy makers may decide that ICT regulators should serve wider public policy goals, including policies relating to climate change. Thus, the question arises, should the mandate of ICT regulators include objectives relating to climate change?

To take one example, regulators typically require competing infrastructures as a way to increase economic efficiency among TSPs. In the mobile sector, policies such as active infrastructure sharing[54] have often been restricted, *"out of concern that it could enable anti-competitive conduct, such as collusion on prices or service offerings eliminating consumer choice. These concerns remain valid, but have to be balanced with advances in technology and applications that enable service providers to distinguish their offerings."*[55] As this author continues, the result of such policies in the case of some *"remote and hard to reach areas, having fewer consumer choices can be balanced against the choice of having no services at all, to at least allow active infrastructure sharing for a limited time until demand for ICT services grow to support multiple network operators.."* Added to this, there are reduced environmental impacts from infrastructure sharing, potentially including reduced energy consumption, hence lower GHGs. Indeed, the combination of the global financial crisis plus the results of regulatory measures related to promoting and increasingly mandating some aspects of infrastructure sharing over the past 5 years means that regulators have realized the importance of creating stimuli designed to drive consumer benefits from service-based competition. Whilst redundant capacity is required for effective competition to occur, in rural, remote, low-income areas business models based on sharing are more likely to be successful.

1.4.4 Should ICT regulators have responsibilities related to climate change?

> "*Climate change……the largest market failure of all time.*"[56]
> Nicholas Stern

It is hard to find examples of sector regulators or associations of regulators with a mandate that explicitly includes climate change. For example, the successor to the European Regulators Group (ERG), the Body of European Sector Regulators for Electronic Communications (BEREC), was set up in 2009. BEREC includes the telecommunication sector regulators of the 27 EU countries, and was established following the adoption by the European Council and European Parliament of the new EU Electronic Communications rules in December 2009.

Box 1.6: Active and Passive Infrastructure Sharing

There are two levels of infrastructure sharing: passive and active. Passive sharing involves components such as the tower mast or pylons, cables, physical site or rooftop, shelter cabinets, power supply, air conditioning, alarm systems, etc. Active sharing includes antennas, antenna systems, backhaul transmission systems and the BTS equipment itself. Passive sharing is becoming increasingly common and reduces the environmental footprint of mobile networks by cutting the number of BTS sites required by each company. In March 2009, Telefonica and Vodafone announced that they would share network infrastructure in Germany, Spain, Ireland and the UK. Active sharing, which shares the site electronics, can have a much larger impact on the networks' carbon footprints, but it has only been implemented in a few mature markets to date. Active sharing agreements include T-Mobile and 3 Group in the UK, Telstra and 3 Group, as well as Vodafone and Optus, in Australia, Tele2 and Telia, as well as Tre and Telenor, in Sweden. In the Republic of Korea, all three operators KT, SK Telecom and LGT invested in KRTnet Corporation in 1996 to construct and manage base station sites jointly used by all operators, leading to co-location of sites and tower sharing.

BEREC's role is to ensure consistent regulation across Europe, and its main job has been described as "*to help ensure fair competition in the single telecommunication market.*" But it is notable that when BEREC published its proposed work programme in January 2010, the list did not include any initiatives related to the role of TSPs in the environment or GHGs in particular.[57] A similar point could be made about practically every other sector regulator; there seem to be few, if any, precedents for the involvement of sector regulators in activities relating to climate change. Accordingly, there is no ready-made blueprint or manual that could serve as a best practice benchmark to be applied across markets and jurisdictions.

Similarly, when UK regulator OFCOM consulted on NGN policy in 2006[58], it noted that the main challenges for public policy could be divided into two main areas, notably: identification and realization of external social benefits arising from next generation access deployments, and the emergence of a digital divide in next generation access availability. There was no mention of environmental issues, which is ironic given the substantial contribution that NGNs could make to reduction of TSP GHGs: one ITU report has identified possible savings of up to 40 per cent in the migration to NGNs.[59]

1.4.4.1 Questions

- Given the potential for ICT to have a beneficial impact on GHGs, is it appropriate for regulators to be given additional duties concerned with environmental matters, particularly those relating to climate change?
- Should ICT regulators now consider the potential for GHG reductions when making regulatory decisions?[60]
- ICT regulators have previously focused on market failure related to the telecommunication sector. If the responsibilities of ICT regulators are now to encompass measures relating to climate change, how should such interventions be implemented, such that the chosen measures do not add further burdens to the sector?
- Given the general consensus about the threat posed by climate change, and the potential of the ICT industry in general, and TSPs in particular, to facilitate the reduction of GHGs, should ICT regulators develop and advocate policies that address climate change?
- If the regulator's core mandate does not include environmental considerations,[61] how should such considerations be incorporated into regulatory policy, particularly where regulatory decisions may result in environmental consequences?
- What role should ICT regulators play with regard to environment-related measures: facilitator, enabler, promoter, awareness raiser?
- Should the ongoing United Nations Framework Convention on Climate Change (UNFCCC) negotiation process make the link between climate change and regulation of the ICT sector?
- How should sector regulators consider policy areas that affect environmental outcomes, such as through beneficial effects on power usage and GHGs? Should regulators factor potential environmental outcomes into their decision making when it comes to policy matters such as the deployment of NGNs, migration from analogue to digital networks, migration from 2G to 3G and beyond[62], and infrastructure sharing?
- What should be the scope and extent of regulatory interventions which are designed to bring about reduced GHG emissions by ICTs?
- What is the legal basis for ICT regulators to become involved in the pursuit of policies to reduce GHGs?
- Would such policies require changes to the primary duties/enabling legislation of ICT regulators?
- How should policy makers ensure that economic players are able to plan effectively for the integration of environmental considerations into ICT sector policies?
- How can ICT regulators develop more effective coordination with other regulators and policy makers to ensure that decisions relating to ICTs recognize any potential GHG implications, whether negative or positive?
- Which other sectors, such as energy, transport, and health, offer the greatest scope for the beneficial linkages between ICTs and reduced GHGs to be brought about?
- How should ICT regulators factor GHG reduction measures into their existing portfolio of policies and regulatory responsibilities?

1.4.5 What is the appropriate form for climate change measures in TSP regulation?

With the increasing awareness of climate change related issues as well as the general framework of laws that apply to all organizations, there will be specific laws that relate to particular sectors, such as TSPs. There are then likely to be operating licences or general authorizations that set out the conditions to which the regulated entities are required to adhere. These will be set out by sector specific regulators.

All regulation is ultimately about behaviour. Some regulation focuses on changing behaviour to bring about the desired objectives, while other regulation aims at reinforcing existing behaviour if the desired objectives are already being met. But the methods that can be employed to bring about the desired objectives take many forms, with varying degrees of formality and legal enforceability. Measures can also be supported with a range of different incentives, penalties, and sanctions to further reinforce the desired behaviours. Typically, these measures fall on a spectrum from formal to informal modes of regulation.

1.4.5.1 Formal regulation

Regulation can be highly formal, such as when it is based on statute. This type of measure normally requires the approval of legislators. It is frequently used to establish the overall framework within which TSPs and their regulators operate. Pursuant to general principles set out in law, TSPs are often granted operating licences or general authorizations, which set out the rights and obligations enjoyed by these market players. If this formal route was to be used as the basis for including climate change measures in TSP regulation, it would likely take the form of specified conditions in such operating licences or general authorizations. However the legislation governing TSPs would likely have to specify that climate change-related conditions could be included as a condition of licence or general authorization. This would be needed to give regulators the authority to take climate change-related matters into consideration in regulatory decisions. So implementing measures aimed at reducing GHGs would likely have to be formalized in the general legislation governing the ICT sector.

1.4.5.2 Informal regulation

Informal measures can also be used to achieve regulatory objectives. Many such measures are based on voluntary compliance. These measures can take many forms:

- Codes of practice and codes of conduct;
- Key Performance Indicators (KPIs);
- Targets;
- Voluntary agreements;
- Guidelines;
- Industry labels ( );
- Best practice information; and
- Public consultation, publication, information and education.

These less formal measures can be implemented and monitored in a variety of ways, for example, through websites, blogs and forms of communication such as social media. Such informal measures serve to steer TSPs and their customers towards more energy efficient (and GHG-reducing) types of behaviour, as considered in the following sections.

1.4.5.3 Questions

- If ICT regulators are to have an active role relating to climate change, is the most appropriate way to implement this role via more formal or less formal measures?
- Should regulators increase their involvement in formal processes related to climate change with national policy-makers, given that regulators have enforcement powers over TSPs and can prove to be key stakeholders in such discussions?
- Should ICT regulators require that TSPs include emissions targets in company performance targets such as KPIs?
- How should sector regulators support the industry in developing codes of conduct, best practice etc on reducing their GHGs?

1.4.6 Should regulators do more to change individual behaviour?

"*Little things can make a big difference.*"
Malcolm Gladwell [63]

There is a (perhaps understandable) tendency in the ICT sector to assume that the way to solve most problems – including GHG reduction – is with a technological fix. However, installed technology often does not work in line with the intentions of the designer, resulting in higher than anticipated energy use (hence GHGs). This underlines the importance of human behaviour when using ICTs, a subject that tends to be overlooked.

There is also an assumption is that, as GHGs are linked to energy use, and energy use is expensive, we can leave it to customers to make their own decisions about how they use ICTs in the most energy-effficient manner. The World Bank points out that, *"The debate about changing individual behaviour has focused on market mechanisms. Better pricing of energy and costing of scarce resources can steer individuals away from carbon-intensive consumption and encourage them to preserve endangered habitats and manage ecosystems better. But the drivers of consumption by individuals and groups go beyond prices. Many cost-effective energy-efficient technologies have been available for years….So, why haven't they been adopted? Because concern does not mean understanding, and understanding does not necessarily lead to action."* [64]

To redress the balance, the following section considers the importance of individual behaviour change. For, as Rajendra Pachauri, Chairman of the IPCC has suggested, the time has come, *"to start looking at the social-science aspects"* of climate change. [65] This is a far from straightforward activity, since, according to Anthony Leiserowitz, Director of the Yale Project on Climate Change *"Human beings' decision-making processes, as individuals and collectively, are probably at least as complicated as the climate system itself."* [66] Angel Gurría, the OECD's Secretary-General,[67] has said that, *"We need to start producing, transporting, consuming, regulating, governing, even thinking, differently; starting today. Climate change means cultural change."*

Such comments add up to the following notion: all of the innovative ICT that is now available, and which will emerge in the future, is not going to help, and may hinder, the process of reducing GHGs unless people also change their behaviour in the right way.

1.4.6.1 Questions

- What role is there for ICT regulators in persuading the public to behave differently so as to reduce the GHGs produced by individuals through the use of energy-saving and clean-energy ICT services and applications?
- Is there a role for regulators to become more involved in promoting responsible consumer behaviour such as turning off equipment when not in use, not replacing devices as frequently, and using less bandwidth?

1.4.7 Why should regulators attempt to change individual behaviour?

> '*It would be easy to give the public information and hope they change behaviour but we know that doesn't work very satisfactorily. Otherwise none of us would be obese, none of us would smoke and none of us would drive like lunatics.*'
> Ian Potter, Director, New Zealand Health Sponsorship Council, New Zealand Herald, June 2007

It is true that *"Everything that happens in the economy happens as the result of an action by some individual,"*[68] and the same applies to our activities relating to climate change. The IPCC's report on climate change mitigation to 2030 notes, *"changes in lifestyle and behaviour patterns can contribute to climate change mitigation across all sectors,"*[69] and in its 2010 report on *Development and Climate Change*,[70] the World Bank notes the importance of considering individual behaviours when addressing climate change (see box 1.7 below).

Disciplines such as social marketing[71] and behavioural economics[72] are increasingly being used to provide insights into human behaviour and how to change it in a positive direction, with applications from health promotion to environmental protection. Perhaps it is now time for ICT regulators to consider using such techniques with regard to changing consumer behaviour to reduce GHGs.

1.4.7.1 Questions

- Is there a role for ICT regulators to address not just the TSPs, but the end users of the services provided by TSPs?
- Should regulators be involved in attempting to change individual behaviours as part of the drive to cut GHGs?
- Should regulators develop programmes to build consumer awareness and education about the impact of usage patterns in ICTs on the environment?
- Do ICT regulators have a role to play in helping overcome barriers to behavioural change?
- Should ICT regulators incorporate insights from disciplines like social marketing and behavioural economics into their attempts to modify the GHG-related behaviours of individuals?

Box 1.7: Insight in the impact of behavioural change on mitigating climate change

A recent report on this topic notes that:

"*First, myriad private acts of consumption are at the root of climate change. As consumers, individuals hold a reservoir of mitigation capacity. A large share of emissions in developed countries results directly from decisions by individuals – for travel, heating, food purchases. U.S. households account for roughly 33% of the nation's carbon dioxide (CO_2) emissions - more than U.S. industry and any other country bar China…. If fully adopted, existing efficiency measures for households and motor vehicles could produce energy savings of almost 30% - 10% of total U.S. consumption. Second, individuals drive the larger processes of change in organizations and political systems. Particularly in democratic countries, much government action is the result of citizen and voter pressures to act. Third, when designing and implementing policy, decision makers apply the same mental processes as other individuals.*"

The report goes on to consider the difficulty of addressing individual behaviours – whether individuals in their roles as consumers, businesses, governments or citizens – in relation to climate change. It points out that understanding the drivers of human behaviour is essential for what it calls "climate-smart development policy. But because human behaviour is complex and often unpredictable, there are many different models of why humans do what they do.[73] There are thus big challenges inherent in attempts to change behaviour.

As one commentator notes, "*The challenge of trying to stimulate behaviour in desired directions can hardly be overestimated. Decades of academic research has sought to explain how policy makers and firms can engage with individuals' motivations in the interests of environmental, social or economic goals. Conventional approaches tend to rely on the provision of digestible, compelling information and appeals to rational decision-making. Such techniques have been fundamental in the design of public policy campaigns for years. Yet research from diverse disciplines within psychology, sociology, biology and medical science highlights the limited scope of these approaches to promote real change. The belief that consumers will change their behaviour on the basis of rational deliberation alone – for instance, by absorbing more and more information about the causes and impacts of climate change – seems unrealistic. Incentives and penalties often fail to achieve expected outcomes and research suggests such appeals to consumer rationales are limited…..*" [74]

Source: World Bank, Development and Climate Change Report 2010.

- What is the role for mechanisms such as choice architecture, defaults, commitment devices and Nudge, based on the findings of social marketing and behavioural economics?[75]
- Should ICT regulators provide information about the energy consumption of ICT devices?
- Is there a role for ICT regulators in producing case studies and similar examples to raise the level of understanding and help kick-start the debate about GHGs and ICTs?
- In what ways can ICT regulators use new forms of ICT services in attempting to change behaviours?

1.4.8 Which new ICT services can regulators use to help change individual behaviour?

"*The Medium is the Message.*"
Marshall McLuhan

"*Mobile phones…have become a must carry item.*"
Rashid, Coulton & Bird [76]

Box 1.8: Changing Behaviour with Social Marketing and Behavioural Economics

Social marketing is defined by the UK's National Social Marketing Centre77 as "*an approach used to achieve and sustain behaviour goals on a range of social issues*" by using "*a range of marketing techniques and approaches (a marketing mix).*

Behavioural economics differs from conventional economics as it recognizes that, as one unknown source put it, "*There is only one way for people to reach the optimal outcome identified by the classical economic models, but a thousand ways to miss that outcome.*" Hence, relying on people's economic rationality (e.g., cutting your carbon footprint can save you money) does not always work. Behavioural economics "*increases the explanatory power of economics by providing it with more realistic psychological foundations.*" [78]

Social marketing and behavioural economics can provide insights into the barriers to behavioural change[79] and are increasingly being used by regulators of financial services[80] and in other sectors.

1.4.8.1 Social media, Web 2.0 and new ICT services

Social networking, driven by increasingly pervasive ICT services and applications, is becoming an integral part of contemporary culture. A Nielsen survey in June 2010 noted that *"three of the world's most popular brands online are social-media related (Facebook, YouTube and Wikipedia) and the world now spends over 110 billion minutes on social networks and blog sites. This equates to 22 per cent of all time online or one in every four and half minutes. For the first time ever, social network or blog sites are visited by three quarters of global consumers who go online, after the numbers of people visiting these sites increased by 24 per cent over last year. The average visitor spends 66 per cent more time on these sites than a year ago, almost 6 hours in April 2010 versus 3 hours, 31 minutes last year."*[81]

One of the reasons for such an explosive growth is the move from per-hour billing for Internet access towards flat rates and unlimited packages. It may seem a long way from climate change to the competition which has led to changes in tariffing for internet access, but this could be seen as a classic example of the Law of Unintended Consequences.

This section considers two aspects of social networking and new ICT services. The first concerns the rising energy use associated with the new ICT services; the second considers how such services might be used to reduce the energy consumed by customers:

1.4.8.2 Energy use and new ICT services

Separating out the energy consumption of new ICT services such as social media and social networking is complex. It is difficult to disaggregate the bandwidth used in telecommunications networks by such services, and similarly difficult to net out the data centre energy requirements. Many of the main players in the sector do not disclose energy use data, which makes such calculation even more difficult. This difficulty has been compounded by the rise of so-called "cloud computing", whereby the internet has facilitated the sharing of resources, software and information, which are typically provided to computers and other devices on-demand. In its report on cloud computing, which uses the Smart 2020 Report as its starting point, Greenpeace International has calculated the figures set out below. Clearly, these figures are not based solely on new ICT services, and the data may require some caution. The figures indicate that the electricity consumption of telecommunications and The Cloud will more than double by 2020, as will the accompanying CO2 emissions.

1.4.8.3 Behaviour change and new ICT services

Social networking, whether Facebook, MySpace or Twitter, is changing how we interact and with whom we interact. Millions of people now communicate details of their professional and personal lives by poking, twittering and posting as a way to create, grow and maintain personal contacts, share ideas and keep up with the news. Social networking has been described as one of the ten inventions that changed the world,[82] and author B.J. Fogg has commented on the rise of a new form of persuasion, which he calls mass interpersonal persuasion (MIP).[83]

Table 1.4: Measuring GHGs from The Cloud

	Derived electricity consumption	Forecast electricity consumption	Δ increase 2007-2020	Conversion to energy use	Derived electricity emissions
	Billion kWh 2007	Billion kWh 2020	Billion kWh 2020	gCO2e/kWh CAIT e factor	MtCO2e 2020
Data centres	330	1012.02	307%	526.6	533
Telecoms	293	951.72	325%	526.6	501
Total Cloud	623	1,963.74	315%		1034

Source: Greenpeace International, Make IT Green: Cloud Computing and its Contribution to Climate Change (Amsterdam: Greenpeace, 2010). Online: www.greenpeace.org/international/en/publications/reports/make-it-green-cloud-computin/

Perhaps the most celebrated recent example of the use of such new ICT services and applications to bring about behavioural change was the campaign for Barack Obama to win the Democratic nomination and then the Presidency of the United States. This campaign has been described in one study[84] as having relevance for *"conducting and building communities around public health campaigns,"* but the subject could just as well be climate change. The authors of this study show how new media were used to energize the public in the Obama campaign, with particular reference to four different ICT areas: 1) the campaign website; 2) the campaign TV channel; 3) social networking sites; and 4) mobile phones. The authors add a fifth, the campaign materials created by supporters who made use of new media.

ICT-enabled social media are increasingly being used in other campaigns to change behaviour. Some recent examples in the UK have included: quitting smoking;[85] persuading unregistered voters to register before the 20 April deadline in the UK 2010 General Election;[86] and a Facebook application run by the Food Standards Agency to promote healthier eating to 13-16 year olds.[87] Campaigns such as these have been added to the toolkits of those wishing to change behaviour because, with three quarters of the world, or 5 billion people, having a mobile phone subscription,[88] *"Mobile phones are the most pervasive technology on the planet….they have become a must carry item along with money and keys."* [89]

Mobile phone applications are now able to collect information about a person's overall energy usage and present this information back to the user. Still to be decided is what should happen to such information.

1.4.8.4 Questions

- Should ICT regulators use new forms of ICT services, including social media, in the attempt to change individual behaviours and promote energy efficiency and the use of clean energy sources in ICT?
- Should ICT regulators use new ICT products, services and applications to facilitate behaviour changes relating to climate change generally?
- Should regulators assume that innovation and market forces, which drive the development of applications for ICT devices (e.g., applications that reduce smartphone energy consumption[90]), will result in GHG reduction?
- Should regulators be addressing not just the TSPs – the usual focus of their regulatory interventions – but also the end users of TSPs' services, whether organizations (corporate, government and SMEs) or individual consumers?
- What is the role for ICT regulators in developing measures to influence the levels of GHGs produced by the end users of TSPs' services?
- If individual behaviour change is desirable, should TSPs and regulators act as facilitators and enablers, focused on the customers of TSPs?
- What form should regulatory interventions take, and should they be primarily based on persuasive rather than coercive measures?

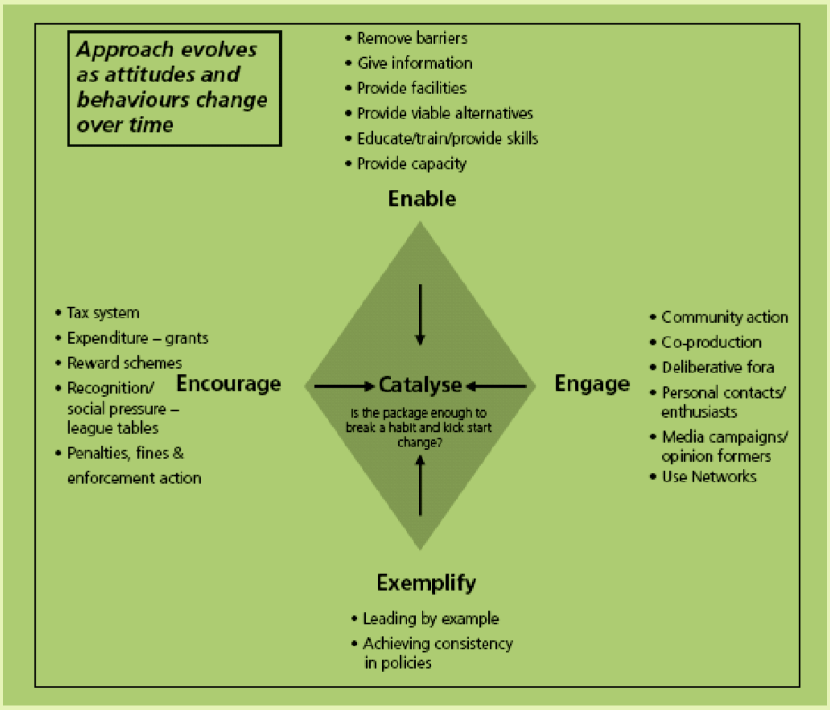
1.4.9 Should ICT regulators act as climate change exemplars regarding their own behaviours?

One of the themes in this paper is the need for ICTs in general and TSPs in particular to show that they have "clean hands" when it comes to GHGs. In this vein, some governments have set out how they intend to act as exemplars, by reducing their own GHG emissions.[91] Should ICT regulators follow suit, with benchmarks and publication of their own GHG-related behaviours?

One way to approach this matter is the "4Es" policy framework, which was originally developed by the UK's Department for Environment, Food and Rural Affairs (DEFRA). The 4Es are four actions that should underpin the government's attempts to change behaviour: Enable, Encourage, Engage and Exemplify.[92]

Some ICT regulators already record their plans for environmental protection and periodically report on their actions. It is important that, in conducting their own activities, sector regulators set a good example in seeking to manage their GHG production. Regulators might undertake this management through their use of buildings and travel; through their use of ICT products and services to substitute for GHG producing activities where possible; and by measuring their GHG footprint. OFCOM, the UK ICT regulator, has commissioned and published research on its own environmental footprint, which may be considered a precedent for such activities.[93]

Figure 1.3: DEFRA and the 4E's Model



Source: DEFRA, A Framework for Pro-environmental behaviours *(London: DEFRA, 2008) , online:* www.defra.gov.uk/evidence/social/behaviour/documents/behaviours-jan08-report.pdf

1.4.9.1 Questions

- Should we expect regulators to act as exemplars of good behaviour regarding their GHG-creating activities?
- Should sector regulators, at the national, regional and international level, exemplify good practice by developing policies that curb their own GHGs?
- How should ICT regulators go about this task?
- Should regulators be required to subject their own GHG-producing activities to a higher degree of scrutiny, with a requirement for greater transparency?
- Should ICT regulators be required to set out their own GHG mitigation policies, establish targets, and publish results?
- Should there be a role for ICT regulators in ensuring that information about best practices is diffused across all relevant regulators (perhaps a task for ITU)?

1.4.10 Should ICT regulators lobby for more effective carbon pricing?

ICTs can be seen as having "clean hands" relative to many other sectors of comparable economic importance. The rising price of energy and more rigorous emissions controls will incentivize companies both inside and outside the ICT sector to find innovative ways to curb GHGs. ICT companies are unusual insofar as these developments will encourage increased take up of their services. But will leaving it to the market provide sufficient incentives? As Greenpeace International notes in its report on Cloud Computing, *"because of the unique opportunities provided to the ICT sector in a carbon-constrained world, the industry as a whole should be advocating for strong policies that result in economy-wide emissions reductions."*[94] One such policy would be to set an appropriate price for carbon. As the OECD notes,

"OECD analysis shows that large reductions in GHG emissions are achievable at relatively low costs, if the right policies are put in place. This includes strong use of market-based instruments worldwide to develop a global price for GHG emissions, "[95]

Figure 1.4 below sets out the rationale for green taxes and the link to low carbon industries of the future.

Figure 1.4: The Rationale for Environmental Taxation

Key messages

Environmental taxes work: numerous studies, including those of the Green Fiscal Commission, have shown that green taxes are effective in reducing the environmental impact on which they are targeted.

Environmental taxes are efficient: there are good reasons why environmental taxes in many situations will achieve environmental improvement at lower cost than other instruments.

