ITU/MIC Japan Symposium on ICTs and Climate Change

Kyoto, 15-16 April 2008

ICTs and Climate Change: ITU background report

1 CONTEXT

In October 2007, the Nobel Peace Prize was awarded jointly to former US vice-president Al Gore and to the United Nations Intergovernmental Panel on Climate Change (IPCC) with a citation "*for their efforts to build up and disseminate greater knowledge about man-made climate change, and to lay the foundations for the measures that are needed to counteract such change*".

The award recognizes that climate change represents a threat to mankind on a similar level to violent conflict and war, and indeed can lead to a breakdown of peace because of the increased competition for the earth's resources. Information and Communication Technologies (ICTs) are undoubtedly part of the cause of global warming as witnessed, for instance, by the millions of computer screens that are left switched on overnight in offices around the world. But ICTs can also be part of a solution, because of the role they play in monitoring, mitigating and adapting to it.

The framework for ITU's concern with the role of telecommunications and information technologies in the protection of the environment was provided initially at the Plenipotentiary Conference, 1994 (Resolution 35[1], Kyoto) and at the World Telecommunication Development Conferences, in 1998 (Resolution 8[2], Valletta), in 2002 (Recommendation 7[3], Istanbul) and in 2006 (Resolution 54[4], Doha). In 2007, ITU and its membership and partners launched a major programme to investigate the specific relationship between ICTs and climate change. At the meeting of the Telecommunication Standardization Advisory Group (TSAG) in December 2007, a Technology Watch Briefing Report on this topic was reviewed[5]. TSAG provided advice to the Director of the Telecommunication Standardization Bureau (TSB) on a number of actions, including the holding of two symposia during the first half of 2008[6]. They will take place in Kyoto, Japan, 15-16 April 2008, co-organized and hosted by the Ministry of International Affairs and Communications (MIC) and in London, UK, 17-18 June 2008, supported and hosted by BT plc.

This report has been prepared by the ITU secretariat as a background paper for the two symposia, drawing upon the *Technology Watch Briefing Report* as well as material from the ITU Telecommunication Development and Radiocommunications Sectors. It looks at the potential role that ICTs play at different stages, from contributing to global warming (section 2), to monitoring it (3), to developing long-term solutions to mitigate its effects, both directly in the ICT sector (4) and in other sectors like energy, transport, buildings etc (5), and finally to helping to adapt to its effects (section 6). This corresponds to the main sessions in the agenda of the two symposia. In addition, an annex to this report looks in more detail at the work currently being carried out in ITU and the campaign for a climate-neutral UN.

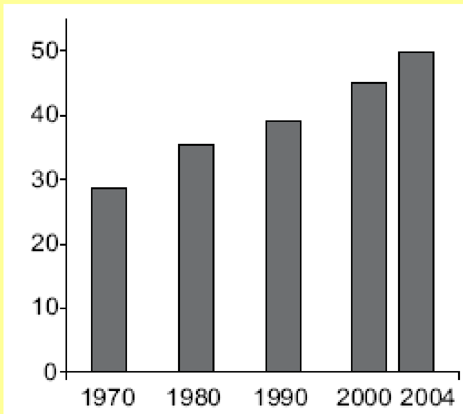


Figure 1: Total Greenhouse Gases (in Gigatonnes of Carbon Dioxide equivalents – $GtCO_2$-eq)
Source: IPCC (WG 3 contribution to 4th assessment report)

2 CLIMATE CHANGE AND THE IMPACT OF ICTS

There are a number of different causes of climate change, many of which are naturally generated (e.g., variations in solar radiation, volcanic activity etc). However, it is man-made climate change that is of major concern because it appears to be leading to a progressive and accelerating warming of the planet, as a result of the release of greenhouse gases (GHG), primarily carbon-based emissions, including carbon dioxide and methane. As shown in Figure 1, taken from the work of the UN Intergovernmental Panel on Climate Change (IPCC), global greenhouse gas emissions have risen by 70 per cent since 1970[7]. As a consequence, global average temperatures have risen by around half a degree centigrade (from 14° to 14.5°C) since 1950, and there has been a rise in sea level of around 10 cm and a reduction of Northern hemisphere snow cover of around 2 million km^2 over the same period (see Figure 2)[8]. Since measurements began, eleven of the warmest annual average temperatures recorded have been in the last twelve years.[9]