Environmental taxes can raise stable revenues: some environmental taxes, like fuel duty, have been raising sizeable revenues for years. Raising them significantly would therefore both achieve environmental improvements and allow other taxes to be lower than they would otherwise need to be.

The public can be won round to green fiscal reform: a number of polls show majority public support for a green tax shift, which increases when people are persuaded that the green taxes really will be instead of other taxes.

The UK's 2020 greenhouse gas targets could be met through green fiscal reform: the economic implications of doing so would be broadly neutral, and the green fiscal reform policy approach would increase employment.

Green fiscal reform would stimulate investment in the low-carbon industries of the future: investing a small proportion of the revenues from green fiscal reform in energy-efficient homes and vehicles, and in renewable energy development, would accelerate the growth of new low-carbon industries with real export potential, as well as increasing the environmental benefits of green fiscal reform.

*Source: UK Green Fiscal Commission, The Case for Green Fiscal Reform, London: Green Fiscal Commission, c/o Policy Studies Institute, 2009. Online:*www.greenfiscalcommission.org.uk

There are a variety of different measures and fiscal instruments that can be employed in order to reduce carbon emissions.[96] Whichever instrument is chosen, the OECD notes the need for *"....a strong and consistent price signal across all GHG-emitting activities. Developing a global carbon price not only reduces the total costs of reducing GHG emissions, but also helps to level the playing field between countries, thus addressing concerns about the potential effects on competitiveness of climate change policies....(carbon) taxes can be a particularly cost-effective approach to reducing GHG emissions."* [97] Carbon taxes also help to speed technological innovation and diffusion.[98] Setting a higher price for carbon (probably around USD 100 per ton of CO2) will encourage increased take up of ICT services and speed the transition to low carbon economy.[99]

This means that a measure such as a carbon tax is in the direct business interests of the ICT sector: it will increase the demand for, and the value of, the use of ICTs to substitute for carbon-generating activities. Until now, the lobbying of the ICT sector has been low in relation to the economic importance of the sector, particularly when compared with the fossil fuel sector.[100] Is it now time to overcome this reticence to lobby, and should regulators develop their own position on the question?

1.4.10.1 Questions

- Given the apparent speed of climate change and the unique possibilities for carbon reduction presented by ICTs, has the time come for ICT regulators to support fiscal incentives that will help speed the transition to a low carbon economy?
- Do ICT regulators have a specific role to play in supporting activities such as GeSI's commitment no 5, *"Work with public policy makers to ensure that the right regulatory and fiscal frameworks are in place"* [101] in order to move the sector in the right direction?
- Should ICT regulators now join forces with the ICT sector in order to lobby/lend support for policies such as a carbon tax?

- Should TSPs join any efforts by the ICT sector to lobby for a carbon tax, and should ICT regulators support a carbon tax?
- Should ICT regulators use their special relationship with government to influence public policy in a way that would favour the ICT sector and speed the transition to low carbon economy?
- Is there a role for ICT regulators to champion the ICT sector in calling for an appropriate price for carbon – e.g., through a carbon tax – as a way to mobilize arguments which incentivize companies to cut GHGs by using innovative ICT solutions?

1.4.11 Overall questions

This section poses overall questions about the potential role for regulators relating to ICTs and climate change:

- Should ICT regulators be involved in encouraging and facilitating the ongoing activities of organizations such as GeSI (and vice versa)?
- Is there a role for ICT regulators in emphasizing climate change issues in the industry's supply chain work and in influencing the end-to-end manufacturing process for electronic equipment?
- How do ICT regulators ensure that energy and climate change matters are fully considered by the organizations that set the technical standards for the ICT industry?
- Should ICT regulators be involved in the formulation of national policies on climate change?
- How do ICT regulators create a policy framework to reduce the ICT sector's own carbon footprint and to embrace environment-friendly technologies and processes in ICT development (e.g., Green IT initiative in Japan, etc.)?

This section has been a (necessarily hypothetical) discussion about a *potential* point of contact between ICT regulators and climate change. The following sections consider three *existing* points of contact between ICTs/TSPs and climate change. As before, each section comprises analysis and discussion, followed by a number of questions that relate to the role of regulators.

1.5 Adaptation: A Current Point of Contact

"*It is not the strongest of the species that survives, or the most intelligent; it is the one most capable of change.*"
Attributed to Charles Darwin

1.5.1 What is Adaptation?

"....a process by which strategies to moderate, cope with and take advantage of the consequences of climatic events are enhanced, developed, and implemented."[102]

There are many definitions of adaptation as it relates to climate change.[103] The one chosen here is particularly appropriate to the ICT sector since it includes the possibility that such adaptation might include taking advantage of the consequences of climate change. This aspect of climate change will be considered in the section on Transformation, below.

First, we consider how climate change will affect the ICT sector and how ICTs will seek to cope with the impact of climatic events.

1.5.2 What are the general consequences of climate change?

Not only countries, but also companies, face increased risks as a result of climate change. For businesses, the consequences will flow both from climate change and from the policies that seek to address it. Businesses face regulatory exposure, physical exposure, competitive exposure, and reputational, including litigational, exposure. Physical risks such as more frequent and more serious storms, floods, droughts, strong winds, heat waves and forest fires pose an obvious threat to the sector. Other risks include water shortages, increased rainfall, and rising sea levels. Any industry that relies on a physical infrastructure, particularly one that is widely distributed, is vulnerable to the effects of climate change. Climate change means an increased risk of service disruption to all network infrastructures, including energy, transport and telecommunications (and these effects are also inter-related, given, for example, the dependence of the telecommunications sector on electrical power). Climate change will likely impact the design of the networks, raising the need for more robust infrastructures, greater technical knowledge, and enhanced engineering capabilities.[104]

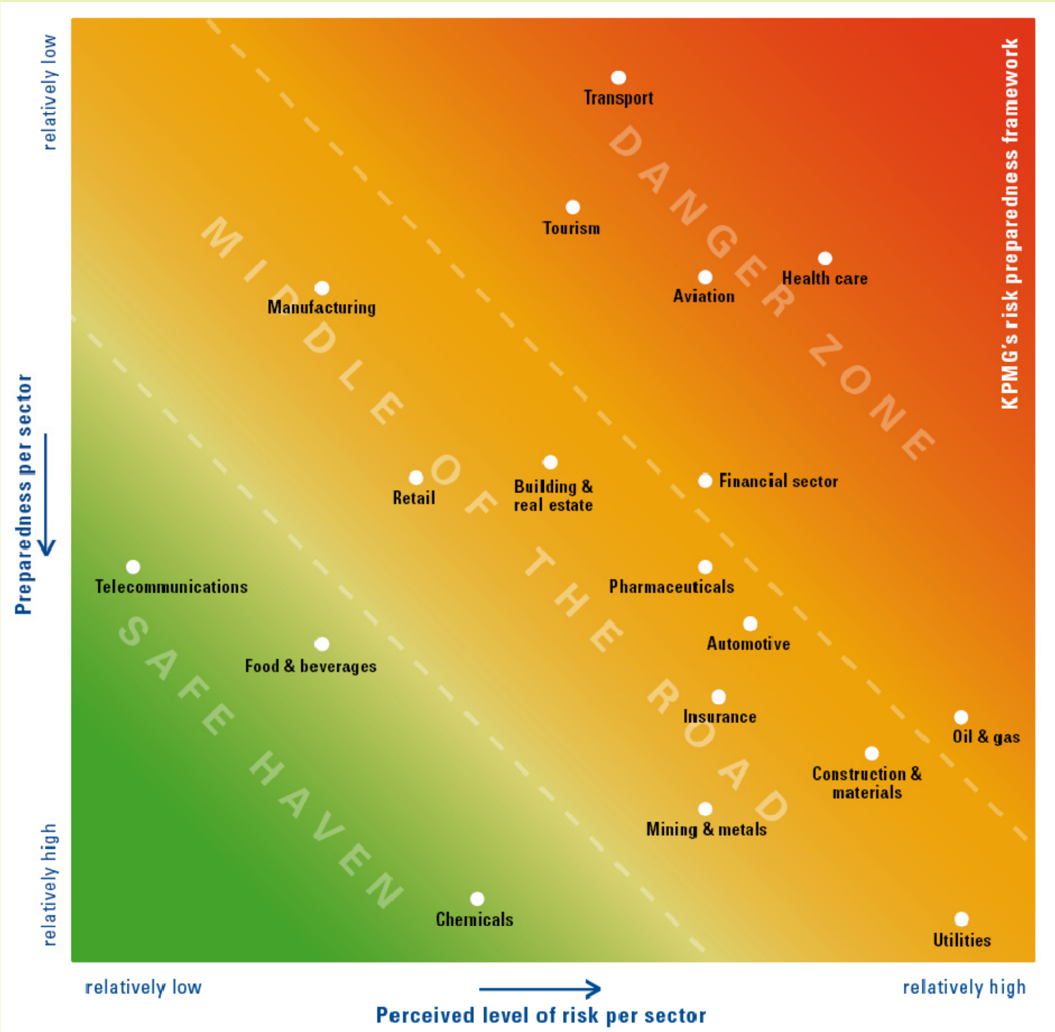
1.5.3 What are the consequences of climate change for ICTs?

Many TSPs are network-based. As with other network-based enterprises, TSPs are vulnerable to the impact of climate change in general and extreme weather events in particular. This is because networks rely on physical equipment, some of which is likely to be situated in locations that are subject to climate-change induced extremes of weather.

In a 2008 survey of climate change risks to business, KPMG[105] found that six major industry sectors were in particular danger: aviation, healthcare, tourism, transport, oil and gas and the financial services sector. All were in KPMG's "danger zone" – highly scored on the risks, yet poorly scored in terms of their preparedness to face these risks. Although KPMG found that the physical risks to the telecommunication sector were relatively low, the study found that of the 18 sectors included in the report, even the three deemed to be in the "safe area", which included telecommunications, were not sufficiently prepared to deal with the new risks associated with climate change. It is also worth noting that "low risk" is not the same as "no risk."

The fact that TSPs are in the "low risk" zone does not mean that they are not subject to an absolute downside from climate change; it just means that they are likely to suffer relatively less than some other industry sectors. This will offer scant comfort to TSP managers when climate change events result in the loss of connectivity or unusable exchanges.

Figure 1.5: Climate Change Risk Chart



Source: KPMG Climate Changes Your Business (2008), online:
www.kpmg.co.uk/news/docs/chart%20for%20climate%20change%20press%20release.pdf

Such TSP managers might feel that, in fact, telecommunications companies are significantly exposed to physical risks since extreme weather conditions could result in network damage and rising insurance costs. TSPs may have to consider protecting or relocating elements of their network that could become exposed to damage from severe weather conditions. This is particularly true in the case of remote sites, especially in developing countries, where road access to the sites is needed for access and often for providing energy supplies.

Such concerns are not hypothetical. Many TSPs are already suffering the effects of climate change, expressed in more frequent severe weather effects. For example, when Hurricane Ivan hit the Caribbean in 2004, it caused exceptional operating costs of £18m relating to business and network restoration, plus a £3m fixed asset write-down for the TSP Cable & Wireless. British Telecom (BT) has said that severe weather systems resulting from climate change have already caused substantial damage to BT's UK operations and cost the company money, with the situation only set to get worse. BT chief executive Ben Verwaayen said in June 2005, *'The gales last winter followed Scotland's wettest summer on record. This meant we experienced numerous cable faults, overhead cables down and a whole car park full of vehicles ruined by floods'.* In 2006, TeliaSonera's fixed network sustained damage costs equivalent to 2 per cent of sales as a result of storms in southern Sweden. BellSouth estimated that Hurricane Katrina resulted in USD400m worth of network damage.

Operators have already begun thinking about climate change when planning the location of new nodes for next generation networks. Wireless technologies may be seen as more resilient, and could fare better than fixed networks when climate-related events strike. As the ITU has noted, *"In many cases, when disaster strikes the "wired" telecommunication infrastructure is significantly or completely destroyed and only radiocommunication services can be employed for disaster relief operation (especially radio amateurs and satellite systems)."*[106] Although not related to climate change, the earthquake disaster which struck Haiti in January 2010 shows what could occur. The massive earthquake killed around a quarter of a million people, made over one million people homeless, and significantly damaged infrastructure and the broader economy. As one commentator notes, *"The mobile networks all suffered damage from the earthquake, and the market leader Digicel lost approximately 30 per cent of its cell sites. Haitel was largely spared as it utilizes large cell towers built to withstand hurricanes and earthquakes. Comcel's network was at least 70 per cent operational within two days following the quake."* [107]

Other consequences of climate change include increases in operators' energy demands, as higher temperatures will, under current running temperatures, require more air conditioning in the exchanges. Network damage will require trucks to be used for repairs, with implications for fuel use. And operators are likely to have to run more back-up generators in areas experiencing extreme weather conditions.

Were sea levels to rise materially, network operators would be likely to have to move or to replace a significant amount of network equipment. For example, equipment positioned in sites at risk of flooding would need repositioning, and displaced populations would likely require new networks to be built. In countries like Bangladesh, more than a fifth of the territory could be under water with a 1m rise in sea levels, highlighting the risk to telecommunication companies in such regions. In other words, it is likely that the consequences of climate change will be very different for TSPs in different regions, and that the requirements for adaptation will, as a consequence, also be different.

TSPs, like other network-based industries, are likely to be adversely affected by climate change. In some cases, climate-change related weather events could result in an inability to provide service to significant numbers of customers.

1.5.3.1 Questions

- Is there a need for new rules that would require TSPs to prepare for the weather shocks that will result from climate change?
- Conversely, are existing measures relating to network and service resilience, disaster recovery, business continuity, quality of service, availability of service etc, likely to be sufficient to cover the contingencies imposed by climate change?
- Should regulators include criteria relating to flood risk and other natural disasters that are likely to be exacerbated by climate change in the requirements for building and locating network infrastructure such as mobile towers and landing stations?

1.6 *Mitigation: A Current Point of Contact*

"The world we have created today as a result of our thinking thus far has problems which cannot be solved by thinking the way we thought when we created them."
Albert Einstein

1.6.1 What is "Mitigation"?

Climate change mitigation refers to measures or actions to decrease the intensity of radiative forcing[108] in order to reduce global warming. Mitigation is different from adaptation (section 1.5 above) in that the latter involves acting to minimize the effects of global warming. Mitigation is about reducing GHG emissions at source or increasing their sinks. (A sink is a natural or artificial reservoir that accumulates and stores carbon-containing chemical compounds. Forests and oceans are the best known examples of sinks.) Formally, mitigation is an activity that contributes to the *"stabilization of GHG concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system."*[109]

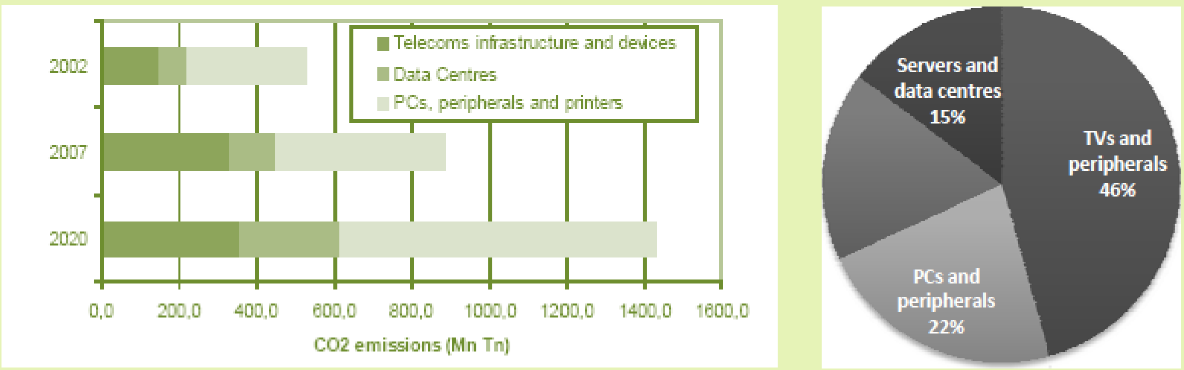
1.6.2 What is the contribution of ICTs to climate change?

"ICTs are far from innocent in the matter of climate change"
ITU[110]

ICTs in total currently contribute an estimated 2-3 per cent of global GHG emissions (see figure 1.6 below).[111] The ITU spells out the main causes:

- The proliferation of user devices, all of which need power and radiate heat. For instance, in the decade between 1996 and 2006, the number of mobile phones rose from 145 million to 2.7 billion (although Ericsson has estimated that 0.13 per cent of global carbon-dioxide emissions are specifically attributable to mobile, compared with 100 times that amount from transport[112]). Over the same period, estimated Internet users grew from 50 million to 1.1 billion. In 1996, virtually all residential Internet users were using dial-up whereas by 2006 a majority had always-on broadband connections, further increasing power use. Today, only five years later, almost a third of the world population are Internet users[113], meaning that power consumption is not likely to decline. Figure 1.7 illustrates the continuing growth in average broadband speeds.

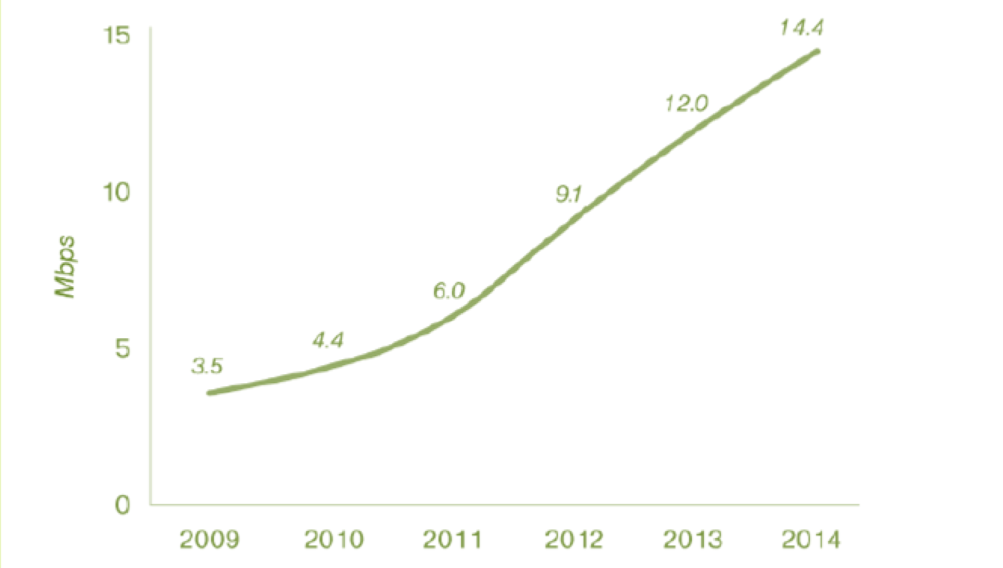
Figure 1.6: The ICT Carbon Bill



Note to right chart: Covers greenhouse gas emissions during production and use phases of the ICT product life cycle.

Source: McKinsey and the Climate Group and OECD (2010), "Greener and Smarter: ICTs, the environment and climate change", online: www.oecd.org/document/30/0,3343,en_2649_34223_42906974_1_1_1_1,00.html

Figure 1.7: The Continuing Growth in Average Broadband Speeds



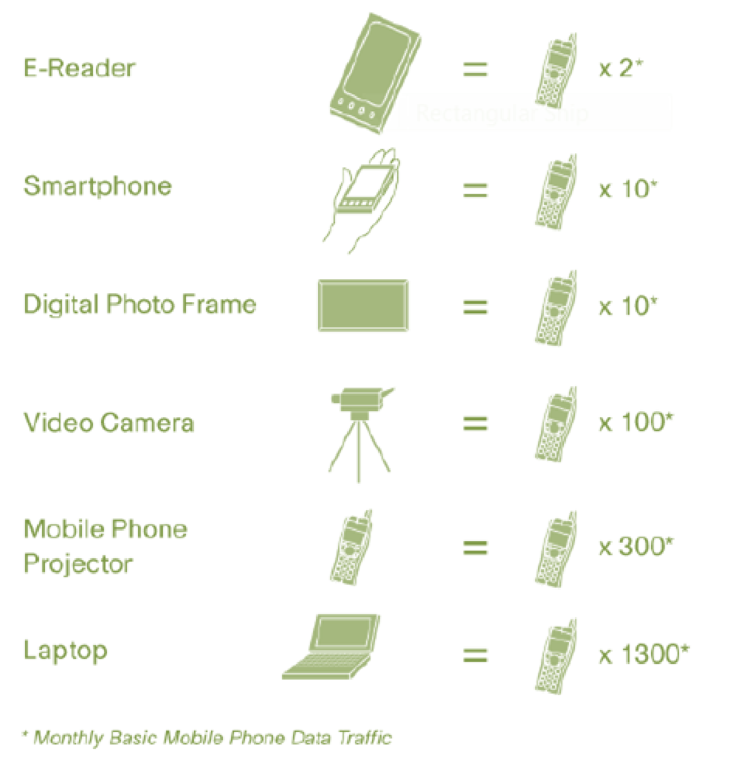
Source: CISCO, Hyperconnectivity and the Approaching Zettabyte Era, CISCO White Paper, 2 June 2010 at 7.

- The increasing power and bandwidth requirements from devices which are able to access more services and applications, particularly mobile devices. Figure 1.8, below, from CISCO, illustrates this point.
- The fact that each individual user is now likely to own more devices. This is more pronounced in the field of consumer electronics, where a typical family in a developed country might own multiple television sets, mobile phones, iPods/MP3 players, as well as a digital cinema, video-recorder, a DVD player, a hard-drive recorder, one or more set-top box decoders etc, many of which (or their chargers) are routinely left on standby overnight.114 But this also applies to multiple ownership and use of network-enabled ICT devices, from PCs to mobile phone handsets, which is often the case in developing countries.
- Rising requirements for power and for cooling as a result of increasing processing power. For instance, third generation (3G) mobile phones, which operate at higher frequencies than 2G ones, need more power than 2G mobile phones (for instance, for Internet access, digital signal processing, polyphonic ringtones, etc). More power is therefore required to keep 3G mobile phones operating.

However, geographical development of ICT markets is uneven. Many developed markets are at or approaching maturity, having followed a deployment path that began with fixed telephony and then moved on to mobile networks and services. In the developing world, mobile penetration rates have frequently leapfrogged the fixed networks. ICT products and services are becoming more widely available in all markets: broadband is being rolled out in fixed and mobile networks, bringing increasing penetration and greater use of connectivity. Other things being equal, this deployment of more devices, growth of services, and increased use of broadband will lead to higher power consumption for ICTs in use.

Even if, as section 1.6 will show, ICT companies produce products and services that can be used to reduce GHGs, ICT firms still have a responsibility to manage and reduce their own direct emissions. As has been noted, *"a company's direct footprint does not include its customers' footprint."*[115] Though ICT may be helping to reduce the carbon footprint of its customers, the ICT provider itself cannot "offset" such reductions against its own GHG emissions. ICT providers need to look at ways to reduce, or mitigate, their own GHG emissions.

Figure 1.8: High-End Handsets, Laptops, and Data Traffic



Source: CISCO, Hyperconnectivity and the Approaching Zettabyte Era, CISCO White Paper, 2 June 2010.

1.6.3 Accounting and reporting ICT GHGs

What is the carbon footprint of an ICT provider? Accounting for and reporting GHG emissions raise difficult questions relating to boundaries. In the modern ICT eco-system, many functions will be outsourced to other providers, from back office functions to the network itself. To which entity should GHGs arising from such outsourced functions be attributed? If we are considering a Virtual Network Operator (VNO), how much of the host network's carbon footprint should be attributed to the VNO? Similar considerations apply to wholesale services provided by underlying facilities-based operators, but that form components of the service provided by other entities to their end customers. Is it acceptable for companies to reduce their carbon footprints by means of such outsourcing?[116] Identifying these effects is complex. Current challenges include the lack of a common system for measuring GHGs, which makes it difficult to benchmark TSP A versus TSP B. The ITU -T Study Group 5 "Environment and climate change" Q18/5 is currently working on a methodology for environmental impact assessment of ICT.[117] (See Box 1.9, below.)

A benchmarking process relating to all sectors was developed by the Greenhouse Gas Protocol Corporate Accounting and Reporting Standard (the WRI Accounting and Reporting Standard) of the World Resources Institute.[118] This process helps companies and other organizations to identify, calculate, and report GHG emissions. The WRI Accounting and Reporting Standard is designed to provide a standard for accurate, complete, consistent, relevant, and transparent accounting and reporting of GHG emissions by companies and organizations, including information on setting organizational and operational boundaries, tracking emissions over time, and reporting emissions. It also provides guidance on GHG accounting and reporting principles, business goals and inventory design, managing inventory quality, accounting for GHG reductions, verification of GHG emissions, and setting a GHG target.

Box 1.9: Counting ICT GHGs

It is currently difficult to compare greenhouse gas emissions of ICT players due to incompatible methods of measuring and accounting for GHGs. The ITU is currently addressing this issue with ITU-T Study Group 5, which has five work areas, including the development of a common methodology for measuring the carbon footprint of the ICT sector. Without such a methodology, the ITU believes it is impossible to provide meaningful comparisons, or establish the business case to go green.

ITU aims to arrive at an internationally accepted common methodology for measuring the following impacts of ICTs on climate change:

- Reduction of ICT's own emissions over their entire lifecycle (direct impact) via power reduction methods
- Mitigation that follows through the adoption of ICTs in other sectors (indirect impact) via CO2 saving calculation methods

An overview of methodologies is due at end 2010, and is expected to cover:

- a definition of ICT sector boundaries and an evaluation of ICT sector impact general principles
- in a first step, on energy and GHG emissions.

Source: ITU, ICTs and Climate Change*, presentation to GeSI Assembly, 14-16 June 2010.*

The WRI Accounting and Reporting Standard defines three 'scopes' to help delineate direct and indirect emissions sources, improve transparency, and provide utility for different types of organization and different types of climate policies and business goals:

- Scope 1: Direct GHG emissions which occur from sources that are owned or controlled by the company. Examples include emissions from combustion in owned or controlled boilers, furnaces, vehicles, etc and emissions from chemical production in owned or controlled process equipment. This source of emissions is likely to be relatively low for most ICT companies compared with high emission industries.
- Scope 2: Electricity indirect GHG emissions, resulting from the generation of purchased electricity consumed by the company. Purchased electricity is defined as electricity that is purchased or otherwise brought into the organizational boundary of the company. These emissions physically occur at the facility where electricity is generated. Given the importance of electricity supplies for powering digital facilities and the services which sit upon them, Scope 2 emissions are the most important source of GHGs arising from the activities of the ICT sector.[119]
- Scope 3: Other indirect GHG emissions, a consequence of the activities of the company, but which occur from sources not owned or controlled by the company. Examples of Scope 3 activities include extraction and production of purchased materials; transportation of purchased fuels; and use of sold products and services.[120] For ICT, this would cover items such as employee travel, whether business-related or for journeys to work.

Table 1.5 below shows how these scopes are manifested in the case of a fixed line TSP, in this case, BT.

1.6.4 First Order Scope 2 effects: GHGs produced by ICTs

By combining the taxonomies of Section 1.3.2: First, Second and Third Order effects and Section 1.5.3: Accounting and Reporting ICT GHGs, it is clear that the main sources of ICT GHGs are First Order, Scope 2 effects. For ICTs, these sources mainly relate to GHGs emitted as a result of the electricity purchased by ICT firms to operate their systems. How significant are such emissions?

The report prepared by McKinsey for the Climate Group and the Global eSustainability Initiative (GeSI), shows that the ICT sector itself contributes between 2-2.5 per cent of global GHGs, at just under 1 Gigatonne of carbon dioxide equivalent (CO2e). The main contributor (40 per cent) to this CO2e is the energy requirements of PCs and data monitors, with data centres contributing a further 23 per cent. Fixed and mobile telecommunications contribute an estimated 24 per cent of the total. As the ICT industry is growing faster than the rest of the economy, this share is likely to increase over time. ICT's share of global GHG emissions (2.5 per cent) is much smaller than its share of gross domestic product (e.g., around 8 per cent of US GDP).[121] Thus, the good news is that, for TSPs, power consumption (hence GHG emissions) related to telecommunications connectivity is a relatively small part of the ICT sector's overall carbon footprint.[122]

Figure 1.9 below shows the sources of emissions in the mobile sector.

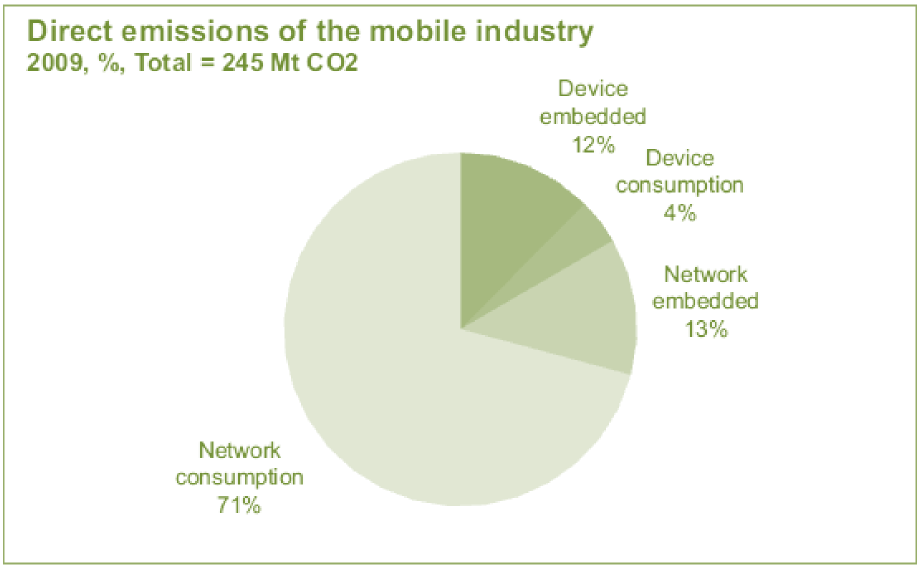
Table 1.5: Scoping BT's GHG emissions

CO_2e tonnes (thousands)	2010	2009	2008	Base year 1997	Change 2009 to 2010	Change 1997 to 2010
Scope 1	212	249	256	414	–15%	–49%
Scope 2 (gross)	1,419	1,448	1,407	1,156	–2%	23%
Sub Total	1,631	1,698	1,663	1,569	–4%	4%
Scope 3	51	73	79	58	–30%	–11%
Total emissions (gross)	**1,682**	**1,771**	**1,742**	**1,627**	**–5%**	**3%**
Less purchase of:						
Renewable electricity	572	591	516	–	–3%	–
CHP low carbon electricity	310	319	337	–	–3%	–
Total emissions (net)	**801**	**860**	**888**	**1,627**	**–7%**	**–51%**

Source: Briefing to analysts by Chris Tuppen, BT's Chief Sustainability Officer, London, 24 June, 2010.

TSPs are carbon-light relative to their contribution to GDP.[123] However, TSPs are often among the largest electricity consumers in their countries. For instance, BT estimates that it accounts for 2 per cent of the electricity consumed by UK businesses. It is impossible to provide a general statement of how such figures translate into overall TSP GHG emissions since these percentages depend on the generating mix in each country, notably, the proportionate contribution of fossil fuels, nuclear and renewable generation to the supply of electricity. Not only can this vary from country to country, but it can also vary from one electricity supplier to another, with some suppliers providing only electricity generated by renewable methods. In fact, TSPs might be able to source a significant proportion of their electricity supply from renewable energy sources.

Figure 1.9: Mobile CO2 emissions



Source: GSMA, in collaboration with The Climate Group, Mobile's Green Manifesto, November 2009 at 10, online: www.gsmworld.com/documents/mobiles_green_manifesto_11_09.pdf.

For example, 90 per cent of the energy consumed by T-mobile Netherlands is green, as is 80 per cent of Orange UK. A contract signed by BT was the largest single purchase of renewable electricity in the UK. But there is currently a shortage of green energy in some countries, which will limit the potential for this form of GHG emissions reduction by TSPs.

1.6.5 What is "The Paradox of ICT"?

At the heart of the story of ICT and climate change lies a paradox. On the positive side is a story of rapid technological transformation, with all that this implies for reduced power consumption per unit of output and, in consequence, proportionate reductions in GHGs per unit of output; on the negative side is continuing market growth that is driving absolute power consumption ever higher and thus creating more GHGs.

The way in which these contradictory trends will play out in terms of future GHGs will depend on three principal factors: improvements in energy efficiency driven by technological development; the market expansion driven by the emerging technologies; and the sources of the electricity used to provide the services. The following sections will consider:

- The positives: mostly technology;
- The negatives: mostly markets;
- Global market trends; and
- Weighing the balance.

1.6.6 What are the positives?

1.6.6.1 Technological developments: from NGNs, LTE and WiMAX to The Green Touch Consortium

Technological transformation in ICTs is creating the opportunity for improved efficiency in electronic and photonic devices, the rise of low-energy switching techniques, improved architectures, new protocols, and developments such as photonics. Many of these developments are reflected in the emergence of Next Generation Networks (NGNs) as the telecommunications industry migrates from today's separate networks (for voice, mobile, data etc) to a single, unified IP-based next-generation network. Since NGNs are considered more energy-efficient compared to traditional PSTN networks[124], there is a case for advocating more rapid migration to NGNs in order to reduce GHGs. Power savings from this transformation in technology can be achieved in a number of ways, as reflected in Box 1.10.[125]

Other measures to curb rising energy use by networks may include:

- Controlling energy in the access network (e.g. sleep mode in modems);
- Reducing the hop count (i.e. "agile" optical bypass), thereby reducing the number of routers that are used;
- Caching and content distribution networks, which place content closer to the end user;
- Continuous improvement in router efficiency;[126]
- Raising the operating temperatures of equipment[127].

Box 1.10: Saving Energy with NGNs

The ICT industry is currently undergoing a revolution as it migrates from today's separate networks (for voice, mobile, data etc) to a single, unified IP-based next-generation network (NGN). Energy savings will be achieved in a number of ways, including:

- A significant decrease in the number of switching centres required. For instance, BT's 21st Century Network (21CN) will require only 100-120 metropolitan nodes compared with its current 3,000 locations;
- Use of routers with higher capacity and higher transmission rates;
- More tolerant temperature specifications for NGN equipment, resulting in switching sites that can be fresh-air cooled in most countries rather than requiring special air conditioning. Alternatively, ICT companies are seeking to locate in cooler climes to reduce cooling-costs: Telus has been reported as considering Quebec for free-cooling 8 months each year.
- NGNs can use more recent standards, such as VDSL2 (ITU-T G.993.2), which specifies three power modes (full, low-power and sleep), compared with, e.g., VDSL with only a single power mode (full power).

Source: ITU, ITU-T Technology Watch Report: "NGNs and Energy Efficiency," August 2008, online:www.itu.int/oth/T2301000007/en. See also www.thegreengrid.org/ and ITU Symposium on ICTs and Climate Change: ITU Background Report, Quito, Ecuador, 8-10 July 2009, online: www.itu.int/dms_pub/itu-t/oth/06/0F/T060F00600C0004PDFE.pdf.

For example, Long Term Evolution (LTE) is one technology choice as networks evolve towards 4G. Sweden was the first country with commercial LTE services, offered in two cities in 2009, and Japan's NTT DoCoMo has announced the world's first commercial LTE network for consumers in 2010, with Verizon in the US spearheading the global LTE rollout. LTE is designed as a flat network architecture, meaning that every device on the network can communicate with every other device without going through intermediary equipment such as a router.

This architecture has several benefits for networks and consumers, including:

- Controlling Reduced latency, due to less equipment for data to pass through. LTE is expected to reduce latency, which is very important for voice communications and video streaming.
- Controlling LTE is optimized for IP traffic. Unlike the complex systems in 2G and 3G networks, which feature a separate, circuit-switched voice network, LTE is designed specifically for data traffic.

Since it offers easier upgrades from 3G and High Speed Downlink Packet Access (HSDPA), with an evolutionary path from legacy mobile radio systems (GSM), LTE can utilize much of the 3G network infrastructure and can work alongside existing 3GPP networks. By squeezing more data into the same amount of bandwidth or radio spectrum, LTE is expected to offer more capacity and increased data speeds. However, since this technology is still being trialled, caution needs to be exercised about such claims.

In theory, LTE should contribute to the move towards more energy-efficient network architecture. But as LTE enables new types of communication, such as increased mobile-to-mobile, always-on connectivity, and greater data throughput, it will enable new bandwidth-hungry applications. This could either increase or reduce GHGs within the ICT sector and in upstream and downstream industries.[128]

Another 4G technology, which has seen commercial (although not nationwide) deployments[129] in more than 100 countries, is WiMax, which could also lead to energy saving, although the relative energy efficiency of WiMax versus LTE is contentious.[130]

Given the activities taking place within the sector and under the aegis of bodies like the Green Touch Consortium (see Box 1.11), it is clear that the GHG-reducing benefits from the type of technological developments described above still have a long way to go before these benefits are fully realized.

1.6.6.2 Infrastructure sharing

One example of reducing environmental impacts and, potentially, energy consumption is by sharing TSP infrastructure, either in the form of passive or active sharing. As one author explains, *"Passive infrastructure sharing involves operators sharing the non-electrical, civil engineering elements of telecommunications networks. This might include rights of way/easements, ducts, pylons, masts, trenches, towers, poles, equipment rooms and their related power supply, air conditioning, and security. Active infrastructure sharing involves operators sharing the active network elements or the intelligence in the network, e.g., base stations and Node Bs for mobile networks and access node switches and management systems for fibre networks."*[131]

Box 1.11: The Green Touch Consortium: Reducing ICT Energy Use to 1000th

The Green Touch Consortium (GTC),[132] which launched in January 2010, comprises a host of ICT companies, and is aimed at creating the technologies needed *"to reduce energy consumption in worldwide ICT networks by a factor of 1000."* Such a reduction is roughly equivalent to being able to power the world's communications networks, including the Internet, for three years using the same amount of energy that it currently takes to run them for a single day. Such a reduction equates to *"7.8 GigaTonnes of CO2, or 15% of the total world emissions predicted by 2020,"* according to Vicente San Miguel, CTO of Telefónica at the launch. In order to achieve the required reductions in energy consumption both by individuals and in aggregate, the Green Touch Consortium aims to deliver, within five years, a reference architecture, specifications, technology development roadmap and demonstrations of key components needed to realize a fundamental re-design of networks (including the introduction of entirely new technologies).

GTC members include TSPs like AT&T, China Mobile, Portugal Telecom, Swisscom and Telefonica; manufacturers such as Alcatel-Lucent (and now Huawei); academic research labs including the Massachusetts Institute of Technology's Research Laboratory for Electronics (RLE), Stanford University's Wireless Systems Lab (WSL) and the University of Melbourne's Institute for a Broadband-Enabled Society (IBES); as well as industrial labs such as Bell Labs, the Samsung Advanced Institute of Technology (SAIT), and Freescale Semiconductor. Other members include a number of non-profits.

Module 2, sections 7.2.3. and 7.5.1 of the ITU Regulatory Toolkit [133] provides further information about forms of infrastructure sharing , and the European Union's Framework Directive[134] includes, as consideration 23, the following,

"Facility sharing can be of benefit for town planning, public health or environmental reasons, and should be encouraged by national regulatory authorities on the basis of voluntary agreements. In cases where undertakings are deprived of access to viable alternatives, compulsory facility or property sharing may be appropriate. It covers inter alia: physical collocation and duct, building, mast, antenna or antenna system sharing. Compulsory facility or property sharing should be imposed on undertakings only after full public consultation."

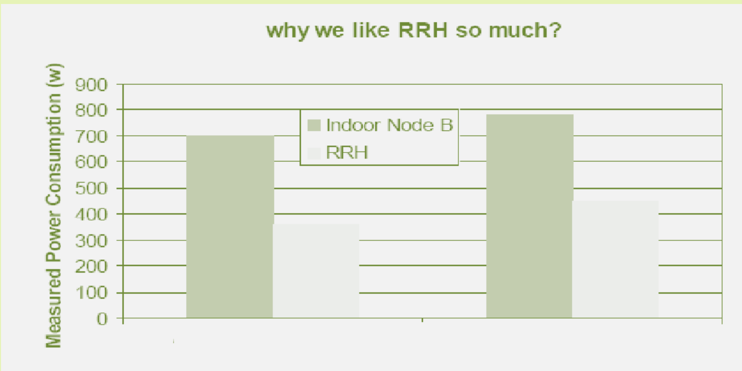
In addition to helping to address environmental concerns, sharing also offers a way of recycling of historic sites and minimizing the built-out of new external structures such as mobile towers. Strategies such as tower sharing and collocation help to manage the coexistence of modern communications infrastructure and historic sites. In the United States, for example, the Federal Communications Commission, the National Conference of State Historic Preservation Officers, and the Advisory Council on Historic Preservation developed an agreement aimed at preventing the construction of unnecessary new communications towers by mandating collocation[135]. Site sharing can limit potential negative effects, since it limits the number of sites while achieving the required coverage. Another beneficial aspect of site sharing is the amount of energy that can be saved when operators share electrical power, which is often in limited supply in developing countries[136]. Today's standard 3G equipment consumes about 4,000 KWh of Grey energy per year per node, which corresponds to 2.5 tons of CO_2, or the equivalent need of 120 trees per node to compensate for the environmental effect. In a developing country with no or little alternative/green energy, network sharing can significantly reduce the environmental impact.

Box 1.12: Alternative power consumption strategies by mobile operators

In 2008, Vodafone Group announced that by 2020 it will reduce its CO_2 emissions by 50% against its 2006/7 baseline of 1.23 million tons (this includes all operating companies based in countries obligated under the Kyoto protocol). Vodafone is developing energy intensity targets as a first step for newly acquired companies to take into account the rapid growth of the networks in emerging markets. The main focus is on cutting energy use in base stations, working with suppliers to improve energy efficiency of new network equipment and trialing renewable alternatives. The Group is also developing products and services that can enable a low carbon economy by helping customers reduce their emissions. This target will be achieved principally by improvements in energy efficiency and increased use of renewable energy.

Some of the concrete options and technologies Vodafone looks at to run radio networks more efficiently are:

- Using Remote Radio Heads (RRH) as a standard deployment solution at the base stations: RRH requires network upgrade programs in yielding successful carbon footprint reduction (eg: +20%ofreduction on avg CO2emission/BTS in 2years in VF Spain(*)).



- Single RAN (radio access network): 2G, 3G and eventually LTE simultaneous deployment & operation in a single box, or simply put: single RAN is used to deliver 2G and 3G with the same infrastructure/base station, and thereby reducing consumption),
- Network sharing:
  - Passive network sharing agreements in 17 national markets;
  - Vodafone Spain has developed in 07/08 the UTRAN sharing agreement with Orange enabling a 40% reduction in the number of required Node Bs for these areas.

Source: Vodafone Group CSR Report August 2008 and VF Spain CSR Report 07/08

Box 1.13: Universal Charger for Mobiles

In October 2009, the ITU endorsed a Universal Charging Solution (UCS) for mobile phones which enables the same charger to be used for all future handsets, regardless of make and model. In addition to dramatically cutting the number of chargers produced, shipped and subsequently discarded as new models become available, the new standard will mean users world-wide will be able to charge their mobiles anywhere from any available charger, while also reducing the energy consumed while charging. The new UCS standard was based on input from the GSMA, which predicts a 50% reduction in standby energy consumption, elimination of 51,000 tonnes of redundant chargers, and a subsequent reduction of 13.6 million tonnes in greenhouse gas emissions each year. ITU Study Group 5 – Environment and Climate Change worked on the necessary standardization, which is based on the Micro-USB interface. UCS chargers will also include a 4-star or higher efficiency rating - up to three times more energy-efficient than an unrated charger.

Source: ITU Press Release, "Universal phone charger standard approved" (22 October, 2009), online: www.itu.int/newsroom/press_releases/2009/49.html.

1.6.6.3 Technical standards

As well as the advances described above, there is also a role for technical standards to bring about reductions in GHGs from ICT networks and services. Boxes 1.13 and 1.14 set out some examples.

Furthermore, switching from analogue to digital broadcasting is likely to result in significant reduction of energy consumption and, as the result, CO2 emission reduction. The ITU Regional Radicommunication Conference 2006 (RRC-06) developed and approved Digital Broadcasting Plan for 120 countries and decided to switch off analogue broadcasting in these countries in 2015 (2020 for some developing countries). The process is based on ITU-R Study Group Recommendations (international standards) BT.1306, BS.1114 and P.1546 providing for a reduction of transmitters' power by almost 10 times and CO2 emissions - by hundreds of thousands of broadcasting transmitters.

1.6.7 What are the negatives?

The impact of ICTs on the environment is growing and will continue to grow. However, compared to other sectors, its negative impact is growing much more slowly and its GHG emissions may even decrease in relative terms compared to the total emissions from all sectors in the coming decade.

Continuing growth in ICT markets is leading to phenomena such as:

- the proliferation of users and services – commercially attractive, but environmentally problematic, since this means more networks and devices, more power consumption and the generation of more heat, which in turn requires more cooling – all of which generates more GHGs.
- Rising power consumption due to new services and applications in broadband, many of which require more processing power.
- More use of applications such as Internet search engines, although the GHG implications of such applications are contentious.[137]

The Law of Unintended Consequences applies again in this context. Markets are regulated to drive the availability of service to as many people as possible, giving users access to advanced and powerful ICTs; however, the resulting proliferation of users and devices has negative effects on the environment.

Box 1.14: Cutting GHGs from routers, servers and switches

Alongside the widespread growth of the Internet, a great deal of ICT equipment, such as routers, servers, and switches, has been installed in telecommunication centres to enable high-speed and large-scale broadband services. A DC power feeding system is commonly used inside a telecommunication centre or a data centre because the power efficiency is higher than that for an AC power feeding system due fewer converters. The power consumption per rack of conventional (legacy-type) equipment such as exchanges or transmission devices is about 2 kW. On the other hand, the power consumption for ICT equipment, such as routers and servers has reached over 7 kW. Therefore, the feeding current is over a hundred amperes using a 48Vdc power feeding system to supply power to ICT equipment. Since power feeding systems in such telecommunication centres are not specified in International standards, the ITU has established a working group to consider this issue, in the attempt to make data centres used in telecommunications more energy-efficient.

For more information on the ITU's efforts to make power feeding systems more efficient, see: www.itu.int/ITU-T/studygroups/com05/sg5-q19.html

To take the example of developing countries, GHGs emitted from increased ICT use might appear trivial in comparison to growth in emissions from developments such as increased car ownership. ICT market growth in developing countries, however spectacular, will produce GHGs emissions that are relatively trivial compared with GHGs produced by phenomena like the growth in car ownership and use. The ITU notes that, *"The average 2G handset user accounts for approximately 25 kilograms (Kg) of CO2 emission per year, or 30 Kg for a 3G user. This adds up to an estimated 93 Megatonnes of carbon produced by all mobile users in the world. The reality behind these figures has driven the growth of environmentally friendly handsets, spearheaded by consumer demand as opposed to initiatives taken by phone manufacturers (see box 1.15 below) ."*[138] In the meantime, mobile operators are also looking into alternatives to expand the market beyond the power grid, thus opening way to sustained growth in the overall volume of GHG emissions (see box 1.16)

The data centres, server farms and telecommunication hotels that have become an essential part of the ICT eco-system have very demanding requirements for electricity and air-conditioning.[139] Such facilities have become essential for the delivery of many telecommunications-based services and applications. Jonathan Koomey's 2007 report [140] showed that computer-servers in US data centres and their associated air conditioners and backup power systems consumed just over 1 per cent of US electricity consumption in 2005 - twice as much consumption than in 2000. This increase resulted from the growth in the number of servers, which went from 5.6 million servers to 10 million over the period. According to figures from the European Union, data centres (which include all buildings and facilities which contain enterprise servers and related server communication equipment to provide some form of data service) account for around 18 per cent of the ICT sector's energy consumption. Across Europe, they consume about 56 TWh of electricity per year.[141]

Box 1.15: Eco-friendly ICT devices

ICT equipment manufacturers have been among the first ICT sector players to join the trend towards eco-friendly industry practices and consumer goods.

Here below are some recent examples of such eco-friendly devices:

- The Asus notebook's case which is covered in bamboo, and all the plastic inside it is recyclable. There is no paint, no spray, or electroplating uses on its components, and lines with cardboard.

- Sony Ericsson GreenHeart™ generation of mobile phones made of recycled plastics, with an energy-efficient display and waterborne paint allowing for 15 per cent decrease in overall CO2 emissions.
- Samsung Blue Earth Phone, a solar powered touchscreen phone competing for less energy cost and manufacturing waste. It has a durable body constructed out of recycled water bottles. A single charge to the battery could last for days due to the passive solar charging. The phone also has a pedometer mode that will encourage you to walk, and while you are walking it will compute your CO2 emissions that you are saving.
- Of 140 million cell phones sold in the US in 2007, only 10% were recycled, according to the US Environmental Protection Agency. Offering a solution to the mounting pile of e-waste is EcoATM, first installed in Omaha, Nebraska in 2009. ECOATM is an automated reuse-and-recycle machine that makes it easy and financially rewarding for consumers to offload their abandoned electronics. The process is simple: a customer feeds the machine an old mobile phone and it analyses the device and assigns it a value. If the phone has a resale value, the customer receives store credit, or can donate the amount to charity. If there's no resale value, customers can choose to have the handset recycled.

Source: Adapted from scienceray.com, sonyericsson.com/greenheart, samsung.com, springwise.com.

Picture source: Asus Bamboo Ecobook

Box 1.16: Off-Grid Charging Solutions for Mobile Phones

Mobile networks are increasingly being deployed in rural areas of emerging markets, where consumer access to the grid is at best limited and unreliable and in many cases non-existent. It is estimated that there are some 485 million mobile users without access to the electricity grid, a factor which severely limits usage opportunities. Usage will in large be dependent on consumers being able to charge the handset through alternative methods, and solar-powered chargers in particular could become a key means of facilitating reliable access to mobile services in these markets. Fortunately, today operators are able to provide people in off-grid areas with solutions to power mobile phones, as this will not only improve quality of life and access to information but can also act as a significant opportunity to fuel economic growth. It is interesting to note that such initiatives are being undertaken on a voluntary basis, without the intervention of the ICT or other regulatory authority.

Recent research has found that there is significant interest in off grid solutions – 60 per cent of mobile operators interviewed already have or are exploring off-grid charging initiatives – but there is currently only limited understanding about the full scope of options and the associated social and business benefits. Pioneers Digicel and Safaricom, however, have demonstrated how the consumer, the environment and the mobile operator can reap the benefits of off-grid charging solutions. A range of charging choices are available that, if implemented effectively, will extend service availability and could boost average revenues per user by 10-14%. According to some estimates, the opportunity for mobile operators through the provision of off-grid charging solutions such as solar phones or external solar chargers in emerging markets can reach USD 2.3 billion*. Thus, commercial incentives rime with self-regulatory industry approach for the benefit of both TSPs and consumers.

*Note: * The market opportunity is calculated by taking the 485 million people, at an average ARPU of USD 4 (GSMA estimate, based on Wireless Intelligence data) and an increase of 10%, on annual basis.*

Source: Adapted from GSMA, Charging Choices, www.gsmworld.com/documents/charging_choices

The energy consumption of data centres are expected to grow faster than any other ICT technology. Forecasts for growth in the number of servers include a McKinsey study which states that *"the world's 44 million servers consume 0.5 per cent of all electricity, with data center emissions now approaching those of countries such as Argentina or the Netherlands."*[142] The study notes that without efforts to curb demand, current projections show worldwide carbon emissions from data centres will quadruple by 2020. According to McKinsey, "*By 2020 the carbon footprint of the computers that run the Internet would be larger than that of air travel."* Such growth is being by the increasing availability of bandwidth and the explosion of bandwidth-hungry (hence energy-hungry) applications like YouTube.

The contribution of individual's telecommunication equipment to the problem of GHGs might be seen as trivial to some experts (see Box 1.17), but with latest figures expected to show 5 billion subscriptions by the end of 2010, recharging of handsets is set to become non-trivial in terms of energy consumption.

The key point that emerges from these differing perspectives is that, when looking at GHGs, we need to consider aggregates rather than individuals: the atmosphere is indifferent to the sources of CO2. Another kilo or another tonne, from whatever source, adds to the quantum of GHGs, raising the PPM figure.

Box 1.17: Individual ICT Users: Bailing the Titanic?

There is a view, expressed by David MacKay, that the contribution of individual's telecommunication equipment to the problem of GHGs is trivial. As he states, "*Modern phone chargers, when left plugged in with no phone attached, use about half a watt….this is a power consumption of about 0.01 kWh per day. For anyone whose consumption stack is over 100 kWh per day, the BBC's advice, always unplug the phone charger, could potentially reduce their energy consumption by one hundredth of one percent…… Obsessively switching off the phone-charger is like bailing the Titanic with a teaspoon. Do switch it off, but please be aware how tiny a gesture it is…All the energy saved in switching off your charger for one day is used up in one second of car-driving. The energy saved in switching off the charger for one year is equal to the energy in a single hot bath."*[143]

Figure 1.10: The Arithmetic of Growth

The Ehrlich equation states that environmental impact (I) is a product of population (P) times affluence or income level (A) times the technological intensity (T) of economic output.

I = P x A x T

For carbon dioxide emissions from fuel combustion, for example, the total emissions are given by the product of population (P) times income (measured as USD of GDP/person) times the carbon intensity of economic activity (measured as gCO2/$)

C = P x $/person x gCO2/$

Using this arithmetic for year 2007, when the global population was about 6.6 billion, the average income level in constant 2000 USD (at market prices) was $5'900, and the carbon intensity was 760 gCO2/$, we find that the total carbon dioxide emissions (C) were:

6.6 c 5.9 x 0.77 = 30 billion tones of CO2.

In 1990, when the population was only 5.3 billion and the average income was $4'700 but carbon intensity was 860 gCO2/$, total carbon dioxide emissions (C) were given by:

5.3 x 4.7 x 0.87 = 21.7 billion tones of CO2.

These numbers are confirmed against those reported in the Energy Information Administration's *International Energy Annual*. The cumulative growth in emissions between 1990 (the Kyoto base year) and 2007 was 39 per cent (30/21.7 = 1.39) with an average growth rate in emissions (r_I) of almost 2 per cent ($r_I = (1.39)^{1/17} - 1 = 1.96\%$)

Source: Tim Jackson, Prosperity Without Growth? The Transition to a Sustainable Economy. (London: Sustainable Development Commission, 2009) at 54, online: www.sd-commission.org.uk/publications/downloads/prosperity_without_growth_report.pdf.

There is a theoretical basis for considering the environmental consequences of technology, population, and market size. This was set out in an axiom put forward by Paul Ehrlich and John Holdren in 1968 and cited by Tim Jackson in 2008 and 2009 (see Figure 1.10: The Arithmetic of Growth).[144] This axiom says that the environmental impact of human activity is a combination of: (P) the number of people on the planet, (A) the level of affluence of the population, and (T) the technology associated with each dollar (USD) we spend. Using this arithmetic and applying it to the ICT sector, it seems clear that projected growth levels will produce a significant aggregate impact on the sector's GHG emissions.

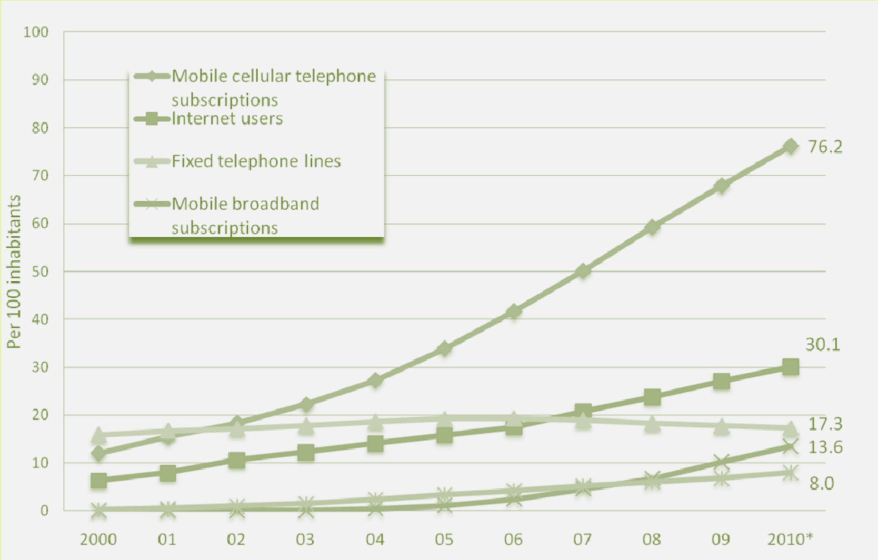
1.6.7.1 Global Market Trends

The global demographics and market developments for ICTs are undergoing dramatic changes. The following table summarizes trends in more developed and less developed countries. Whilst more developed countries are seeing markets at or approaching saturation, markets in less developed countries continue to expand.

Table 1.6: ICT Trends in More Developed and Less Developed Countries

UN classification "more developed"	UN classification "less developed"
• Population = 1.2bn • Higher per capita GDP • High penetration of fixed broadband • Rapid growth in mobile broadband (3G networks) • Markets becoming mature	• Population = 5.5bn • Lower per capita GDP • Low penetration of fixed broadband • Mobile broadband overtakes fixed broadband • Markets still expanding

Figure 1.11 Global ICT development, 2000-2010



** Estimates*

Source: ITU World Telecommunication/ICT Indicators Database.

The main ICT trends relevant to climate change continue to be the sustained growth in development, adoption and penetration of ICT technologies, and the substitution of early Internet technologies by broadband, and increasingly by mobile broadband. These developments are combining to produce a growth in ICT-sector GHG emissions.

1.6.8 The paradox of ICT: Weighing the balance

When it comes to the overall impact of ICT GHGs, the aggregate effect of these technology positives and market negatives is extremely difficult to predict. The combination of technological innovation and market liberalization is a recipe for disruption, and the attempt to predict outcomes is equally subject to this disruption. In the light of such uncertainty, it is only possible to depict some scenarios, based on currently foreseen technologies, likely market developments, and the potential impacts on energy use. Given the number of variables, it is currently impossible to weigh the balance. Table 1.7 depicts some possible developments driven by the interaction of technologies and markets.

Table 1.7: ICT technology scenarios: some possible outcomes for energy use

Technology	Markets	Impact on energy use: +ve (positive) - reduces energy use and GHGs -ve (negative) – increases energy use and GHGs
NGN core networks drive down energy consumption per unit of output	Increasing demand for NGN-based services produces rapid growth in demand	+ve
Higher bandwidth for fixed and mobile broadband services	Higher demand for bandwidth (and energy) intensive services	-ve
LTE and WiMax	Higher penetration of fixed and mobile broadband generates more services, more applications, more demand	+ve or –ve
Green Grid Consortium outputs		+ve

Technology	Markets	Impact on energy use: +ve (positive) - reduces energy use and GHGs -ve (negative) – increases energy use and GHGs
New services and applications for other sectors	Dematerialization and decoupling of energy from industrial sectors, as take up of ICT services leads to substitution of atoms by bits	+ve
Cloud computing[145] using ubiquitous network connectivity to access scalable computing and storage resources, online. Enabled by combining existing technologies such as virtualization and high-bandwidth internet connectivity	Boost of trend towards dematerialization and decoupling of energy from industrial sectors. But applications that have been implemented on legacy systems will migrate to cloud systems under the paradigm shift from "owning" to "leasing" IT. If each single system is to provide a highly reliable system on a continuous basis, it must have high redundancy, which may require higher energy consumption.[146] The GHG impact of cloud computing depends on its energy efficiency, its impact on overall demand, and the degree to cloud computing is powered by renewables.	+ve or –ve
Internet of things[147] - integration of sensors, RFID chips using low- or very-low-power devices into enterprise and consumer systems	Provides options for controlling power consumption and optimizing resource use across networks. In addition, embedded intelligence in the things themselves can further enhance the power of the network by devolving information processing capabilities to the edges of the network.	+ve
Fully-networked car[148]	Fully networked car could be either: another trivial device, or a potential GHG saver due to efficiency and convenience of real-time traffic information and management, increased fuel efficiency, providing information such as parking availability or public transport schedules and applications with precise and reliable information.	+ve or –ve
Overall Impact		**Technological developments = potentially +ve, but outcomes depend on consequential changes in behaviours**

1.6.9 TSP motives and methods for mitigating GHGs

ICTs in general, and TSPs in particular, are already making efforts to mitigate their own GHGs. This could be seen as a form of self-regulation, although it is equally the case that many such initiatives are being undertaken because they help to deliver the business goals of the TSP. Some of these motives are explored in the next section.

1.6.9.1 Why do TSPs mitigate their GHGs?

Reasons why TSPs are already mitigating their GHGs, and can be expected to continue to do so, include:

- to reduce energy costs;
- to meet increasingly stringent emission controls;
- to deliver corporate social responsibility (and brand reputation[149]);

Box 1.18: Mobileone (M1) – Energy Saving Programme

Singapore mobile operator MobileOne (M1) expects to achieve up to a 35% reduction of its telecommunication networks' carbon footprint by early 2011. M1 is using Nokia Siemens Networks Flexi Multiradio base stations, and the vendor is modernizing M1's 2G network to prepare it for a smooth transition to Long Term Evolution (LTE). In addition, M1 started an LTE trial in February 2010, in collaboration with Nokia Siemens Networks. M1 says that the trial marks another step in M1's commitment to deliver an energy efficient, high-speed mobile broadband service to its subscribers.

Source: Nokia Siemens Networks, "M1 looks at 35% reduction in carbon footprint in Singapore; LTE trial in February" (18 January, 2010), online: www.nokiasiemensnetworks.com/press/press-releases/m1-looks-35-reduction-carbon-footprint-singapore-lte-trial-february.

- to extend market penetration by delivering telecommunication services to more customers; and
- to differentiate service offers and reach out to niche markets such as consumers with green affiliation, etc.

1.6.9.2 Reducing energy costs

Energy costs are one of the largest operating expenses borne by TSPs, whether fixed or mobile. Nokia Siemens Networks (NSN) notes that 80 per cent of energy in a mobile network is used by the base stations, and energy is the third-largest part of a mobile operator's OPEX. NSN claims the possibility of savings in energy costs as follows: radio access networks - up to 35-40 per cent in existing networks and up to 65-70 per cent in a new installation. Energy savings can also be obtained from optimizing the entire mobile network through comprehensive network planning, remote optimization and maintenance.[150]

1.6.9.3 Meeting emission controls

TSPs are subject to emissions controls like any other entity. However, most of the GHGs associated with ICTs result from their electricity consumption (Scope 2 effects). This means that existing emission controls will not bear down significantly on the ICTs themselves. However, TSPs are normally significant purchasers of electricity in their geographies. They can influence the emissions of their bought-in electricity by making deals with providers of "green" electricity, *i.e.* electricity based on renewable sources. Some TSPs have already concluded such contracts, but the regulatory regime that affects such purchases is the regulation of the electricity market, not the regulation of ICTs.

Table 1.8 illustrates the voluntary emission reduction commitments made by various TSPs.

1.6.9.4 Corporate social responsibility

Like other businesses, ICT companies do not exist in isolation. As well as the shareholders, to whom companies have a primary financial responsibility, businesses also have responsibilities to employees, customers, suppliers, and the local community. A company's products and services, and the way it produces and distributes them, have an impact on the environment. Corporate social responsibility (CSR) is about understanding how a business impacts on the wider world. It means taking a responsible attitude to all the stakeholders of a business, going beyond the minimum legal requirements, and following a set of principles that can also help to support brand and that may contribute to the bottom line. Many ICT companies, including TSPs, have well-developed CSR policies, which often include sustainability targets and commitments to CO2 reductions.

Box 1.19: Internode – Carbon Neutral ISP with Green Electricity And Renewables

Australian ISP Internode has been carbon-neutral since 2008. The ISP has over 170,000 subscribers Australia-wide and sources 100% of its electricity needs from renewable energy. Internode has orientated its equipment upgrade purchasing decisions towards energy efficiency and sustainability. The company has started to invest in its own renewable energy infrastructure, running a number of remote sites via solar cells. With operators forced to pay a premium for piping power to remote areas and to provide expensive, long-lasting battery backups, it is becoming cost-competitive to run such sites on solar. The company has also spent around A$500,000 on a Cisco telepresence system to obviate the need for travel between the business hubs of the Australian telecommunication industry in Sydney and Melbourne, hundreds of kilometres from Internode's Adelaide head office.

Source: Dylan Bushell-Embling, "Australian ISP goes carbon neutral", Telecomasia (16 Nov., 2009), online: www.telecomasia.net/content/australian-isp-goes-carbon-neutral?page=0%2C0 and the related case study on Internode published by Carbon Planet, online: www.carbonplanet.com/downloads/Case_Study_Internode.pdf.

Table 1.8: Voluntary Emission Reduction Commitments of Various TSPs

Company	Target Reduction %	Baseline	Target Date	Comment
Alcatel-Lucent	10	2007	2010	CO2 emissions of facilities
Bell Canada	15	Not given	2012	GHG emissions
British Telecommunications	80	1996	2020	CO2 emissions
Deutsche Telekom	20	2006	2020	CO2 emissions
Ericsson	15-20	2006	2008	Energy efficiency
France Telecom	20	2006	2020	CO2 emissions
Motorola	6	2000	2010	CO2 emissions
Nokia	18	2006	2010	CO2 emissions
Nokia Siemens Networks	20-49	2007	2009-2010	Energy consumption of products
Sony Ericsson	20	Not given	2015	CO2 emissions
Telecom Italia	30	2007	2008	Eco-efficiency indicator
Telenor	40	2008	2017	CO2 emission efficiency
Vodafone	50	2006/7	2020	Co2 emissions

Source: based on EU data from 2009, as compiled by GSMA, in collaboration with The Climate Group, Mobile's Green Manifesto, November 2009 at 21, online: www.gsmworld.com/documents/mobiles_green_manifesto_11_09.pdf

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Box 1.20: BT – Carbon Reduction Programme

BT has reduced carbon emissions by 60% since 1996 and intends to reduce its absolute carbon footprint by 80% by 2016, in comparison to 1997 levels. BT is working towards this target by increasing its reliance on teleworking and making more flexible arrangements for its employees to reduce travel costs, according to a BT spokesperson.

BT also has a target of an 80% reduction in its global carbon *intensity* (a measure which relates emissions to money-value contribution to GDP developed specially for BT) by 2020 compared to a 1997 baseline. This measure, the Carbon Stabilisation Intensity Target, was developed specially for BT, and was announced in June 2008.

Source: BT.

Box 1.21: Nokia Siemens Networks Off-Grid Renewables

Nokia Siemens Networks (NSN) has set a target: to make renewable energy the primary choice for powering remote base station sites by 2011. At present, most of these sites are powered by diesel generators.

Nokia Siemens Networks has set concrete targets based on energy savings in watts:

- GSM/EDGE BTS 650W in 2010 (800W in 2007)
- WCDMA BTS 300W in 2010 (500W in 2007)
- Mobile WiMAX BTS 700W in 2010 (1130W in 2007)
- Power reduction VDSL in 2009 49% (compared to 2007)

Source: Nokia Siemens Networks, White Paper: Good Green Business Sense (2008), online: http://w3.nokiasiemensnetworks.com/NR/rdonlyres/13368E3E-58C4-4BF7-882F-4FE0F5D4C24F/0/Sustainability.pdf.

1.6.9.6 How do TSPs mitigate their GHGs?

Given the existing incentives to cut GHGs, as set out above, many TSPs are already engaged in policies and processes to reduce their impact on the climate. These policies and processes can be classified as being designed to reduce: First Order, Scope 2 effects and First Order, Scope 3 effects.

First Order, Scope 2 effects

For TSPs, First Order, Scope 2 effects mainly relate to GHGs emitted as a result of the electricity TSPs purchase in order to operate their systems. These include examples such as:

- Generating renewable energy on their own sites using technologies such as wind power or solar energy for cell phone masts. France Telecom and Vodafone are using solar energy in some of their exchanges and base stations, for example.
- Running data centres at higher temperatures. BT's exchanges have been redesigned to withstand higher temperatures, up to 30°C. Air-conditioning has been replaced by fresh air coolers which pump outside air to the heart of the exchange. Ozone depleting air-conditioning is only needed in the hottest periods of the year for the biggest exchanges and is strictly monitored.

Box 1.22: The Solar Cyber Café

Computer Aid International is a UK registered charity that aims to reduce poverty through IT solutions. The charity has shipped over 160,000 ex-corporate refurbished computers to developing countries. These computers are then used by educational, health and not-for-profit organisations for communities in remote locations where the technology is most lacking.

Many of the rural African communities that most need the services provided by Computer Aid often have no electricity supply or an underdeveloped grid system, meaning that electricity supply is often 'down' for hours each day. Some rural towns use diesel generators, but fuel supply difficulty again means that supply is inconsistent. Computer Aid International came up with the idea of developing a self-contained 'cyber café' that produced its own energy.

Firefly Solar, which designs, hires and sells portable solar generators, worked with Computer Aid to develop the idea of a solar powered Internet café and conduct a feasibility study. As a result, Firefly were awarded the contract to design and build a series of converted shipping containers into fully furbished Solar Cyber Cafes providing a consistent electrical supply. The shipping containers are fully insulated and include electric lighting, desks, chairs and an eleven user computer network based on thin client technology, using a fraction of the power needed by conventional PCs. The systems are able to link in to Africa's Largest WiFi network, or the containers own satellite uplink.

These systems are solely powered by the integral off grid solar generator designed and built by Firefly. The system will operate all year round in high and low seasons in a number of African countries.

The first Solar Cyber Café has been shipped out to Macha in Zambia and is located 70km away from the nearest tarmac road. The second has been shipped to Kenya and the 3rd is already on its way to Zambia. Firefly hopes that many more containers will be converted in the future offering internet to thousands of individuals across the continent.

Source: Firefly Solar, at www.fireflysolar.co.uk/content/computer-aid-international-solar-cyber-cafe-project

- The Green Grid Consortium referenced above includes various projects to reduce power consumption by data centres.

Other examples of TSPs moving to reduce their Scope 2 emissions include:

- Migrating to Next Generation Networks – see Box 1.10 above, and
- Infrastructure sharing - see Box 1.6 above.

First Order, Scope 3 effects

For ICTs, Scope 3 effects relate to indirect GHG emissions arising from the activities of the company, covering things such as employee travel, whether business related or for journeys to work. Examples of initiatives to reduce these effects include:

- Using vehicles that rely on alternative fuel technologies. For example, Deutsche Telekom and BT are introducing natural gas vehicles. This will help to partially offset the impact of higher energy costs. However, given the scale of energy consumed by the sector, it is unlikely to offset the total energy demand completely.
- Reducing truck rolls and vehicle fleet mileage. For example BT in London is minimizing truck-roll through van sharing initiatives, considering phasing new hybrid technology vehicles into its fleet, championing BT Group policy on car clubs and fostering environmentally-friendly driving by employees

1.6.9.7 Questions

Set out below are some questions regarding the potential involvement of ICT regulators in activities undertaken by TSPs to mitigate their own GHGs:

- Is there a role for ICT regulators in developing and deploying measures that affect the GHGs produced by TSPs?
- If TSPs are already taking action to mitigate their own GHGs to meet their business goals, notably, saving costs, extending markets, complying with emission controls, and meeting CSR objectives, what is the role for regulation?
- If there are GHG-curbing activities that TSPs could undertake but that do not meet business goals, and are therefore not being implemented, should TSPs be compelled to do so by ICT regulators?
- If there is a conflict between increased CAPEX[151] which will result in reduced GHGs (and, usually, reduced OPEX), is it appropriate that regulators become involved in such business decisions?
- If TSPs are required to meet mitigation requirements, should this be left to general pollution control laws and regulation that affect players in all markets rather than ICT regulators?
- Should there be more collaboration between industry regulators and sector-specific regulators concerning the reduction of GHGs?
- Is there a need for a generally accepted, ICT industry-wide methodology for the carbon footprinting of ICT products and services or does this fall within the scope of existing schemes such as the Carbon Disclosure Project?[152]
- What form should GHG mitigation policies take, if the chosen measures are not to add further burdens to the sector?
- Should regulators be encouraging and facilitating voluntary measures like that in the computer industry, such as the Climate Savers Computing Initiative (CSCI)[153]?
- Should ICT regulators consider compensating TSPs for activities that reduce GHGs as part of their policy and regulatory decisions? For example, is there a role for ICT regulators in giving regulatory relief for investment decisions such as earlier migration to NGNs, if such moves result in reduced GHGs?
- Should ICT regulators create concrete incentives for environment-friendly practices in ICT development (e.g., subsidies through Universal Service Funds for network deployments using renewable energy or incentives for sharing rather than duplicating infrastructure)?
- What is the justification for ICT regulators to provide relief for measures such as earlier moves to NGNs, if such measures provide commercial benefits to TSPs such as lower energy costs and hence lower OPEX?
- Should regulators intervene to create industry players that focus exclusively on the provision of infrastructure, in order to prevent duplication and reduce GHGs? For example, some countries (e.g. India and Pakistan) now licence or register “infrastructure providers” such as tower companies, whose sole purpose is to provide certain kinds of infrastructure such as towers and masts.

- Should regulators mandate infrastructure sharing and prohibit the construction of new infrastructure? (unless sharing is not possible).[154]
- Should ICT regulators be more involved in developing standards for energy efficiency in ICT equipment, namely by participating in the work of standard-setting organizations such as the ITU, ETSI and ISO?[155]
- Should ICT regulators be pressing for advanced implementation of emissions-reducing technology in ICTs?
- Is there a role for regulators in supporting the development of Codes of Practice/Codes of Conduct for industry players, such as the *European Commission Codes of Conduct* (see box 1.23)

1.7 Transformation: A Current and Future Point of Contact

"*Low carbon economy will transform world like the first industrial revolution.*"
Headline, The Guardian, 2 July 2009

1.7.1 What is 'transformation'?

Curbing dangerous GHG emissions requires us to move to a low carbon economy. This move will produce winners and losers. One report from McKinsey notes that, *"the outcome may be as unambiguous as it was when the industrial revolution shifted business from manual labour to energy-intensive factories."*[156] The report notes that companies in all sectors will need to develop a strategic response to three major developments that will occur during the transformation to a low carbon economy:

- efforts to optimize the carbon efficiency of existing assets and products, from infrastructure to supply chains and finished goods;
- growing demand for new low-carbon solutions; and
- public policy and the widespread belief of long term higher energy prices.

The report goes on to advocate that firms adopt the following strategic response to these developments:

- raise the carbon productivity of existing assets;
- pursue new business growth and sow the seeds for future expansion; and
- develop a regulatory strategy that helps to shape public policies that benefit the environment and business alike.

Box 1.23: Codes of Conduct

EU Code of Conduct on Broadband

Broadband equipment accounts for around 15% of the ICT sector's overall energy consumption, or about 47 TWh in 2010 in the EU, hence the Code of Conduct on Broadband, which has existed since 2007. The Code sets maximum power consumption, (in consumer premises and telecom operators' substations) for broadband equipment such as modems, switches, routers and home gateways. Energy savings are achieved through the mandatory use of the best available low energy components.

This Code (plus another on Data Centres), provides a platform which brings together European stakeholders to discuss and agree voluntary actions to improve energy efficiency. In addition to these two Codes, there are three other codes relating to digital TV services, efficiency of external power supplies and AC uninterruptible power systems.

These Codes are managed and produced by the European Commission's Joint Research Centre, and are aimed at informing and stimulating the ICT industry to reduce energy consumption in a cost-effective manner without hampering the critical function of the facility or the equipment. By signing the codes of conduct, the individual companies voluntarily commit themselves to reducing energy consumption by an agreed amount in a pre-defined time scale through the adoption of best practices.

Source: www.alphagalileo.org/ViewItem.aspx?ItemId=86177&CultureCode=en

All these strategic responses are relevant to ICTs in general and TSPs in particular. While ICT makes its own contribution to the world's carbon footprint (around 2 per cent to 2.5 per cent of global GHGs and growing), ICTs can also play a major role in reducing the world's carbon footprint. The services sector, of which ICTs are a part, is, in principle, less energy-intensive than many industrial sectors (with exceptions such as transport-intensive fields) and thus well-placed to help reduce GHGs.

Figure 1.13 below shows BT's vision of a future ICT-enabled Smart Community.

1.7.2 How can ICT transform other sectors?

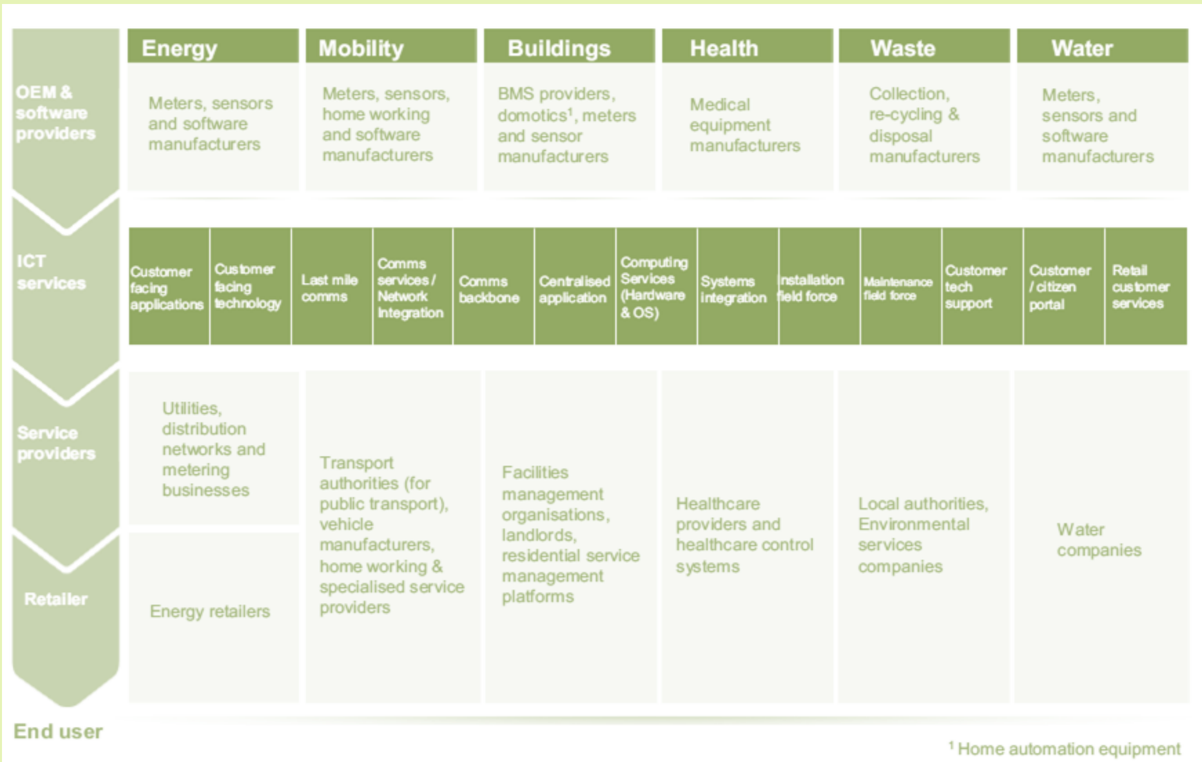
TSPs can help players in other sectors to become aware of their own GHGs through techniques to monitor carbon production and energy consumption. But TSPs can also develop, and help others develop, innovative products, services and business models that reduce GHGs across the economy, particularly by substituting ICT for more energy intensive modes of business and communication.

Other than ICT, no other sector can achieve such enabling effects, which fall into these two categories:

- Second Order effects: arising from the potential of ICT to change processes in other sectors, and
- Third Order effects: resulting from collective medium or longer-term adaptation of behaviour (e.g. consumption patterns) or economic structures.

The strategic use of ICTs can contribute significantly to energy efficiency and sustainable economic growth. ICTs can enable other sectors to reduce GHGs through phenomena such as teleworking and teleconferencing, various services and applications, smart grids, sustainable networks, energy-efficient data centres, intelligent cars, smart buildings, and energy-efficient workspaces. ICTs thus have the potential to transform other sectors, and to decouple economic growth from environmental impacts, with reductions in GHGs as a result of process changes, de-materialization and virtualization.

Figure 1.13: ICT services in SMART Communities



Source: BT. Briefing to analysts by Chris Tuppen, BT's Chief Sustainability Officer, London, 24 June, 2010.

Box 1.24: The e-Environment Toolkit

The ITU Telecommunication Development Sector (ITU-D) has developed an E-Environment Toolkit that provides policymakers with principles and guidelines for the development and deployment of electronic applications and services in the area of the environment. The objective of the first module of the Toolkit is to help countries to assess the potential contribution that ICTs can make to reduce energy consumption and green house gas (GHG) emissions and to support Member States in the evaluation of their current capacities and the identification of needs and definition of priorities, as a basis for the development of national e-Environment and e-sustainability strategies and action plan for climate change and sustainable development. A core practical tool in this Toolkit is the e-Environment Readiness Index (EERI). The EERI can be used both as a tool for evaluating the e-Environment readiness of a country to use ICTs for mitigating and adjusting to the impacts of climate change, as well as a process for establishing baseline knowledge about the potential use and impact of ICT systems with respect to the environment."

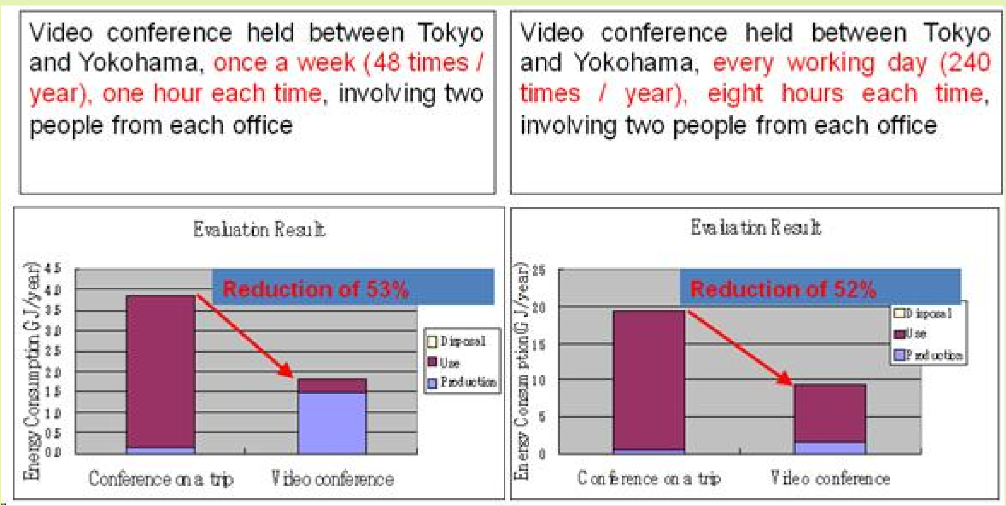
See: www.itu.int/ITU-D/cyb/app/e-env.html

Examples of how ICTs can enable other sectors to reduce their GHGs include:

- ICTs can reduce the need for travel and transportation of goods by bridging distance, through online retailing and by the use of "smart inventory" systems and "just in time" delivery.
- ICTs can increase efficiency and innovation by allowing people to work and learn (and to teach) in more flexible ways (see Box 1.25 below).
- ICTs can shift productive focus from products to services and allow for dematerialization across the economy (see Box 1.26 below).[157]
- ICTs can increase efficiency and convenience of government and business services, saving travel and waiting time and cost for customers/citizens (e.g., through e-government services, online ordering, mobile payments, etc.).
- ICTs can work as enablers for increased productivity in other sectors, through the use of information systems and/or automation in processes; the benefits also include the optimization of energy and human resources needed. (See also sections 1.7.2 and 1.7.3 below.)

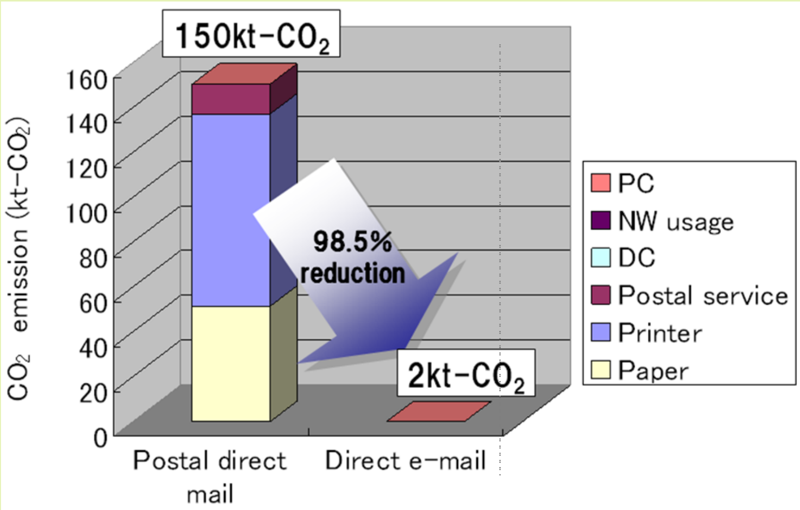
Some studies have estimated that by deploying ICTs in strategic areas, GHG reductions of over 40 per cent could be achieved by 2050 - five times more than the estimated GHGs emitted by ICTs in that year. One of the first studies to consider this was published by the Association of European Telecoms Network Operators (ETNO). ETNO noted, *"By 2020, a better integration of broadband-enabled applications in all sectors of the economy, such as the building, transportation and energy distribution, could help saving up to 15 per cent of global CO2 emissions."* [158]

Box 1.25: Comparison between videoconferencing and business trips in terms of energy use



Source: *www.itu.int/ITU-T/climatechange*

Box 1.26: Comparison of GHG emissions of postal mail and e-mail services



Source: *www.itu.int/ITU-T/climatechange*

ETNO's work has since been joined by a number of other studies, which have demonstrated the ways in which ICTs can reduce GHGs. These studies used different methodologies, applied across different geographic and different sectors, so it is not possible to make direct comparisons between them. However, the following table gives a flavour of potential GHG reductions that can be achieved by implementing additional ICT-based solutions.

Table 1.9: Scope for ICTs to reduce GHGs: Selected examples

Operator	Estimated reduction in GHGs	Study
China Mobile	Estimates direct CO2 emissions savings from low carbon telecom solutions provided by China Mobile in 2008 at 48.5 million tonnes (just over six times the company's own emissions). For 2009, the savings were 58.2 million tonnes (almost six and a half times company emissions).	China Mobile and WWF, Low Carbon Telecommunication Solutions in China: Current Reductions and Future Potential (Beijing: WWF, 2010), online: wwf.panda.org/?193193/China-study-shows-huge-potential--of-low-carbon-telecom-solutions [China Mobile/WWF, Low Carbon Telecommunication Solutions in China, 2010].
GeSI	Estimated emission savings of 15%, i.e. 7.8 GtCO_2e – of global "Business As Usual" emissions in 2020.	The Climate Group, on behalf of the Global e-Sustainability Initiative (GeSI), Smart 2020, Enabling the low carbon economy in the information age, (2008), online: www.smart2020.org/_assets/files/02_Smart2020Report.pdf [GeSI, Smart 2020].
Telstra	Identifies seven opportunities for Australia to reduce or avoid the release of carbon emissions into the atmosphere by 2015, totalling almost 5%, or around 27 million carbon tonnes per year.	Telstra, Towards A High Bandwidth, Low Carbon Future: Telecommunications-based Opportunities to Reduce Greenhouse Gas Emissions (2007), online: www.telstra.com.au/abouttelstra/download/document/telecommunications-climate-change-blueprint-in-brief.pdf
Vodafone	Identifies 13 specific opportunities, supported by mobile services, that could, by 2020 save 2.4% of expected EU emissions – 113 million tonnes of CO_2e.	Accenture and Vodafone, Carbon Connections: Quantifying mobile's role in tackling climate change, July 2009, online: www.vodafone.com/etc/medialib/cr_09/carbon.Par.76396.File.tmp/carbon_web_2009.pdf

Whatever the scope may be in future for such GHG reductions using ICTs, people and businesses are currently taking advantage of just a fraction of the services that could be available via the Internet. In his book *The World is Flat*, Thomas Friedman notes, *"Globalization 3.0... particularly the combination of the PC, the microprocessor, the internet and fiber optics...is a work in progress,"*[159] a work that has been enabled by, and has the potential to be transformed by, the products and services made available in the new ICT ecosystem.

Globalization 3.0 also brings significant opportunities for ICT players to develop and market innovative products and services. As identified above by McKinsey, these ICT products and services can reduce dependence on, for example, carbon-intensive travel (especially as travel becomes more expensive). The deployment of digital processing widely into the environment – what is variously called ambient intelligence, ubiquitous computing, the Internet of things, or just 'smart' technology, is still at the early stages. Wider deployment and penetration of high speed broadband on fixed and mobile networks, the impact of Moore's Law and economies of scale mean that ICT is becoming both pervasive and cheaper. More widespread use of information management technologies, developments like RFID and beyond, where everything is tagged, coupled with developments such as data mining, agent-based software and talk-to technology mean that we are only at the beginning of what is possible.[160] In such a world, there is massive scope for reduced GHGs through lower demand for carbon-intensive goods and services, as well as the development of low-carbon technologies.

1.7.3 Where will ICTs be transformative?

GeSI has developed a taxonomy to consider the impact of smart use of ICTs in a number of areas. GeSI shows that ICTs can drive down GHGs by supporting the deployment of developments such as:

- Smart grid
- Smart buildings
- Smart logistics
- Smart motor systems
- Dematerialisation

The technical and market potential for ICTs in supporting such deployments is described in Annex 1. The rest of this section considers some of the complexities of the transformation to a low carbon economy, and the potential for regulatory involvement.

1.7.4 What are the unintended consequences of energy efficiency?

1.7.4.1 Absolute and relative decoupling

Between 1990 and 2000 the carbon intensity of the US economy declined by 17 per cent yet total emissions increased by 14 per cent .[161] As Tim Jackson has pointed out[162], it is vital to distinguish between 'relative' and 'absolute' decoupling. (See Box 1.27, below.)

1.7.4.2 Carbon shifting

Saving energy is normally viewed as beneficial in and of itself. However, this is not without its challenges. For example, dematerialization may be another form of carbon shifting – moving the source of GHGs from the desktop to the data centre. Replacing memory on hard drives with data saved "in the cloud" means that individual users have achieved dematerialization. But the huge data centres supporting the cloud are far from being non-material. It may be that the attractiveness of the concept of dematerialization bumps into one of the truths of Newtonian physics, that nothing that is lost in nature is still valid.

Box 1.27: Absolute and relative decoupling

"*Relative decoupling refers to a situation where resource impacts decline relative to GDP. Impacts may still rise, but they do so more slowly than the GDP. The situation in which resource impacts decline in absolute terms is called 'absolute decoupling'. Needless to say, this latter situation is essential if economic activity is to remain within ecological limits. Evidence for declining resource intensities (relative decoupling) is relatively easy to identify. The energy required to produce a unit of economic output declined by a third in the last thirty years, for instance. Global carbon intensity fell from around one kilo per dollar of economic activity to just under 770 grams per dollar. Evidence for overall reductions in resource throughput (absolute decoupling) is much harder to find. The improvements in energy (and carbon) intensity noted above were offset by increases in the scale of economic activity over the same period. Global carbon emissions from energy use have increased by 40% since only 1990 (the Kyoto base year).*"

Source: Tim Jackson, Prosperity Without Growth? The Transition to a Sustainable Economy, (London: Sustainable Development Commission, 2009), online: www.sd-commission.org.uk/publications/downloads/prosperity_without_growth_report.pdf

1.7.4.3 Third order effects

Third order GHG effects enabled by ICTs may be ambiguous and may eventually result in either positive or negative changes when they bump into the realities of human behaviour. There are two possible effects of increases in energy efficiency, notably the *Khazzoom-Brookes* postulate and the *Rebound Effect.*[163] Each is considered below:

- The Khazzoom-Brookes postulate states that when money is saved through energy efficiency, that saving is often subsequently spent on other, more energy intensive processes. The net result is that overall energy consumption is reduced less than might be expected and may even increase.
- The Rebound Effect[164] occurs when new activities (and therefore additional environmental impacts) arise as a result of behavioural influences. For example, a better-insulated house needs less fuel to maintain a given temperature, but as their fuel costs decline, people tend to turn up the thermostat. In fact, average domestic temperatures are estimated to have increased from 16ºC in 1990 to 19ºC in 2002. While the Rebound Effect may result in lower energy reductions than expected, it is unlikely to result in an overall *increase* in consumption.

1.7.5 What is the role for standardisation, monitoring, accounting, rethinking and transforming?

The ICT sector is characterized by a mix of open and proprietary standards. In the telecommunication sector, there has long been an emphasis on the standards needed to underpin effective interconnection of networks and equipment, whether at the national, regional or international level. Such standardization work continues today, and may be one of the more effective ways for regulators and quasi-regulatory bodies to become involved in the acceleration of the transition to a low carbon economy driven by ICTs.

For example, the monolithic model of electricity generation using vertically integrated suppliers is giving way to the possibilities of distributed generation enabled by smart grids (see Annex). Such smart grids are heavily dependent on ICTs to ensure their effective operation. ICT standardization bodies can become more involved in such cross-sectoral developments, as Box 1.28 below illustrates.

Box 1.28: ITU Smart Grid standards initiative

A new ITU group has been established to identifyistandards for new Smart Grid deployments. ”There was a need to engage with a wider community,” according to Malcolm Johnson, Director of ITU’s Telecommunication Standardization Bureau. "In this case, the Focus Group allows access to all stakeholders and in particular a key part of the Smart Grid equation — the electricity companies themselves.” The new Focus Group aims to bring all players together in an environment where they can create global specifications for the service-aware utilities network of tomorrow. Smart Grid will consist of solutions based on both current and future telecommunication technologies for command and control, metering, and charging. ITU’s new Focus Group will explore these requirements and corresponding standardization needs. Further, the idea that Smart Grid principles could apply to the telecommunication system itself could be a topic for discussion.

Many governments have earmarked significant portions of their stimulus packages for Smart Grids. In the United States, for example, the American Reinvestment and Recovery Act has allocated USD 4.5 billion for investments in the Smart Grid. In Europe, the European Parliament has approved an agreement reached by the EU Institutions on a package of legislation to liberalize energy markets, including electricity and gas directives, which require EU member states to ‘ensure the implementation of intelligent metering systems’.

The Focus Group on Smart Grid will survey existing national standards initiatives to see whether these can be adopted at an international level, and will also perform a gap analysis to identify new standardization requirements that will then be taken forward by relevant ITU-T Study Groups. This exploratory phase will be relatively short before work starts on the development of the standards necessary to support the global rollout of Smart Grid technologies.

In the field of Smart Grids, ITU experts have already agreed on specifications for Smart Grid products for home networks. The specifications include a ‘low complexity’ profile that will allow multiple manufacturers to develop products that deliver the low power consumption, low cost, performance, reliability, and security that is required for Smart Grid and other lower bit rate applications.

Members of HomeGrid Forum, an independent body set up to promote ITU-T’s home networking standard, G.hn, are active participants in Smart Grid standardization efforts worldwide, including those led by NIST, IEEE, ISO/IEC, and SAE. In 2009, HomeGrid Forum formed a Smart Grid initiative group, which will help to bring a range of G.hn-based devices to the Smart Grid market and home energy management applications.

Source: ITU Press Release, “ITU introduces Smart Grid standards initiative” (May 12, 2010), online: www.itu.int/net/pressoffice/press_releases/2010/21.aspx.

Box 1.29: Smart 2020: A Role for ICT Regulators?

Some of the main themes from GeSI's Smart2020 Report are set out below, including possible modes of regulatory involvement:

Standardise[165] (i) Direct action: develop protocols to enable smart systems to interact. Following its symposia on "ICTs and Climate Change", the ITU has established a Focus Group within its Telecommunication Standardization Sector (ITU-T) to study how to reduce ICT equipment emissions, and how ICTs can assist in cutting emissions in other infrastructure sectors such as energy, transportation and buildings.[166]

Examples include the UN initiative in Africa to team up with mobile phone companies and other partners to install 5,000 new weather stations, the World Telecommunication Standardization Assembly 2008 (WTSA-08) on ICT standardization requirements for combating climate change, etc; Ensure energy standards are included in technological standards development. (ii) Enabling action: develop ways for devices "outside" the ICT sector to message about energy consumption. Sector regulators could impose certain requirements on mobile handsets such as smart phones, type approval measures (certification of equipment) general terms and conditions can encourage providers to use energy efficient technology.

Monitor to make energy and carbon emissions visible: (i) Direct action: Monitor energy consumption of ICT products and networks. (ii) Enabling action: ICT can incorporate monitoring information into the design and control of energy use

Account, by linking monitoring with accountability: (i) Direct action: Make energy use transparent throughout the supply chain by reporting and labelling. (ii) Enabling action: ICT can provide the software tools and platforms to improve accountability of energy and carbon throughout service and product life cycles

Rethink: Optimise for energy efficiency, and find alternatives to high-carbon development (i) Direct action: Optimise its own products and services and continue to deliver radical product innovation. (ii) Enabling action: ICT can offer new innovations that, if considered during the design phase of buildings, roads and other infrastructure can change our current ways of living

Transform, by implementing smart low carbon infrastructure at scale (i) Direct action: Make the ICT sector an exemplar of low carbon technologies (ii) Enabling action: ICT can apply smart and integrated approaches to energy management of systems and processes, incorporating system-wide benefits from both automation and behaviour change.

1.7.5.1 Regulation and Transformation

For some initiatives relating to ICTs and CO_2 reduction, self-regulation may work well. For others, it may be necessary to modify existing ICT regulatory regimes to create incentives to reduce GHGs. Beyond such ICT regulatory incentives, it is likely that there will be a need for greater cross-sectoral regulation and cooperation among regulators both within and beyond the ICT sector.

Some examples of how greater cross-sectoral regulation might be achieved are provided in Box 1.30 below, as set out by the GSMA.

In summary, self-regulation and regulatory incentives may be appropriate for some ICT activities relating to climate change. As a first step, it would be appropriate for investigation to begin on the scope for cooperation among regulators both within and beyond the ICT sector.

1.7.5.2 Questions

- Where is the boundary line between measures that affect all sectors and measures that are ICT-specific?
- Is there scope for a more active role for policymakers and ICT regulators to encourage, facilitate and incentivize the processes of transformation?
- Should the reduction of energy intensity across the economy be seen as a market-driven process of evolution using services and solutions from ICT players, or should it be driven by a more active role for ICT regulators?
- Is there a role for regulators to assist ICTs to reduce GHGs in other sectors, and if so, how far should such a role extend?
- Should ICT regulators pick up the themes identified in the GeSI Smart 2020 report and should they become more involved in cross-sectoral activities?[167]
- Does climate change mitigation suggest that ICT regulators should adopt more horizontal policies that engage all relevant partners, including businesses and residential users, and that involve a variety of measures, including fiscal incentives, to prefer low-carbon solutions to traditional ones?

Box 1.30: GSMA policy for government and regulatory support to assist mobile industry to reduce its emissions

The initiatives of the mobile industry to reduce its direct emissions rely on the development of an enabling regulatory framework and the creation of tax or other economic incentives to support the business case. Necessary policy support measures include:

- Facilitating the development of a common framework to measure the mobile industry's energy and environmental performance, and that of other sectors, for example by aligning national and regional methodologies with those being developed by ETSI and ITU in conjunction with the mobile industry and other private sector players. With such measurement standards in place, encourage further innovation among suppliers of mobile communications network equipment towards energy efficiency.
- Fostering innovation in low GHG footprint handset manufacturing, e.g., by reducing tax or providing tax incentives on handsets with low GHG footprints or with a high share of recyclable materials.
- Supporting investment in GHG emission-reducing technologies and processes by mobile operators, including antennas with reduced manufacturing GHG footprint and more energy efficient radio equipment for base-stations. This can be achieved, for example, by enabling some form of carbon credit, tax incentive or low interest financing to help incentivise capital investment in energy efficient and low GHG equipment.
- Supporting the current efforts of the mobile industry to reduce its emissions by sharing infrastructure. Active sharing of site electronics, which will reduce the number of sites required by each company, is currently not possible in many countries given competition rules.
- Ensuring spectrum availability, especially making harmonised low-frequency spectrum available to reduce the need for densely-constructed mobile networks. For example, it takes three times as many base stations to build a 3G network using the 2100 MHz spectrum band as it does using 850 MHz. It should be noted, however, that the use of lower frequencies also implies the lower data transmission rate.
- Supporting broadband infrastructure deployment by supporting the roll out of energy efficient networks through streamlining planning approval and providing investment incentives.
- Protecting the intellectual property rights of technology owners, in order to sustain and broaden investments in clean technology innovation and efficiency improvements.
- Supporting pilots of renewables-powered base stations in geographies where it makes sense by offering operators power utility status to allow for local small scale power generation in communities where such activity is beneficial, and consider using development funds to reach Project viability as needed. Development of local skills in green technologies could provide significant local and national benefits in countries where such initiatives are launched.

Source: GSMA, in collaboration with The Climate Group, Mobile's Green Manifesto

- Should there be light touch regulation in some areas to recognize the positive externalities created by the ICT sector when it assists other sectors to reduce their energy consumption?
- What is the role of ICT regulators in working to ensure ubiquitous high-capacity connectivity to enable teleworking and increased productivities in other sectors?
- What is the role of ICT regulators in creating an enabling environment for the development of new ICT services and applications that are potentially GHG reducing?
- Should ICT regulators be developing targeted policies and regulations in key areas such as promoting renewable energy sources and reducing power consumption (or the use of energy efficient technologies and equipment such as NGNs)?
- How can ICT regulators help to formulate and disseminate best practice guidelines on integrating a stronger environmental focus into their activities?
- Do ICT regulators have a role in stimulating demand for "environmentally-conscious" ICT services and devices?
- If there is a view that ICT regulators should have a role in promoting the positive effect of introducing new "green" ICT technologies, how should this happen without imposing unnecessary financial burdens on market players and consumers?
- Should ICT regulators become more closely involved in climate change issues in other sectors, for example, by encouraging the provision of services (including e-government, etc.) that use telecommunications to reduce travel, thus reducing GHGs?

- Is there a need for ICT regulators to increase their focus on consumer protection and consumer empowerment in order to ensure consumers are able to make informed decisions?
- Do ICT regulators have a role in helping overcome barriers to behavioural change in order to stimulate take up of ICTs in the attempt to mitigate GHGs from activities in other sectors?
- Do ICT regulators need to reinvent regulatory models and transit towards "distributed models" for regulation and decision support?

1.8 Going Forward

The ITU has run a number of special events, produced several publications, and is now actively considering the relationships between ICTs and climate change. These activities have prompted Sami Al Basheer Al Morshid, Director of ITU Telecommunication Development Bureau to note that *"we intend to be a mirror for the social and economic effects of ICT trends as they develop, providing regulators and policy makers with the insights and guidance they need to make key decisions for the constituencies they serve including proper consideration of challenges related to issues such as privacy, online protection and climate change."*[168]

As part of this process, this discussion paper has been prepared as a contribution to the Global Symposium for Regulators, to take place in Dakar, Senegal in November 2010. It is intended as a contribution to a debate that is only starting. Climate change is a contentious subject. The possibility that ICT regulators should have some specific involvement relating to climate change is bound to be controversial. Comments on the paper, and contributions to the debate, can be sent to the ITU at gsr@itu.int no later than 30 November 2010.

Annex 1.1: The transformative potential of ICTs

This Annex uses the GeSI taxonomy to consider the impact of the smart use of ICTs to drive down GHGs in other sectors, what the McKinsey Institute has described as *"wiring for a sustainable world"* based on *"the Internet of Things".*[169] Issues for regulators that emerge from this analysis are covered in the main paper. GeSI particularly considers the transformational potential of deploying ICTs in the following areas:

- Smart grid;
- Smart buildings;
- Smart logistics; and
- Smart motor systems.

A.1.1 What is the "smart grid"?

According to the UK's Department for Energy and Climate Change, "The transition to a low carbon economy will involve major changes to the way we supply and use energy; transforming our electricity system lies at the heart of these changes. Integral to this transformation will be an electricity grid that is fitted with more information and communications technology progressively over time. The result will be a 'smarter' grid, that gives a better understanding of variations in power generation and demand, and allows us to use that information in a dynamic and interactive way to get more out of the system."[170]

What is the technology which underlies the Smart Grid? One US expert has described it as "An enabling platform that integrates the latest digital and information technologies into the nation's electric delivery network for enhanced operational intelligence and connectivity throughout all application areas."[171] Some models place a pervasive broadband network at the heart of the Smart Grid, enabling it to play a transformative role in meeting energy, environmental, and transport goals, including energy independence, reduced GHGs, and clean energy generation. Whatever the technological variant, the Smart Grid uses new (and existing) ICT systems and processes to provide more information on demand flows and allows intermittent power, from wind, or inflexible power from nuclear, to be more easily integrated into the wider electricity system. Smart Grids represent a move away from the more monolithic, utility-style operations of existing energy networks. Current and emerging ICT systems are the mechanism that will enable this to happen. The Smart Grid, which is heavily reliant on ICTs for monitoring, management, and control of previously integrated electricity supply and distribution systems, could be particularly important for developing countries, where the lack of ICTs is often directly related to the lack of electricity.

One component of the Smart Grid may be smart metering[172] at the consumer premises, moving away from the traditional electro-mechanical meters which have been used in many countries for over a century. According to a 2006 report, smart meters can perform a large variety of functions, from remote meter reading to offering real-time tariff information to the consumer. Key capabilities are: measuring energy consumed, both in terms of quantity and when (i.e. on a time-interval basis); two-way communication; storing interval-data and transferring it remotely to a data collector/utility; and displaying consumption, tariff, and other information. The authors describe such advanced metering technology not so much as an end in itself but as "an important gateway," part of the Smart Grid that enables energy suppliers to improve market operation through better energy management and through the discovery of new retail opportunities. Smart metering also enables small and medium enterprises (SMEs) and households to achieve energy savings through improved feedback on energy consumption and expenditure, as well as enabling the development of demand-response at an individual level and providing new scope for micro-generation.[173]

The actual energy saving (hence GHG-reducing) impact of smart meters has not yet been subject to proper testing since energy savings has not been the motivation for transitioning to smart metering up to now. A 2008 study[174] considered smart meter trials in selected countries found varying outcomes: in Ontario, a smart metering trial resulted in a 6.0 per cent average conservation effect across all customers (results varied according to the type of metering and tariffing involved). However, a trial run in France (Tempo Tariff, EdF) found no impact on overall consumption.[175]

Of course, another dimension of Smart Metering is that it removes the need for travel by meter-readers, who would hitherto carry out their duties by using some form of GHG-emitting road transport.

A.1.2 What are "smart buildings"?

According to Deutsche Bank[176], existing buildings and their heating account for about 8 per cent of global

GHGs. There is scope for huge reductions in this figure by smart use of ICTs, as confirmed in a study[177] published in 2009 by the European Commission's Directorate-General for Information Society and Media. The report notes that more than 40 per cent of energy consumption in Europe is attributable to heating and lighting in buildings and that buildings are the largest source of CO2 emissions in the EU15 (including their electric power consumption). Most of this energy consumption is due to space and water heating. As the EC points out, *"Buildings can be considered as energy intensive systems through their whole life cycle.....the building operation phase accounts for 85 per cent of the total energy consumption."*

The study focuses on ICTs as a support to energy efficiency in so-called smart buildings. A "smart building" is defined as the building itself, including equipment and devices, the envelope, and the potential connection with the outside (e.g. electric grids). As the study notes, *"It is clear that if "green buildings" are to become commonplace, that this can only be facilitated by ICT."* Some examples cited in the report are:

- New ICT based Neighbourhood Management Systems to allow peer-to-peer sharing of energy produced through renewable schemes;
- New ICT based meters that will allow households not only to buy but also to sell energy; and
- ICT will allow information on energy consumption of every energy-consuming appliance in a home or a building to be provided in real-time, in a user friendly way, thereby empowering citizens to take decisions that lead to energy savings.

A.1.3 What are "smart logistics"?

Fourteen per cent of the world's GHG emissions stems from transport, of which private cars account for a large share. In the U.S. and in the European Union, emissions from transport account for 25 per cent and 19 per cent of total GHG emission respectively.[178] The transport sector thus offers scope for major mitigation of GHGs, but the effect of such measures may be counteracted by growth in the sector. The challenge then, is to deliver transport or its alternatives in a way that is sustainable, robust and safe and bring about reductions in annual vehicle mileage.

Selecting from those options that have an ICT component, the IPCC[179] highlights the following:

- Improved vehicle efficiency measures, leading to fuel savings, in many cases have net benefits (at least for light-duty vehicles). However, as the IPCC notes, *"the market potential is much lower than the economic potential due to the influence of other consumer considerations, such as performance and size."* (These considerations are less applicable to businesses than to personal motorists. For example, retailer TK Maxx is introducing new telematics equipment in all its vehicles, limiting speeds to just over 50mph and monitoring driving efficiency, while inaugurating a delivery share scheme with other retailers).
- Modal shifts from road to rail and to inland and coastal shipping and from low-occupancy to high-occupancy passenger transportation, as well as land-use, urban planning and non-motorized transport, which offer opportunities for GHG mitigation, depending on local conditions and policies.
- Medium term mitigation potential for CO2 emissions from the aviation sector can come from improved fuel efficiency, which can be achieved through a variety of means, including technology, operations, and air traffic management. However, such improvements are expected to only partially offset the growth of aviation emissions. Total mitigation potential in the sector would also need to account for non-CO2 climate impacts of aviation emissions.

As the IPCC goes on to note, reducing GHGs in the transport sector is often a co-benefit of addressing traffic congestion, air quality, and energy security.

Box 1.31: Intelligent Transport

The ITU has carried out some work on intelligent transport systems (see related ITU-T technology watch report and ITU-R Land Mobile Handbook (including Wireless Access) - Volume 4: Intelligent Transport Systems) and their impact on the environment, and electric vehicles (session 5, 2010 FNC workshop)

Online: http://www.itu.int/ITU-T/worksem/ict-auto/201003/ and http://www.itu.int/publ/R-HDB/publications.aspx?lang=en&parent=R-HDB-49

One of the more thorough analyses of the potential contribution of ICTs to GHG reduction in the transport sector is *Smarter Moves,* published by The Sustainable Development Commission.[180] The study examined the scope for achieving a major cut in carbon emissions from land-based personal mobility using 'in-reach' technologies. ICT was highlighted as turning the vision for convenient, joined up, multimodal sustainable mobility into reality. The study explored the scope for ICTs to:

- Reduce the need for travel;
- Influence travel mode choice;
- Change driver behaviour;
- Change vehicle behaviour;
- Increase vehicle loading factor; and
- Improve the efficiency of transport networks;

The key findings were that ICTs could support a range of ways to make mobility and our lifestyles more sustainable. ICTs can allow people to work without commuting, hold international meetings without flying, and identify the most sustainable way of making a journey. ICTs can promote more efficient use of vehicles and make the vehicles themselves more efficient. ICTs can also ensure that the transport networks for those vehicles are used as efficiently as possible. The report found that the following applications appeared to have the most significant potential for improving overall sustainability:

- enabling home working and travel avoidance;
- speed limit enforcement particularly through the use of intelligent speed adaptation;
- delivering congestion charging and road pricing;
- reducing barriers to the use of public transport and improving the journey experience; and
- facilitating car sharing, car clubs, and eco-driving;

However, the SDC research also identified a number of significant challenges, including a lack of conclusive evidence of ICTs being successfully used to improve overall sustainability within transport and the fact that travel behaviours tend to be habitual for the vast majority of journeys (84 per cent of trips in the UK are under 10 miles and in locations where travellers have already adopted, and become accustomed to, preferred travel modes). In such circumstances the provision of ICTs to provide journey information is unlikely to significantly improve the sustainability of mobility. The requirement for revenue funding was seen as a further challenge to increasing use of ICTs: initial capital investment for ICT interventions may be relatively small but ICT systems require funding for software and hardware support and maintenance, running costs, regular software updates, computer hardware updates, and roadside hardware replacement. Whereas a typical computer's working lifetime may be five to ten years, roadside hardware may have a lifetime of 10-20 years.

In addition, public transport service information was found to be not always available and not accessible in a form which can be utilised by third parties to provide accurate travel tools and assist people in making convenient, joined-up, door-to-door journeys. There is a need for government to take the lead in ensuring that such information is freely available and accessible. The report also highlighted the need to ensure that increasing the use of ICTs does not lead to increased inequalities in the UK transport system, given the number of households that do not have internet access or own a mobile phone.

Following up the theme of reducing congestion, a report from the UK employers organization, the CBI, in March 2010[181] agrees that ICT has a role to play, but that technology alone is not enough, since *"an overhaul of the way we work is needed.* The CBI's proposals to cut congestion on the roads include road pricing and lift sharing, both of which are more effectively enabled by ICTs[182], and universal broadband access to facilitate video conferencing and other technologies which can help people to work in novel ways, and at different times. Similarly, ETNO has considered the role of ICT in enabling home working (teleworking) and teleconferencing, hence reducing business travel to meetings. According to ETNO if one out of every three business trips was replaced by a video conference, Europe would realize a 33 million tonne reduction of CO2 emissions.[183]

But as the CBI notes, ICT alone is not enough: there is a need for flexible working patterns to bring higher productivity to firms, help to cut emissions and reduce congestion as more people work remotely or change the times they travel. More generally, while the technology already exists to deliver many of the required solutions, many mitigation options are faced with barriers, especially those that arise from consumer preferences and a lack of policy frameworks.

One area identified in the SDC report as having potential were car clubs,[184] which replace ownership with rental as a preferred model for personal mobility. These have undergone rapid growth in recent years. Working on a Pay-As-You-Go model, charges are based on how long you have the car and how far you drive. The annual cost of using car club cars is normally dramatically less than the cost of owning a car and there are major claims of carbon saving: according to StreetCar UK, every car-share results, on average, in six private cars being taken off the road. One reason why such schemes have become more widespread is that they depend on technologies that have become ubiquitous in recent years, like the web, smartcards and telecommunications.

It is also notable that some of the mitigation policies that apply to the transport sector have a major ICT component – for example, congestion charging.

A.1.4 What are "smart motor systems"?

As the section on Smart Motors in the GeSI report notes, motors can be inefficient as they operate at full capacity, regardless of load: what makes a motor "smart" is when it can be controlled to adjust its power usage to a required output, usually through a VSD and intelligent motor controller (IMC), a piece of hardware controlling the VSD. There is a lack of information about energy consumption in motor systems and where savings can be made within a factory. ICT's main role in the short term is to monitor energy use and provide data to businesses so they can make energy and cost savings by changing manufacturing systems.

The ICT sector has additional roles to play. Simulation software is required to help improve plant and manufacturing process design. Wireless networks that allow inter-machine and system communication would improve efficiency across an entire factory. Given that much of the growth in industrial energy demand has been in emerging economies, with China alone accounting for about 80 per cent of the growth in the last 25 years, the potential for large-scale utilization of smart motor systems will be greatest there.

The GeSI Report describes the role of ICT in helping to mitigate global carbon emissions from motor systems and industrial process optimization.[185] It refers to initiatives such as Energy Smart in Australia, BC Hydro's Power Smart in Canada and Motor Decisions Matter in the US as examples of ICTs and other businesses working to identify optimal use of smart motors in their processes, producing substantial carbon and economic savings. GeSI gives the example of the Energy Smart Business Program, *"which states that properly sized, energy efficient motors with electronic VSD* [Variable Speed Drive, which controls the frequency of electrical power supplied to a motor] *and improved gears, belts, bearings and lubricants use only 40* per cent *as much energy as standard systems..."*

A.1.5 What is dematerialisation and decoupling?

"*We are moving from atoms to bits...we are not waiting on any invention. It is here. It is now. It is almost genetic in its nature, in that each generation will become more digital than the preceding one.*"

Nicholas Negroponte[186]

Dematerialization is the process by which concepts and ideas substitute for physical resources and human brawn in the production of goods and services. Alan Greenspan, former Chairman of the US Federal Reserve Board said in 1996, *"...the weight of current economic output is probably only modestly higher than it was a half century ago, value added, adjusted for price change, has risen well over threefold....Radical transformations in what we produce in the way of goods and services and how we produce them occur perhaps once or twice in a century, at most."* Some examples of this process include: the replacement of vacuum tubes by transistors; the replacement of copper wire with fibre optics; buildings that provide more floor space using less physical material; word processors mean less effort is required to produce a manuscript; steel mills are run by computers, as are many other industrial processes; answer phones are replaced by voicemails; CDs (and DVDs) are replaced by downloads; and downloads are replaced in turn by Spotify[187].

The use of ICTs is one of the ways that this process can be accelerated. But how many standard economic activities can be made weightless and/or frictionless? Of those that can, which ones will? How will business and consumer behaviour change when they do? And how will those changes affect energy consumption and therefore GHG emissions?

Alongside the process of de-materialization, and accompanying the shift from manufacturing to service-based activities in the developed economies, is a decoupling of economic growth from energy consumption. In making business more efficient, information technology is reducing the energy and materials needed for each USD, £ or EUR of output, and increasing overall productivity. A study by the Rand Corporation[188] considered four 20-year scenarios of ICT evolution (2001-2021) for the US Department of Energy covering implications for future US electricity requirements; it found that:

- Increased power consumption by ICT equipment is the most direct and visible effect, but not necessarily the most important.
- The effects that ICTs have on energy management, e-commerce, telework, and related trends are likely to be much more consequential.
- Even large growth in the deployment and use of digital technologies only modestly increases overall US electricity use in the next two decades.
- The biggest energy concern for a digital society is how to provide the higher-quality and more-reliable power demanded by ICTs.

Another study found that not only had the Internet revolutionized the relationship between economic growth and the environment, but energy demand growth had slowed substantially since the start of the Internet boom. The study noted that the idea that, *"The Internet is the cause for rising energy demand in the US" is a myth: demand would be much higher without Internet savings….the internet economy could fundamentally and permanently alter the historic relationship (between economic growth and energy intensity) allowing faster growth and with less energy use than seen in the past…generating both structural and efficiency gains."*[189] The study found that the reasons for reduced energy intensity (in the USA) were 33-50 per cent due to structural economic changes (i.e., the shift out of energy intensive industries) and 50-66 per cent due to increased energy efficiency in other sectors.

ANNEX 1.2: ITU INTEGRATED CHECKLIST ON REGULATOR'S INVOLVEMENT IN CLIMATE CHANGE ISSUES

Rationale: Arising from the main themes set out in the discussion paper on ICT regulation and climate change, a number of questions need to be asked and answered. Those have been grouped into regulatory checklists at the end of each section of this paper. Here below you will find the full, integrated Regulator's checklist. The checklist is a tool that ICT regulators may use to evaluate the effort needed to get involved in the area of climate change. Completing the checklist helps identify key issues that should be considered during the process of taking on new responsibilities related to climate change and the development of regulations and other regulatory initiatives in this field, while recognizing the diversity of economic and political environments and the different scope and nature of regulatory authorities. When thoroughly completed, the checklist creates a framework for decision making that sets out key principles to guide regulators through the complexity of the design and implementation of high-quality, effective and targeted regulatory response in this area in compliance with international best practices.

How it works: This checklist is intended to facilitate your analysis of the possible involvement of your institution in the area of climate change and identify the implications such an involvement may have in terms of policy, regulatory mandate and human resources. You do not need to answer questions that are not relevant.

A GENERAL FRAMEWORK FOR REGULATOR'S INVOLVEMENT IN CLIMATE CHANGE ISSUES

A1 How should ICT regulators factor GHG reduction measures into their existing portfolio of policies and regulatory responsibilities?

A2 Which other sectors, such as energy, transport, and health, offer the greatest scope for the beneficial linkages between ICTs and reduced GHGs to be brought about?

A3 How can ICT regulators develop more effective co-ordination with other regulators and policy makers to ensure that decisions relating to ICTs recognize any potential GHG implications, whether negative or positive?

A4 How should policy makers ensure that economic players are able to plan effectively for the integration of environmental considerations into ICT sector policies?

A5 Would such policies require changes to the primary duties/enabling legislation of ICT regulators?

A6 What is the legal basis for ICT regulators to become involved in the pursuit of policies to reduce GHGs?

A7 What should be the scope and extent of regulatory interventions which are designed to bring about reduced GHG emissions by ICTs?

A8 How should sector regulators consider policy areas that affect environmental outcomes, such as through beneficial effects on power usage and GHGs? Should regulators factor potential environmental outcomes into their decision making when it comes to policy matters such as the deployment of NGNs, migration from analogue to digital networks, migration from 2G to 3G and beyond , and infrastructure sharing?

A9 Should the ongoing United Nations Framework Convention on Climate Change (UNFCCC) negotiation process make the link between climate change and regulation of the ICT sector?

A10 What role should ICT regulators play with regard to environment-related measures: facilitator, enabler, promoter, awareness raiser?

A11 If the regulator's core mandate does not include environmental considerations, how should such considerations be incorporated into regulatory policy, particularly where regulatory decisions may result in environmental consequences?

A12 Given the general consensus about the threat posed by climate change, and the potential of the ICT industry in general, and TSPs in particular, to facilitate the reduction of GHGs, should ICT regulators develop and advocate policies that address climate change?

A13 ICT regulators have previously focused on market failure related to the telecommunication sector. If the responsibilities of ICT regulators are now to encompass measures relating to climate change, how should such interventions be implemented, such that the chosen measures do not add further burdens to the sector?

A14 Should ICT regulators now consider the potential for GHG reductions when making regulatory decisions?

A15 Given the potential for ICT to have a beneficial impact on GHGs, is it appropriate for regulators to be given additional duties concerned with environmental matters, particularly those relating to climate change?

B MODALITIES OF REGULATOR'S INVOLVEMENT

B1 Is there a role for ICT regulators to address not just the TSPs, but the customers of the services provided by TSPs?

B2 Should regulators be involved in attempting to change individual behaviours as part of the drive to cut GHGs?

B3 Should regulators develop programmes to build consumer awareness and education about the impact of usage patterns in ICTs on the environment?

B4 Do ICT regulators have a role to play in helping overcome barriers to behavioural change?

B5 Should ICT regulators incorporate insights from disciplines like social marketing and behavioural economics into their attempts to modify the GHG-related behaviours of individuals?

B6 What is the role for mechanisms such as choice architecture, defaults, commitment devices and Nudge, based on the findings of social marketing and behavioural economics?

B7 Should ICT regulators provide information about the energy consumption of ICT devices?

B8 Is there a role for ICT regulators in producing case studies and similar examples to raise the level of understanding and help kick-start the debate about GHGs and ICTs?

B9 In what ways can ICT regulators use new forms of ICT services in attempting to change behaviours?

B10 What role is there for ICT regulators in persuading the public to behave differently so as to reduce the GHGs produced by individuals through the use of energy-saving and clean-energy ICT services and applications?

B11 Is there a role for regulators to become more involved in promoting responsible consumer behaviour such as turning off equipment when not in use, not replacing devices as frequently, and using less bandwidth?

C ICT REGULATORS AS EXEMPLARS

C1 Should we expect regulators to act as exemplars of good behaviour regarding their own GHG-creating activities?

C2 Should sector regulators, at the national, regional and international level, exemplify good practice by developing policies that curb their own GHGs?

C3 How should ICT regulators go about this task?

C4 Should regulators be required to subject their own GHG-producing activities to a higher degree of scrutiny, with a requirement for greater transparency?

C5 Should ICT regulators be required to set out their own GHG mitigation policies, establish targets, and publish results?

C6 Should there be a role for ICT regulators in ensuring that information about best practices is diffused across all relevant regulators?

D REGULATORS AS FACILITATORS OF SUSTAINABLE MARKET DEVELOPMENT

D1 Should ICT regulators be involved in encouraging and facilitating the ongoing activities of organizations such as GeSI (and vice versa)?

D2 Is there a role for ICT regulators in emphasizing climate change issues in the industry's supply chain work and in influencing the end-to-end manufacturing process for electronic equipment?

D3 How do ICT regulators ensure that energy and climate change matters are fully considered by the organizations that set the technical standards for the ICT industry?

D4 Should ICT regulators be involved in the formulation of national policies on climate change?

D5 How do ICT regulators create a policy framework to reduce the ICT sector's own carbon footprint and to embrace environment-friendly technologies and processes in ICT development?

Endnotes

1 Note, however, that ICTs produce GHGs at a lower intensity than most sectors considered, relative to each sector's contribution to GDP.

2 Although many ICT products and services are becoming more energy-efficient, such (relative) improvements are typically being out-run by growth in the (absolute) number of services, devices and users.

3 This paper cannot provide a definitive answer to that question, but there are many studies that conclude that ICTs are a (relatively) small part of the overall problem, and a (potentially) large part of the overall solution. See, for example:

- ITU Background Paper on ICTs and Climate Change, July 2009, online www.itu.int/dms_pub/itu-t/oth/06/0F/T060F00600C0004PDFE.pdf
- Accenture and Vodafone, *Carbon Connections: Quantifying mobile's role in tackling climate change*, July 2009, online: www.vodafone.com/etc/medialib/cr_09/carbon.Par.76396.File.tmp/carbon_web_2009.pdf
- China Mobile and WWF, *Low Carbon Telecommunication Solutions in China: Current Reductions and Future Potential* (Beijing: WWF, 2010), online: http://wwf.panda.org/?193193/China-study-shows-huge-potential--of-low-carbon-telecom-solutions [China Mobile/WWF, *Low Carbon Telecommunication Solutions in China,* 2010].
- Dennis Pamlin & Katalin Szomolányi, *Saving the climate @ the speed of light: First roadmap for reduced CO2 emissions in the EU and beyond* (Brussels: WWF/ETNO, undated), online: www.etno.be/Portals/34/ETNO%20Documents/Sustainability/Climate%20Change%20Road%20Map.pdf.
- ETNO, *Background Report: Greenhouse Gas effects of ICTs* (2005), online: www.etno.be/Portals/34/events/VIS2005/projectdocu_Final.pdf.
- Telstra, *Towards A High Bandwidth, Low Carbon Future: Telecommunications-based Opportunities to Reduce Greenhouse Gas Emissions* (2007), online: www.telstra.com.au/abouttelstra/csr/reports.cfm.
- The Climate Group, on behalf of the Global e-Sustainability Initiative (GeSI), Smart 2020, *Enabling the low carbon economy in the information age*, (2008), online: www.smart2020.org/_assets/files/02_Smart2020Report.pdf [GeSI, Smart 2020].
- Intellect, *High Tech, Low Carbon*, (London: Intellect UK, 2008), online: www.intellectuk.org/hightechlowcarbon.
- John A. "Skip" Laitner & Karen Ehrhardt-Martinez, *Advanced Electronics and Information Technologies: The Innovation-Led Climate Change* (Brussels & Washington: American Council for an Energy-Efficient Economy & AeA Europe, 17 September 2007), online: www.aeanet.org/aeacouncils/AeAEurope_Energy_Efficiency_Report_17Sep07.pdf.

4 *Lorenz Erdmann et al., The Future Impact of ICTs on Environmental Sustainability, Institute for Prospective Technological Studies, August 2004, available online at:* www.ictregulationtoolkit.org/en/Publication.3507.html.

5 GeSI, *Smart 2020*, supra note 3

6 Cited by Total Telecom Executive Insight, *After Copenhagen: Tackling Climate Change* (2009), online: http://headley.co.uk/headturner/execinsight.

7 As the ITU has expressed it, "*ICT sector regulators need to maintain a delicate balance between a hands-on or hands-off approach to regulation. This is a critical exercise to ensure a healthy development of the sector, while meeting social goals.*" From Chapter 1 in ITU, *Trends in Telecommunication Reform 2009* (ITU: Geneva, 2010).

8 China Mobile/WWF, *Low Carbon Telecommunication Solutions in China*, 2010, *supra* note 3.

9 World Economic Forum, *ICT for Economic Growth: A Dynamic Ecosystem Driving The Global Recovery* (WEF: Davos, 2009) at 2, online: www.weforum.org/pdf/ict/ICT%20for%20Growth.pdf.

10 See, for example, Parliamentary Office of Science and Technology, *Postnote,* December 2008, online: www.parliament.uk/documents/post/postpn319.pdf.

11 For a detailed overview of the history of licensing in the ICT sector, see ITU-*info*Dev *ICT Regulation Toolkit*, "Authorizaiton Trends", online: www.ictregulationtoolkit.org/en/Section.524.html.

12 ITU-*info*Dev *ICT Regulation Toolkit, "Regulation in Transition to Competitive Market"*, online: www.ictregulationtoolkit.org/en/Section.1686.html.

13 For example, it was reported early in 2010 that Google has been granted a license to trade energy on the US wholesale market, in an attempt to better manage energy costs. One analyst commented that this would allow Google to supply its "energy hungry data centers" directly, as well as reduce the risks of time-variable prices. The comment continued to say that, as a global company, when Google faces peak demand in Europe, demand will be lower in the US. Therefore Google could potentially move its processing capacity from regions experiencing peak demand to areas in the world where there is either green or simply low-cost energy readily available. Google could also shape its local demand by spreading its processing resources to other locations, taking advantage of the market conditions in that particular region. The report noted that it is unlikely that this type of energy load switching could most likely only be done in such a dynamic and flexible manner if Google supplied itself. Facing rises in energy prices, this kind of arbitrage could help energy-intensive companies better manage their costs. All of which is by way of pointing out that non-traditional players like Google are significant consumers of electricity, and hence emitters of GHGs, but would fall outside the scope of conventional telecommunications regulation.
See David Mayne, *Google: managing its energy demand is the key to a low-cost supply*, (London: Datamonitor, 2010), online: http://about.datamonitor.com/media/archives/3784

14 ITU, *Trends in Telecommunication Reform 2009* (ITU: Geneva, 2010) at 14.

15 ITU, *Trends in Telecommunication Reform 2009* (ITU: Geneva, 2010) at 17

16 As measured under Life Cycle Assessment.

17 For more information about WTO agreements, see www.wto.org/english/docs_e/legal_e/legal_e.htm#agreements.

18 Anne Larilahti, *IT can do far more than reduce its own footprint*, Nokia Siemens Networks, 9 October, 2008.

19 For more information on the "other" environmental consequences of ICTs, see: Eftec and Plexteck, Understanding the Environmental Impact of Communication Systems: Final Report (London: Ofcom, 2009), online: www.ofcom.org.uk/research/technology/research/sectorstudies/ [Eftec and Plexteck, Final Report] and Eftec and Plexteck Understanding The Environmental Impact Of Communication Systems: Appendices, (London: Ofcom, 2009), online: www.ofcom.org.uk/research/technology/research/sectorstudies/ [Eftec and Plexteck, Appendices].

20 Information derived primarily from BBC Weather Centre on Climate Change, online: www.bbc.co.uk/climate/evidence/carbon_dioxide.shtml. CO2 ppm data from Earth Systems Research Laboratory (ESRL)/National Oceanic and Atmospheric Administration (NOAA), as published at http://co2now.org/.

21 United States Environmental Protection Agency, "Frequently Asked Questions About Global Warming and Climate Change: Back to Basics", April 2009, online: www.epa.gov/climatechange/downloads/Climate_Basics.pdf

22 Martin Rees, President of the Royal Society, interviewed on BBC Radio 4, 10 March, 2010, podcast available at: http://downloads.bbc.co.uk/podcasts/radio4/today/rss.xml.

23 *"It is now clear that man-made greenhouse gases are causing climate change. The rate of change began as significant, has become alarming and is simply unsustainable in the long-term." Climate Change,Your Essential Guide.* UK Met Office www.metoffice.gov.uk/climatechange/guide/quick/

24 Martin Rees, President of the Royal Society, interviewed on BBC Radio 4, 10 March, 2010, podcast available at: http://downloads.bbc.co.uk/podcasts/radio4/today/rss.xml.

25 Nicholas Stern, *Stern Review: The Economics of Climate Change: Executive Summary* (2006), online: www.hm-treasury.gov.uk/d/Executive_Summary.pdf.

26 William R. L. Anderegg, James W. Prall, Jacob Harold & Stephen H. Schneider, *Expert credibility in Climate Change*, Proceedings of the National Academy of Sciences of the United States of America, 2010, online: www.pnas.org/content/early/2010/06/04/1003187107.

27 The press release for the Met Office review noted that the IPCC's fourth assessment report, published in 2007 came to a more confident assessment of the causes of global temperature change than previous reports and concluded that 'it is likely that there has been significant anthropogenic warming over the past 50 years averaged over each continent except Antarctica'. Since then, warming over Antarctica has also been attributed to human influence, and further evidence has accumulated attributing a much wider range of climate changes to human activities. Such changes are broadly consistent with theoretical understanding, and climate model simulations, of how the planet is expected to respond.

See: Met Office, "Climate Change and Human Influence", Press Release 5 March 2010, online: www.metoffice.gov.uk/corporate/pressoffice/2010/pr20100305.html.

See also Peter A. Stott, Nathan P. Gillett, Gabriele C. Hegerl , David J. Karoly, Dáithí A. Stone, Xuebin Zhang & Francis Zwiers, *Detection And Attribution Of Climate Change: A Regional Perspective* (2010) 1 Wiley Interdisciplinary Reviews: Climate Change 192 [Stott et al., 2010]. The abstract of this article is available at Wiley Online Library, online: http://www3.interscience.wiley.com/journal/123310513/abstract?CRETRY=1&SRETRY=0.

28 IPCC, *Fourth Assessment Report: Climate Change 2007* (Geneva: IPCC, 2007), online: www.ipcc.ch/publications_and_data/ar4/syr/en/contents.html.

29 Peter A. Stott, Nathan P. Gillett, Gabriele C. Hegerl , David J. Karoly, Dáithí A. Stone , Xuebin Zhang, Francis Zwiers (2010) *Detection And Attribution Of Climate Change: A Regional Perspective* (March 2010) John Wiley & Sons 2010. http://www3.interscience.wiley.com/journal/123310513/abstract?CRETRY=1&SRETRY=0

30 David Easterling, *Trends in Climate Related Disasters*, Presentation made to IPCC Scoping Meeting, 23-26 March, 2009. For an abstract of this presentation, see: www.ipcc-wg2.gov/AR5/extremes-sr/ScopingMeeting/extremes_speakers.html.

31 Royal Society, *Preventing Dangerous Climate Change: The Need for A Global Agreement* (London: Royal Society, 2009), online: http://royalsociety.org/Preventing-dangerous-climate-change/ .

32 World Bank, *World Development Report 2010: Development and Climate Change* (Washington, D.C.: The World Bank, 2010), online: http://econ.worldbank.org/WBSITE/EXTERNAL/EXTDEC/EXTRESEARCH/EXTWDRS/EXTWDR2010/0,,menuPK:5287748~pagePK:64167702~piPK:64167676~theSitePK:5287741,00.html.

33 GeSI, *Smart 2020*, *supra* note 3.

34 GeSI, *Ibid.*

35 For information on GCOS, see: www.wmo.int/pages/prog/gcos/.

36 See also: www.itu.int/publications/publications.aspx?lang=en&media=electronic&parent=R-HDB-45-2008 and www.itu.int/dms_pub/itu-t/oth/06/0F/T060F00600C0004PDFE.pdf.

37 Peter Madden & Ilka Weißbrod, *Connected: ICT and Sustainable Development* (2008), online: www.forumforthefuture.org/files/Connected.pdf.

38 Adapted from the definition of IPCC, online: www.ipcc.ch/ipccreports/tar/wg2/pdf/wg2TARchap18.pdf

39 See e.g. L. Hilty, P. Arnfalk, L. Erdmann, J. Goodman, M. Lehmann & P Wäger (2006), *The relevance of information and communication technologies for environmental sustainability – A prospective simulation study* (2006) 21 Environmental Modelling & Software1618.

40 As Ovum has noted, "There is much inconsistency in the calculation methodologies for energy use and CO2 emissions used by telecoms operators

- Not all operators include emissions produced by staff travel
- Some include, and some exclude, the emissions of the vehicle fleet
- There is much confusion over the correct way to treat emissions "saved" by the use of "green tariff" electricity
- Operators use different conversion factors to mediate between energy use and CO2 emissions, making comparisons between them difficult."

Jeremy Green and Daniel Subramaniam (2010) *Telecoms operators' green and carbon reduction strategies*

41 Jon Stern, "Evaluating Infrastructure Regulators - Developing UK and International Practice," a CRI Occasional Lecture, Royal Society, 26 September 2006, online: www.bath.ac.uk/management/cri/pubpdf/Occasional_Lectures/17_stern.pdf.

42 Sophie Trémolet & Diane Binder, Response to "What are the foundations for regulatory activities in infrastructure?", Regulatory Challenges Frequently Asked Questions in *Body of Knowledge on Infrastructure Regulation,* Public-Private Infrastructure Advisory Facility, World Bank & Public Utility Research Center, University of Florida, 2009, online: www.regulationbodyofknowledge.org/faq/foundHistoric/.

43 ITU Telecommunication/ICT Regulatory Database 2010.

44 Richard Walters, "Antisocial Networking," *Financial Times*, 20 February, 2010.

45 Christopher Caldwell, "Is Google now a Monopoly?" *Financial Times*, 27 Feburary, 2010. According to Caldwell, "*Google is to the 21st century what certain railroads were to the late 19th. It creates conditions for economic activity unthinkable before its advent….Google accounts for 80% of online search revenues in the US and 90% in Europe and the UK"*

46 "*Facebook passes Google as most-viewed site in US in past week,*" Guardian 15 March, 2010, online: www.guardian.co.uk/technology/blog/2010/mar/15/facebook-passes-google-share-us.

47 See e.g. the case brought by the EU's Competition Directorate-General, DGIV v. Microsoft, for abuse of a dominant position under EU competition law.

48 "Apple Updates iPhone Programme, Says 450,000 iPads Sold," *Business Week*, 8 April, 2010, online: www.businessweek.com/news/2010-04-08/apple-unveils-iphone-program-says-450-000-ipads-sold-update1-.html.

49 Galit Zadok & Riikka Puustinen, *The Green Switch: Designing for Sustainability in Mobile Computing* (2010), online: www.thegreenswitch.org/wp-content/uploads/2009/12/TheGreenSwitch_publication_Jan2010.pdf.

50 *Ibid.*

51 Figures from GSMA, in collaboration with The Climate Group, *Mobile's Green Manifesto.* (2009), online: www.gsmworld.com/documents/mobiles_green_manifesto_11_09.pdf

52 The *Fortune 500* list ranks American companies in terms of size. As of 26 March 2010, Apple had a market value of close to $209.4 billion and assets valued at over $53.8 billion. Revenues were up 12.5% on the previous year, at more than $36.5 billion, and profits up 18% to about $5.7 billion. This information was derived from electronista.com, online: www.electronista.com/articles/10/04/15/still.well.behind.hp.microsoft.dell/ and Report of Fortune 500 Rankings at CNN Money.com http://money.cnn.com/magazines/fortune/fortune500/2010/full_list/.

53 ITU, "Foreword", *Trends in Telecommunication Reform 2009* (ITU: Geneva, 2010).

54 As the GSMA notes, "*There are two levels of infrastructure sharing: passive and active. Passive sharing involves components such as the tower mast or pylons, cables, physical site or rooftop, shelter cabinets, power supply, air conditioning, alarm systems, etc. Active sharing includes antennas, antenna systems, backhaul transmission systems and the BTS equipment itself. Passive sharing is becoming increasingly common and reduces the environmental footprint of mobile networks by cutting the number of BTS sites required by each company. In March 2009, Telefonica and Vodafone announced that they would share network infrastructure in Germany, Spain, Ireland and the UK. Active sharing, which shares the site electronics, can have a much larger impact on the networks' carbon footprints, but it has only been implemented in a few mature markets to date. Active sharing agreements include T-Mobile and 3 Group in the UK, Telstra and 3 Group, as well as Vodafone and Optus, in Australia, Tele2 and Telia, as well as Tre and Telenor, in Sweden. In South Korea, all three operators KT, SK Telecom and LGT invested in KRTnet Corporation in 1996 to construct and manage base station sites jointly used by all operators, leading to co-location of sites and tower sharing*." GSMA/The Climate Group, *Mobile's Green Manifesto, supra* note 52.

55 ITU, "Chapter 2: What Do We Mean By 6 Degrees Of Sharing?" in *Trends in Telecommunication Reform 2008* (ITU, Geneva, 2008), online: www.itu.int/ITU-D/treg/Events/Seminars/GSR/GSR08/discussion_papers/Overview_Final_web.pdf.

56 Stern, *supra* note 28.

57 BEREC Work Programme 2010, online: http://erg.eu.int/doc/publications/berec/bor_10_15_berec_wp_2010_consultation_100209.pdf.

58 OFCOM, *Regulatory Challenges Posed By Next Generation Access Networks: Public Discussion Document* (London: Ofcom, 2006), online: www.ofcom.org.uk/research/telecoms/reports/nga/nga.pdf.

59 ITU Background Paper on ICTs and Climate Change, July 2009, online www.itu.int/dms_pub/itu-t/oth/06/0F/T060F00600C0004PDFE.pdf ; see also Dittberner Associates, *Prime Prospects - Identification and Forecast of Digital Switch Replacements and Augmentations,* Research Report (2003), online: www.dittberner.com/reports/about51.php.

60 Examples of relevant regulatory decisions include: TSP migration from existing networks to NGNs; granting permission for infrastructure sharing; using alternative energy sources; and providing universal services in off-grid locations.

61 For converged sector regulators, digital broadcasting would be another aspect of policy with potential energy, hence GHG, implications. But this is outside the scope of this report. For more on this, see (i) Eftec and Plexteck, *Final Report, supra* note 19 and (ii) Eftec And Plexteck, *Appendices, supra* note 19.

62 TeliaSonera launched the world's first 4G service in Stockholm and Oslo in December 2009, according to the Financial Times: "Huawei contract win is blow to Ericsson", *Financial Times,* 18 December, 2009.

63 Malcolm Gladwell, *The Tipping Point* (London: Abacus, 2000).

64 The World Bank, *World Development Report 2010: Development and Climate Change* (Washington, D.C.: The World Bank, 2010) at 322, online: http://econ.worldbank.org/WBSITE/EXTERNAL/EXTDEC/EXTRESEARCH/EXTWDRS/EXTWDR2010/0,,menuPK:5287748~pagePK:64167702~piPK:64167676~theSitePK:5287741,00.html [World Development Report 2010].

65 Cited in David Zax, "The Last Experiment," *SEED Magazine*, 22 April 2009, online: http://seedmagazine.com/content/print/the_last_experiment/.

66 Cited in David Zax, *ibid*.

67 Angel Gurría, "Towards A Green Economy: Policies to Tackle Climate Change", Remarks delivered at the National Forum on Energy, Environment and Climate Change Policy, Mexico City, 25 August 2009, online: www.oecd.org/document/36/0,3343,en_2649_34361_43544996_1_1_1_1,00.html

68 S.E.G. Lea, Roger M. Tarpy, & Paul Webley, *The Individual in the Economy* (2007) Introduction to Part II at 133. Cambridge: Cambridge University Press.

69 The IPCC report goes on to note the following important points:

- Lifestyle changes can reduce GHG emissions. Changes in lifestyles and consumption patterns that emphasize resource conservation can contribute to developing a low-carbon economy that is both equitable and sustainable.
- Education and training programmes can help overcome barriers to the market acceptance of energy efficiency, particularly in combination with other measures.
- Changes in occupant behaviour, cultural patterns and consumer choice and use of technologies can result in considerable reduction in CO2 emissions related to energy use in buildings.
- Transport Demand Management, which includes urban planning (that can reduce the demand for travel) and provision of information and educational techniques (that can reduce car usage and lead to an efficient driving style) can support GHG mitigation.
- In industry, management tools that include staff training, reward systems, regular feedback, documentation of existing practices can help overcome industrial organization barriers, reduce energy use, and GHG emissions.

B. Metz, O.R. Davidson, P.R. Bosch, R. Dave, L.A. Meyer, eds., "Mitigation in a cross-sectoral perspective: Mitigation in the short and medium term (until 2030)" in *Contribution of Working Group III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, 2007* (Cambridge: Cambridge University Press, 2007), online: www.ipcc.ch/publications_and_data/ar4/wg3/en/spmsspm-c.html [IPCC, "Mitigation in the short and medium term"]

70 *World Development Report 2010*, supra note 66 at 322.

71 See e.g. Gerard Hastings, *Social Marketing: Why Should the Devil Have All the Best Tunes?* (London: Butterworth-Heinemann, 2007). See also the work of the National Social Marketing Centre at: www.nsms.org.uk.

72 Daniel Kahneman, *Maps Of Bounded Rationality: A Perspective On Intuitive Judgment And Choice,* Nobel Prize Lecture (Princeton University, Department Of Psychology, 8 December, 2002), online: http://nobelprize.org/nobel_prizes/economics/laureates/2002/kahnemann-lecture.pdf

73 For an overview see: Andrew Darnton, *Reference Report: An Overview Of Behaviour Change Models And Their Uses,* Government Social Research Behaviour Change Knowledge Review, Centre for Sustainable Development, University of Westminster, 2008, online: www.gsr.gov.uk/downloads/resources/behaviour_change_review/reference_report.pdf

74 Sheridan Nye, *The Challenge Of Changing Consumer Behaviour For Sustainable Consumption* (2007), online: www.ictandclimatechange.com/page21.htm.

75 Richard H Thaler & Cass R Sunstein, *Nudge: Improving Decisions About Health, Wealth, and Happiness* (Yale: Yale University Press, 2008).

76 Omer Rashid, Paul Coulton & William Bird, *Using NFC to Support and Encourage Green Exercise* (2008), online: http://eprints.lancs.ac.uk/21202/1/getPDF6.pdf

77 See www.nsmcentre.org.uk/what-is-social-marketing.html

78 Colin Camerer and George Loewenstein, "Behavioural Economics: Past, Present and Future" in C. F. Camerer, G. Loewenstein & M. Rabin, eds., *Advances in Behavioural Economics* (Princeton, Princeton University Press, 2004) 3.

[79] See, for example: Stephen Young & Viv Caisey, "Mind Shift, Mode Shift. A Lifestyle Approach To Reducing Car Ownership and Use, based on Behavioural Economics and Social Marketing" in *Perspectives in Public Health* (London: Royal Society for Public Health, 2010). For an abstract of this article, see: http://rsh.sagepub.com/cgi/rapidpdf/1757913909354151v1.

[80] See, for example: Financial Services Authority, *Financial Capability: A Behavioural Economics Perspective* (2008), online: www.fsa.gov.uk/pubs/consumer-research/crpr69.pdf.

[81] "Social Networks/Blogs Now Account for One in every Four and a Half Minutes Online," 15 June 2010, online: http://blog.nielsen.com/nielsenwire/online_mobile/social-media-accounts-for-22-percent-of-time-online/.

[82] A panel of 20 scientists from the British Science Association drew up a list of the top 10 things that have changed the world. See Richard Gray, "Top 10 'inventions' that changed the world," *Daily Telegraph*, 13 March 2009, online: www.telegraph.co.uk/science/4981964/Top-10-inventions-that-changed-the-world.html

[83] B.J. Fogg, *Mass interpersonal persuasion: An early view of a new phenomenon* (in process), Third International Conference on Persuasive Technology, Persuasive 2008 (Berlin: Springer, 2008). For the latest version, see www.bjfogg.com or www.bjfogg.com/mip.html.

[84] Lorien C. Abroms & R. Craig Lefebvre, "Obama's Wired Campaign: Lessons for Public Health Communication" (2009) 14 Journal of Health Communication 415, online: http://socialmarketing.blogs.com/r_craiig_lefebvres_social/2009/09/free-copy-of-obamas-wired-campaign.html. Obama had more than 2 million American supporters on Facebook, compared with just over 600,000 for McCain, according to Matthew Fraser and Soumitra Dutta, cited in the Guardian, 3.5.10.

[85] *Facebook helps users quit smoking.* A Facebook application to help people quit smoking has been launched by a charity. WeQuit will help people and their friends challenge each other to give up nicotine as well as create rewards for success and forfeits for failure. Quitters will also be able to raise money for charity and track each other's progress by accessing www.WeQuit.co.uk/facebook and adding the application to the social networking site. Figures released by the Office of National Statistics (ONS) show that smoking was most common among 20 to 24-year-olds (30%) in 2008 and least common among those aged 60 or over (13%).

[86] In a tie-up with the Electoral Commission, Facebook users were asked if they have registered to vote. If they say "No" they will be sent to a page linked to the Electoral Commission that lets them enter details online. They then have to print out this page and post it to their local council's electoral registration office. The address for this is automatically created on the page once someone has entered their own location details. The Electoral Commission says applications have to be sent by post, and not simply via email, because of a legal requirement to prevent electoral fraud. The Electoral Commission estimates 3.5 million people who were eligible to vote in England and Wales in 2001 were not registered. Electoral Commission spokesman Clinton Proud said the Facebook exercise was part of the organisation's remit to expand access to the democratic process. *"If you're not registered, you can't vote - it's very simple. By downloading and printing a form through Facebook, users can now make sure that they are able to have their say on election day,"* he said. Richard Allan, director of policy at Facebook, said many of the site's users were traditionally excluded from politics. "*One of the strengths we have is to try and capture that group, particularly the 18-24 year-old voters, who have often not turned out to vote, and use the fact that many of the things on Facebook are familiar to them to get them engaged."* See "Facebook and Electoral Commission Launch Voter Push," *BBC News*, 9 April, 2010, online: http://news.bbc.co.uk/go/pr/fr/-/1/hi/uk_politics/election_2010/8610298.stm. A subsequent Guardian report noted that 14,000 voter registration forms were downloaded directly through Facebook, and around 9,000 a day through the About My Vote site run by the Electoral Commission, the first time it had used the site. Guardian, 3.5.10

[87] The application, known as *blink*, provided lifestyle features and addressed issues that concerned teens, with the theme of healthier eating running throughout in a 'cool' and appealing way. By integrating with their Social Networks, the FSA felt that it could allow teens to choose information relevant to them, upload their own [moderated] content including articles, real life stories and Youtube videos. As the site is integrated with the Social Networking sites all activity conducted by teens is seen by their peers, making it very easy for them to pass on information, raise discussion around healthier eating with their friends and make healthy eating a status indicator. Through a 'Brand ambassador programme' the site is promoted by teenagers through online networks, but also out in the playground and other social activities. The aim is to embed all of the communication messages as long term behaviour changes for the target audience to adopt. Content includes online peer support networks for making behaviour change, competitions and quizzes, recipes and a one week challenge which links into the smallsteps4life website currently under development. The evaluation of the site will be based upon a two phase tracking study and qualitative evidence taken from the site and users of the site, at http://apps.facebook.com/blink-mag
Source: email to the author from Samantha Montel, Senior Scientific Officer, Food Standards Agency, London www.food.gov.uk; www.eatwell.gov.uk.

88 "*Mobile usage reaches 5bn milestone*", Financial Times, 3.7.10. Also, *"Smartphone Business*" in Financial Times, Lex Column, 18.9.10, based on research by iSuppli.

89 Omer Rashid, Paul Coulton & William Bird, *Using NFC to Support and Encourage Green Exercise* (2008), online: http://eprints.lancs.ac.uk/21202/1/getPDF6.pdf. The ITU estimates that mobile phone subscriptions will reach 5 billion by the end of 2010. See ITU Press Release, online: www.itu.int/newsroom/press_releases/2010/06.html.

90 Galit Zadok & Riikka Puustinen, *The Green Switch: Designing for Sustainability in Mobile Computing* (2010), online: www.thegreenswitch.org/wp-content/uploads/2009/12/TheGreenSwitch_publication_Jan2010.pdf.

91 DEFRA, *A Framework for Pro-environmental behaviours* (London: DEFRA, 2008) at 53, online: www.defra.gov.uk/evidence/social/behaviour/documents/behaviours-jan08-report.pdf.

92 *Ibid*.

93 Xana Villa Garcia, *A Carbon Audit and Ecological Footprint of OFCOM* (Oxford: Best Foot Forward, 2007), online: www.ofcom.org.uk/about/accoun/carbonaudit.pdf.

94 Greenpeace International, *Make IT Green: Cloud Computing and its Contribution to Climate Change* (Amsterdam: Greenpeace International, 2010), online: www.greenpeace.org/international/en/publications/reports/make-it-green-cloud-computing/.

95 OECD, "Climate Change Policies," *OECD Policy Brief*, August 2007, online: www.oecd.org/dataoecd/58/18/39111309.pdf [OECD, "Climate Change Policies"].

96 For a critical view of one such measure, carbon cap and trade, see Annie Leonard, "The Story of Cap and Trade", online: http://storyofstuff.com/capandtrade//?utm_source=Free+Range+Fans&utm_campaign=270115a499-Story_of_Cap_Trade12_4_2009&utm_medium=email.

97 "*Several policy instruments can help put a price on GHG emissions: carbon or energy taxes, the removal of environmentally harmful subsidies, tradable permit schemes and the project-based flexibility mechanisms of the Kyoto Protocol to the United Nations Framework Convention on Climate Change (UNFCCC).....a priority is to extend their use and to link them so as to provide a strong and consistent price signal across all GHG-emitting activities. Developing a global carbon price not only reduces the total costs of reducing GHG emissions, but also helps to level the playing field between countries, thus addressing concerns about the potential effects on competitiveness of climate change policies....(carbon) taxes can be a particularly cost-effective approach to reducing GHG emissions.*" OECD, "Climate Change Policies," OECD Policy Brief, August 2007, online: www.oecd.org/dataoecd/58/18/39111309.pdf [OECD, "Climate Change Policies"].

98 *Ibid.*

99 "*Although both a tax on emissions and a cap and trade system use the power of markets to achieve their desired results, a tax is generally the more efficient approach,*" according to the Director of the US Congressional Budget Office. See: "Approaches to Reducing Carbon Dioxide Emissions" ,CBO Testimony, Statement of Peter R Orszag before the Committee on the Budget, U.S. House of Representatives, 1 November 2007, online: www.cbo.gov/ftpdocs/87xx/doc8769/11-01-CO2Emissions.pdf
A carbon tax has the benefit of being clear, simple and quick to implement. It is cost-effective and easy to understand. It is also likely to be unpopular, if set at a price that actually changes behaviour to reduce GHGs. David MacKay's (a Chief Scientific Advisor to the UK Department of Energy and Climate Change) takes the view that the only sure way to reduce GHGs is with a meaningful price for carbon: "*The principal problem is that carbon pollution is not priced correctly. ...meaning that the price of emitting carbon dioxide should be big enough such that every running coal power station has carbon capture technology fitted to it. Solving climate change is a complex topic, but in a single crude brushstroke, here is the solution: the price of carbon dioxide must be such that people stop burning coal without capture....Experts say that a long-term guaranteed carbon price of something like $100 per ton of CO2 will do the trick.*"
See David MacKay (2009) *Sustainable Energy: Without the Hot Air*. www.withouthotair.com/.

100 As the Financial Times has noted, "*most politicians....have let themselves be intimidated by interests whose vocal but unrepresentative protests against any action on climate change drown out the reasonable majority of companies....If governments dared to embark on real efforts to limit emissions – be it through carbon taxes or cap-and-trade, as long as it has more than a token impact – the private sector would take it in its stride. It would even thrive, especially the low-carbon companies and sectors that would emerge to replace those unable to kick their carbon habit.*"
See "A Changing Corporate Climate," *Financial Times*, 19 February, 2010, online: www.ft.com/cms/s/0/430f1aa8-1d8d-11df-a893-00144feab49a.html

101 GeSI, *Smart 2020, supra* note 3.

102 This definition is taken from B. Lim & E. Spanger-Siegfried (eds), I.Burton, E. Malone, S. Huq, *Adaptation Policy Frameworks for Climate Change. Developing Strategies, Policies and Measures* (UNDP, 2005), as cited in Ellina Levina & Dennis Tirpak *Adaptation To Climate Change: Key Terms,* International Energy Agency/Organisation For Economic Co-Operation And Development, Environment Directorate, 2006, COM/ENV/EPOC/IEA/SLT(2006)1, online: www.oecd.org/dataoecd/36/53/36736773.pdf [Levina & Tirpak, 2006].

103 Three other definitions of adaptation are set out below. All are cited Levina & Tirpak, 2006, *ibid.*

(i) "Adaptation - Adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities. Various types of adaptation can be distinguished, including anticipatory and reactive adaptation, private and public adaptation, and autonomous and planned adaptation." From IPCC TAR (2001) *Climate Change 2001: Impacts, Adaptation and Vulnerability.* IPCC Third Assessment Report, Cambridge University Press.

(ii) "Adaptation - Practical steps to protect countries and communities from the likely disruption and damage that will result from effects of climate change. For example, flood walls should be built and in numerous cases it is probably advisable to move human settlements out of flood plains and other low-lying areas…" UNFCCC (1992) *United Nations Framework Convention on Climate Change*

(iii) "Adaptation - The process or outcome of a process that leads to a reduction in harm or risk of harm, or realisation of benefits associated with climate variability and climate change." UK Climate Impact Programme. UKCIP (2004) *Costing the impacts of climate change in the UK*. Oxford: UK

104 *World Development Report 2010, supra* note 66 at 19.

105 KPMG, *Climate Changes Your Business* (2008), online: www.kpmg.co.uk/news/docs/chart%20for%20climate%20change%20press%20release.pdf.

106 ITU "Radiocommunications and Climate Change: Mitigation" www.itu.int/ITU-R/index.asp?category=information&rlink=climate-change&lang=en

107 "Haiti – Telecoms, Mobile and Broadband," Budde.com (2010), online: www.budde.com.au/Research/Haiti-Telecoms-Mobile-and-Broadband.html

108 The IPCC defines radiative forcing as a measure of "the influence a factor has in altering the balance of incoming and outgoing energy in the Earth-atmosphere system and is an index of the importance of the factor as a potential climate change mechanism." For more on radiative forcing, see S. Solomon et al., eds. "Technical Summary 2.5: Net Global Radiative Forcing, Global Warming Potentials and Patterns of Forcing" in *Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, 2007* (Cambridge: Cambridge University Press, 2007), online: www.ipcc.ch/publications_and_data/ar4/wg1/en/tssts-2-5.html.

110 OECD, *Definition of the Rio Marker on Climate Change (Mitigation):* "Aid Targeting The Objectives Of The Framework Convention On Climate Change Mitigation" (undated), online: www.oecd.org/dataoecd/18/31/44188001.pdf.

110 ITU, *ICTs and Climate Change,* ITU-T Technology Watch Report #3, December 2007, online: www.itu.int/dms_pub/itu-t/oth/23/01/T23010000030002PDFE.pdf [ITU, ICTs and Climate Change].

111 OECD, "Greener and Smarter: ICTs, the environment and climate change", 2010, online: www.oecd.org/document/30/0,3343,en_2649_34223_42906974_1_1_1_1,00.htmlGartner and Press Release, "Gartner Estimates ICT Industry Accounts for 2 Percent of Global CO2 Emissions," 26 April 2007, online: www.gartner.com/it/page.jsp?id=503867.

112 Cited in "Rising energy prices add impetus to the greening of the mobile industry" *3G Wireless Broadband*, Vol. 10, Issue 15, 3 September, 2008.

113 According to the ITU Telecommunication/ICT Regulatory Database, the estimated number of Internet users by end 2010 is 2.1 billion, www.itu.int/icteye.

114 For more on this, see The Energy Saving Trust,*The Ampere Strikes Back* (London: The Energy Saving Trust, undated), online: www.energysavingtrust.org.uk/aboutest/news/ampere/.

115 Robert Webb & Antony Turner *What would a genuinely carbon neutral BT look like?* (London: Carbonsense and BT, 2006), online: http://carbonsense.com/documents/CarbonSense_whatwouldagenuinelycneutralBTlooklike_000.pdf.

116 A similar concern applies at a global level to dematerialisation, where carbon-intensive production processes are shifted from developed to developing world locations, reducing the carbon footprint of the developed country at the expense of the developing. See, for example, New Economics Foundation & Open University, *China dependence: the second UK Interdependence re-*

port, (London: New Economics Foundation & Open University, 2007) online: www.neweconomics.org/press-releases/%E2%80%98china-dependence-going-life-uk-world-whole-goes-ecological-debt

117 See: www.itu.int/ITU-T/studygroups/com05/sg5-q18.html.

118 *The Greenhouse Gas Protocol*, Rev. Ed., World Resources Institute (March 2004), online: http://pdf.wri.org/ghg_protocol_2004.pdf [Greenhouse Gas Protocol].

119 Scope 2 GHG emissions of this kind were those avoided by BT when it became the UK's largest buyer of "green" electricity in 2004. See "BT Goes Green," *Guardian* (14 November, 2004), online: www.guardian.co.uk/business/2004/oct/14/ethicalbusiness.utilities

120 *Greenhouse Gas Protocol, supra* note 119.

121 GeSI, *Smart 2020, supra* note 3.

122 See Eftec and Plexteck, *Final Report, supra* note 19 and Eftec and Plexteck, *Appendices, supra* note 19. TSPs also run some very large vehicle fleets. For example, Deutsche Telekom runs 41,000 vehicles in Germany and BT runs 32,000 vehicles in the UK. Hence, there is major scope for TSPs to reduce truck rolls and vehicle deployment and mileage, particularly as NGNs reduce the number of local exchanges.

123 According to the Stern Review, for example, the ICT sector is less energy-intensive than many other industries. The figures for the UK are that, for telecommunications, 0.82% of total costs stem from energy, while the sector produces 2.29% of total UK economic output; for electricity production & distribution, 16.07% of total costs are energy and the sector produces 1.08% of UK economic output. At the other end of the spectrum is the banking and finance sector, where 0.27% of total costs are energy, while the sector produced 4.05% of UK output (or it did when the figures were compiled, pre-Credit Crunch!) Source: Nicholas Stern, *Stern Review: The Economics of Climate Change: Executive Summary* (2006), online: www.hm-treasury.gov.uk/d/Executive_Summary.pdf.

124 ITU-T's NGN Global Standards Initiative.

125 ITU-T, *NGNs and Energy Efficiency,* Technology Watch Report #7, August 2008, online: www.itu.int/oth/T2301000007/en. See also www.thegreengrid.org/, as cited in Background Report for ITU Symposium on ICTs and Climate Change, hosted by CITIC, Quito, Ecuador, 8-10 July 2009, online: www.itu.int/dms_pub/itu-t/oth/06/0F/T060F00600C0004PDFE.pdf; and ITU, ICTs and Climate Change, supra note 112 at 6, Box 2, online: www.itu.int/dms_pub/itu-t/oth/23/01/T23010000030002PDFE.pdf.

126 Taken from Rodney S. Tucker *et al., Energy Consumption in IP Networks,* presentation at Network Solutions to Reduce the Energy Footprint of ICT, ECOC, Brussels, 21-25 September, 2008, online: www.ecoc2008.org/documents/ECOCSymposiumPresentationRTucker.pdf.
For other presentations from this conference, see: Network Solutions to Reduce the Energy Footprint of ICT, ECOC, Brussels, 21-25 September, 2008, online: www.ecoc2008.org/programme.asp#greenict. See also Symposium on Sustainability of the Internet and ICT, University of Melbourne, 25-26 November, 2008, online: www.ee.unimelb.edu.au/green_internet/.

127 For example, there are millions of mobile base stations deployed worldwide, consuming large amounts of energy. It had been widely believed that base stations needed to be maintained at 25 degrees Celsius to function, but in fact many will function up to 40 degrees, producing major energy savings. More savings can come through software-driven efficiencies such that, even without further technological breakthroughs, the use of more modern equipment from vendors can result in a 70% reduction in energy consumption. See Larilahti, *supra* note 18.

128 For more on this, see the Mobile Broadband Blog, online: http://mobilebroadbandblog.co.uk/2009/04/what-is-lte/ and Ericsson Press Release on LTE agreement for voice and SMS services (4 November, 2009), online: www.ericsson.com/ericsson/news/archive/2009/091104_one_voice.shtml.

129 www.wimaxmaps.org/

130 Some observers consider that an unoptimized WiMax network needs more power than LTE networks. LTE's access technology SC-FDMA (uplink) appears less to consume less power than WiMAX's OFDMA, as SC-FDE and LP-OFDMA/SC-FDMA signals have lower peak-to-average power ratio (PAPR), because of its inherent single carrier structure. LP-OFDMA/SC-FDMA has drawn attention as an attractive alternative to OFDMA, especially in the uplink communications where lower PAPR greatly benefits the mobile terminal in terms of transmit power efficiency. For more information, see Slide 15 of www.slideshare.net/marioeguiluz/analysis-wimax-vs-lte. See also: www.circleid.com/posts/20090310_wimax_vs_lte/; www.fujitsu.com/downloads/MAG/vol45-4/paper05.pdf; www.rfdesignline.com/212001568;jsessionid=VT4ABR3WFP05HQE1GHPCKHWATMY32JVN?pgno=1;

www.wimaxforum.org/sites/wimaxforum.org/files/document_library/wimax_hspa+and_lte_111809_final.pdf; www.gsmworld.com/documents/26022007161857.pdf; and www.circleid.com/posts/20090310_wimax_vs_lte/.

131 Susan Schorr, *What Do We Mean By 6 Degrees Of Sharing?,* Discussion Paper prepared for the 8th Global Symposium for Regulators, Pattaya, Thailand, 11-13 March, 2008 (Geneva: ITU, 2008), online: www.itu.int/ITU-D/treg/Events/Seminars/GSR/GSR08/discussion_papers/Overview_Final_web.pdf.

132 "Telecoms JV aims to make systems greener," *Financial Times*, 11 January, 2010, online: www.ft.com/cms/s/0/a6201454-fed3-11de-a677-00144feab49a.html.

133 www.ictregulationtoolkit.org/en/index.html

134 Directive 2002/21/EC of the European Parliament and of the Council of 7 March 2002 on a common regulatory framework for electronic communications networks and services (Framework Directive).

135 Nationwide Programmatic Agreement for the Collocation of Wireless Antennas, at: www.achp.gov/docs/PA_FCC_Nationwide.pdf

136 ITU-infoDev ICT Regulation Toolkit, Module 2, Section 7. www.ictregulationtoolkit.org/en/index.html

137 See e.g. the comment at Lessradiation.co.uk regarding the New Scientist article "Search's Dirty Secret" published 3 April, 2010, online: www.lessradiation.co.uk/2010/04/. Google states that its own data centres use about half the energy of a typical data centre and that the energy used per Google search is about 1kJ (0.0003 kWh) of energy to answer the average query, equivalent to 0.2g of CO2 (0.007 ounces). As Google points out, "*Not only is energy use very small, web searches often take the place of more carbon- and time-intensive activities, such as driving a car to a library or spending hours navigating shopping malls*." Google goes on to equate the CO2 emissions of an average daily newspaper on 100% recycled paper to 850 of their searches. See: www.google.com/corporate/green/datacenters/.

138 ITU, *Trends in Telecommunication Reform 2009* (ITU: Geneva, 2010) at 11.

139 See, for example: L. Brand *et al., Data Centres And Telecoms Hotels: After The Space Race* (London: Ovum, 2002) and S. Young *et al., Telecoms Hotels, Co-location And Data Centres* (London: Ovum, 2000).

140 Jonathon G. Koomey, *Estimating Total Power Consumption By Servers In The US And The World,* Final Report (Stanford: Lawrence Berkeley National Laboratory and Stanford University, 2007), online: http://enterprise.amd.com/Downloads/svrpwrusecompletefinal.pdf.

141 Source: www.alphagalileo.org/ViewItem.aspx?ItemId=86177&CultureCode=en

142 William Forrest, James M Kaplan & Noah Kindler "Data Centers: How to cut carbon emissions and costs" in McKinsey on Business Technology, Winter 2008, online: www.mckinsey.com/clientservice/bto/pointofview/pdf/BT_Data_Center.pdf.

143 David MacKay (2009) *Sustainable Energy: Without the Hot Air.* pp68-69 www.withouthotair.com/.

144 Tim Jackson, *Prosperity Without Growth? The Transition to a Sustainable Economy,* (London: Sustainable Development Commission, 2009), online: www.sd-commission.org.uk/publications/downloads/prosperity_without_growth_report.pdf

145 Information from ITU Telecommunication Standardization Sector, Focus Group on Cloud Computing, study period 2009-2012, Geneva, June 2010.

146 See Greenpeace International, *Make IT Green: Cloud Computing and its Contribution to Climate Change* (Amsterdam: Greenpeace International, 2010), online: www.greenpeace.org/international/en/publications/reports/make-it-green-cloud-computing/.
See also related commentary by Vuk Trifkovic: *Greenpeace sparks debate on the environmental impact of cloud computing* (London: Ovum, 2010), online: http://about.datamonitor.com/media/archives/4055.

147 For ITU information on the Internet of things, see: http://web.itu.int/dms_pay/itu-s/opb/pol/S-POL-IR.IT-2005-PDF-E.pdf

148 For ITU resources on the fully networked car, see: www.itu.int/ITU-T/worksem/ict-auto/200803/index.html

149 BP's experience following the May 2010 blow-out at its well under the Deepwater Horizon rig in the Gulf of Mexico illustrates a worst case example of the reputational damage that can be caused by environmental mismanagement.

150 Nokia Siemens Networks, White Paper: *Good Green Business Sense* (2008), online: http://w3.nokiasiemensnetworks.com/NR/rdonlyres/13368E3E-58C4-4BF7-882F-4FE0F5D4C24F/0/Sustainability.pdf

151 CAPEX refers to capital expenditure, incurred when a business spends money to acquire or upgrade fixed assets such as equipment, property or industrial buildings. OPEX refers to operating expenses, notably the ongoing costs for running a product, business, or system.

152 The Carbon Disclosure Project is an independent not-for-profit organization holding the largest database of primary corporate climate change information in the world, based on information from thousands of organizations across the world. These entities measure and disclose their greenhouse gas emissions and climate change strategies through CDP. See: www.cdproject.net/en-US/Pages/HomePage.aspx

153 Climate Savers Computing (CSCI), a nonprofit group of eco-conscious businesses, conservation organizations and consumers dedicated to reducing the energy consumption of computers and reducing the environmental impact of new and emerging technologies. It was started in 2007 by Google and Intel, and aims to help members *"increase deployment of high-efficiency computer systems and power management technologies that save money, reduce energy consumption and decrease GHGs. CSCI membership numbers more than 500 organizations including Dell, Google, HP, Intel, Microsoft and World Wildlife Fund."* CSCI members commit to choosing systems that meet or exceed the latest ENERGY STAR specification for a majority of their PC and volume server computer purchases and to using power-management tools on PCs. CSCI has developed the bronze, sliver, gold and platinum compliance levels to help identify the highest energy-efficient products and systems.
See: www.climatesaverscomputing.org/about/faq/#4

154 For example, the most recent allocation of spectrum in Canada also came with a requirement to share infrastructure as a term of the licence.

155 Such activities are already taking place at the international level with work such as the ITU's Telecommunication Standardization Sector (see earlier refernce to NGNs, the work of ITU-T Study Group 5 .) and Radiocommunication Sector (standards on green wireless systems/applications, including work on international spectrum/satellite orbit regulations, regional agreements).

156 Per-Anders Enkvist, Tomas Nauchler & Jeremy M Oppenheim, "Business Strategies for Climate Change" in The McKinsey Quarterly, 2008 No. 2, *Confronting Climate Change*.

157 See Nicholas Negroponte, *Being Digital* (1995). London: Vintage Books

158 Pamlin & Szomolányi, *supra* note 3.

159 Thomas L Friedman, *The World is Flat* (London: Penguin, 2007) at 207, 210.

160 Bill Sharpe & Tony Hodgson, *Intelligent Infrastructure Futures Technology Forward Look: Towards a Cyber-Urban Ecology* (London: Department of Trade and Industry, 2006), online:
www.foresight.gov.uk/Intelligent%20Infrastructure%20Systems/Technology_Forward_Look.pdf.

161 See Centre for Alternative Technology, *zerocarbonbritain: A New Energy Strategy* (Machynlleth: Centre for Alternative Technology, 2007) at 70, online: www.zerocarbonbritain.com/

162 Jackson, *supra* note 144 at 8 www.sd-commission.org.uk/publications/downloads/prosperity_without_growth_report.pdf.

163 Extracted from Centre for Alternative Technology, *supra* note 160 at 71.

164 A 2007 report produced by the Sussex Energy Group reviewed over 500 papers and reports to analyse the nature, operation and importance of rebound effects. Examples of rebound effects include: a driver who replaces a car with a fuel-efficient model, only to take advantage of its cheaper running costs to drive further and more often; a family that insulates their loft and puts the money saved on their heating bill towards an overseas holiday; or a phone call which may replace the need to deliver a message personally but could equally be used to set up a meeting which requires travel. In addition, ICTs can make it easier to travel (e.g., users are able to find out bus schedules more easily, or to better coordinate meetings and other travel related events). Rebound effects can be both direct (e.g. driving further in a fuel-efficient car) and indirect (e.g. spending the money saved on heating on an overseas holiday). Evidence from the report is that direct rebound effects are usually fairly small – eg less than 30% for households. Much less is known about indirect effects, although the study suggests that in some cases, particularly where energy efficiency significantly decreases the cost of production of energy intensive goods, rebounds may be larger.
See Steve Sorrell, The Rebound Effect Report: An Assessment of the evidence for economy-wide energy savings from improved energy efficiency (Brighton: Sussex Energy Group, 2007), online:
www.ukerc.ac.uk/Downloads/PDF/07/0710ReboundEffect/0710ReboundEffectReport.pdf
See also: Runar Brannlund, Tarek Ghalwash & Jonas Nordstrom, "Increased energy efficiency and the rebound effect: Effects on consumption and emissions" (2007) 29:1 Energy Economics, online: www.sciencedirect.com.

165 "*Standards can be defined as technical specifications that may be adhered to by a producer, either tacitly or as a result of a formal agreement. Standards may be developed by national standards bodies, regional bodies such as ETSI and global partnerships such as 3GPP (which includes ETSI as a member). Standards bodies are not the only source of standards, with market processes creating de facto standards and proprietary standards.....Standards play a key role in the diffusion and use of ICT, for example standards underpin the Internet (and increasingly, Internet applications), wireless systems including WiFi and 3G and next gener-*

ation fixed core and access technologies including GPON." Brian Williamson & Philippa Marks *Standardisation in ICT: Current Economic Perspective* (Plum Consulting, London, 2009)

166 ITU, *Trends in Telecommunication Reform* 2008 (Geneva: ITU, 2008). For more information, see www.itu.int/ITU-T/focusgroups/climate/index.html. See also Dr. Yuji Inoue, "Climate Change and ICT Standardization," presentation to ITU Kyoto Symposium on ICT & Climate Change, 15 - 16 April, 2008, online: www.itu.int/dms_pub/itu-t/oth/06/0F/T060F0060080025PDFE.pdf.

167 Pamlin & Szomolányi, *supra* note 3.

168 ITU, "Forward" in *Trends in Telecommunication Reform 2009* (ITU: Geneva, 2010).

169 Jacques Bughin, Michael Chui, and James Manyika (2010) *Clouds, big data, and smart assets: Ten tech-enabled business trends to watch*. McKinsey Quarterly, August 2010. McKinsey Global Institute.

170 Department of Energy and Climate Change, *Smarter Grids: The Opportunity,* DECC Discussion Paper (London: Department of Energy and Climate Change, 2009), online: www.decc.gov.uk/en/content/cms/what_we_do/uk_supply/network/smart_grid/smart_grid.aspx.

171 Eric Lightner, "Smart Grid Activities at the Department of Energy," presentation at National Broadband Plan Workshop: Energy, Environment, and Transportation Director, Smart Grid Task Force, US Dept of Energy, Office of Electricity Delivery and Energy Reliability, 25 August, 2009, online: www.broadband.gov/ws_eng_env_trans.html.

172 There is no single definition of smart metering, and smart meters may or not require a telecommunications link, since other modes of communication can be used. A smart-meter system comprises an electronic box *and* a communications link. At its most basic, a smart meter *measures electronically how much energy is used, and can communicate this information to another device.* For both electricity and gas, there are two main smart-meter types : AMR – One-Way Communication from the Meter to the Data Collector – as a minimum enabling Automated Meter Reading; AMM - Two-Way Communication between the Meter and the Supplier - enabling a wider range of functions known as Automated Meter Management. See: Gill Owen & Judith Ward, *Smart Meters: Commercial, Policy and Regulatory Drivers* (London: Sustainability First, 2006), online: www.sustainabilityfirst.org.uk/docs/2006/smart%20meters%20pdf%20version.pdf.

173 *Ibid.*

174 The following smart metering trials were reviewed in the 2008 study by Sustainability First: Ontario Energy Board Smart Price Pilot; Country Energy Smart Metering Trial, New South Wales, Australia; Energy Australia Strategic Pricing Study; California Statewide Pricing Pilot; Norway Trial; Tempo Tariff, EdF France; California Information Display Pilot. See: Sustainability First/Engage Consulting, *International Smart Meter Trials - Selected Case Studies* (2008), online: www.sustainabilityfirst.org.uk/docs/2008/Sustainability%20First%20&%20Engage%20Consulting%20-%20International%20Trials%20-%20Tariffs%20and%20Consumer%20Stimuli%20-%20Selected%20Case%20Studies%20-%20May%202008.pdf.

175 According to a study by Sustainability First published in 2006, "*The major long term evidence to date on energy-saving is from a Norwegian study based on 'informative-billing' in homes with electric heating – not smart metering – where savings of 4-8% were achieved. A major UK study suggests 3-5% is possible for homes without electric heating. Short-term results with smart prepayment meters in Northern Ireland have shown a 3% energy saving. It therefore seems reasonable to estimate energy savings, on a cautious basis, at around 1-3%. A 3% saving would be £10.50 off an average electricity bill. A 1% saving would equal 8% of the UK's domestic CO2 target.*" Gill Owen and Judith Ward. *Smart meters: commercial, regulatory and policy drivers* (2006) www.sustainabilityfirst.org.uk/publications/smartmeters.htm

176 Deutsche Bank, *Climate Change and Sectors: Some Like It Hot!* (2007), online: www.dbresearch.com/PROD/CIB_INTERNET_EN-PROD/PROD0000000000212401.pdf

177 European Commission Directorate-General Information Society and Media, ICT for Sustainable Growth Unit, *ICT for a Low Carbon Economy: Smart Buildings,* Findings by the High-Level Advisory Group and the REEB Consortium On the Building and Construction Sector (2009), online: http://ec.europa.eu/information_society/activities/sustainable_growth/docs/sb_publications/smartbuildings-ld.pdf.

178 Stern, *supra* note 28.

179 IPCC, "Mitigation in the short and medium term," *supra* note 71.

180 Sustainable Development Commission, *Smarter Moves: How Information Communications Technology Can Promote Sustainable Mobility* (London: Sustainable Development Commission, 2010), online: www.sd-commission.org.uk/publications/downloads/SDC_Smarter_Moves_w.pdf. See also *Moving Waves*, the blog by one of

the paper's authors, Jeremy Green, about how ICT can help to make personal transport more sustainable, http://smartermobility.blogspot.com

181 Confederation for British Industry, *Tackling Congestion, Driving Growth - A New Approach To Roads Policy* (2010), online: www.cbi.org.uk/ndbs/press.nsf/0363c1f07c6ca12a8025671c00381cc7/ac77d2168797ed7f802576e3004dc9d3/$FILE/Tackling%20congestion,%20driving%20growth%20-%20A%20new%20approach%20to%20roads%20policy.pdf.

182 For an example of lift sharing using social media technologies (in this case, Facebook), see the service run by Craig Slater at: www.isanyonegoingto?.com.

183 Dennis Pamlin & Katalin Szomolányi, Saving the climate @ the speed of light: First roadmap for reduced CO2 emissions in the EU and beyond (Brussels: WWF/ETNO, undated), online: www.etno.be/Portals/34/ETNO%20Documents/Sustainability/Climate%20Change%20Road%20Map.pdf.

184 For more information on car sharing/car clubs see www.carsharing.net/. Examples at: www.citycarclub.co.uk/; www.streetcar.co.uk/; and www.ucarshare.com/secure/Home.aspx ;

185 GeSI (2008) *Smart 2020, supra* note 3 at 3/33.

186 Nicholas Negroponte, *Being Digital,* 1995. London: Vintage Books.

187 Reducing the amount of carbon-rich 'product' made and distributed around the world in planes, trains, and automobiles has been described as one benefit of Spotify.

188 Walter S. Baer, Scott Hassell, & Ben A. Vollaard, *Electricity Requirements for a Digital Society,* RAND Corporation (2002), online: www.rand.org/pubs/monograph_reports/MR1617/.

189 Joseph Romm, *The Internet and the New Energy Economy,* Center for Energy and Climate Solutions, Global Environment and Technology Foundation (2010), online: www.rand.org/scitech/stpi/Evision/Supplement/romm.pdf.