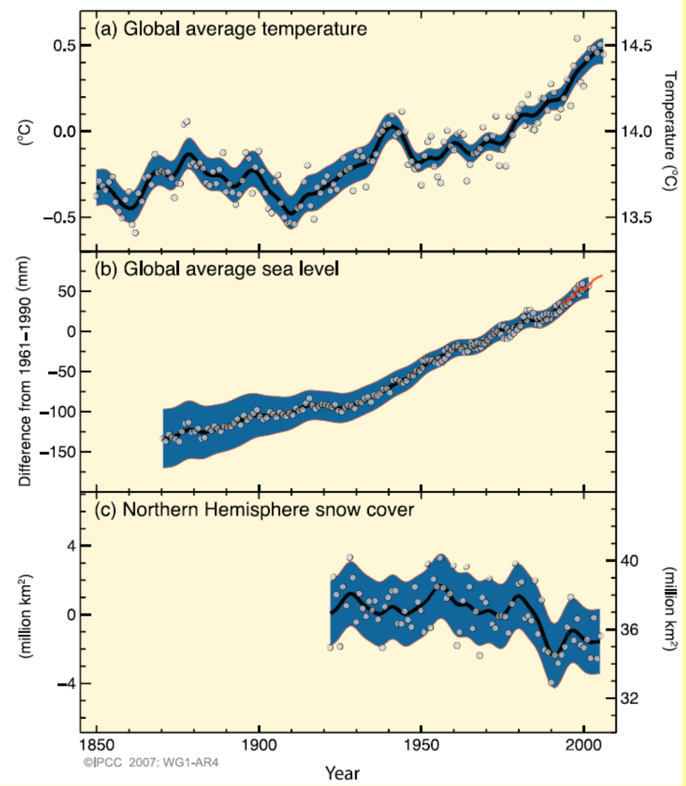


Figure 2: Long-term changes related to the climate
Source: IPCC, WG1 contribution to 4th assessment report.

The primary sources of GHG are energy production and consumption, transport, buildings, land-use change, agricultural byproducts, waste management etc. Other industries, including the ICT Sector, generate around 4 per cent of total GHG, but this is much higher—around 14 per cent—if indirect energy use is included. The ICT Sector itself (excluding the broadcasting sector) contributes between 2-2.5 per cent of GHG[10], at just under 1 Gigatonne of carbon dioxide (CO_2) equivalent. The main constituent (40 per cent) of this is the energy requirements of PCs and data monitors, with data centres contributing a further 23 per cent (Figure 3). 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, it is likely that this share will increase over time[11]. However, ICT's share of global GHG emissions (2.5 per cent) is much smaller than its share of Gross Domestic Product (which is around 8 per cent of US GDP, for instance). The main output of the ICT Sector is information rather than physical goods ("bits", not "atoms"), a concept sometimes referred to as "dematerialization". Thus, ICTs can contribute greatly to finding a solution to reducing the remaining 97.5 per cent of global emissions from other sectors of the economy.

Nevertheless, ICTs are a significant cause of global warming. This comes from a number of sources:

- The major contribution of ICTs to climate change comes from 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. 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.

- In addition to the proliferation of users, each individual user may now own many more devices. For instance, in the field of consumer electronics, whereas twenty years ago a single television might have provided entertainment for a household, now a typical family in a developed country might own multiple radio receivers, television sets, 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 are routinely left on standby overnight or during absences for work, vacation etc.

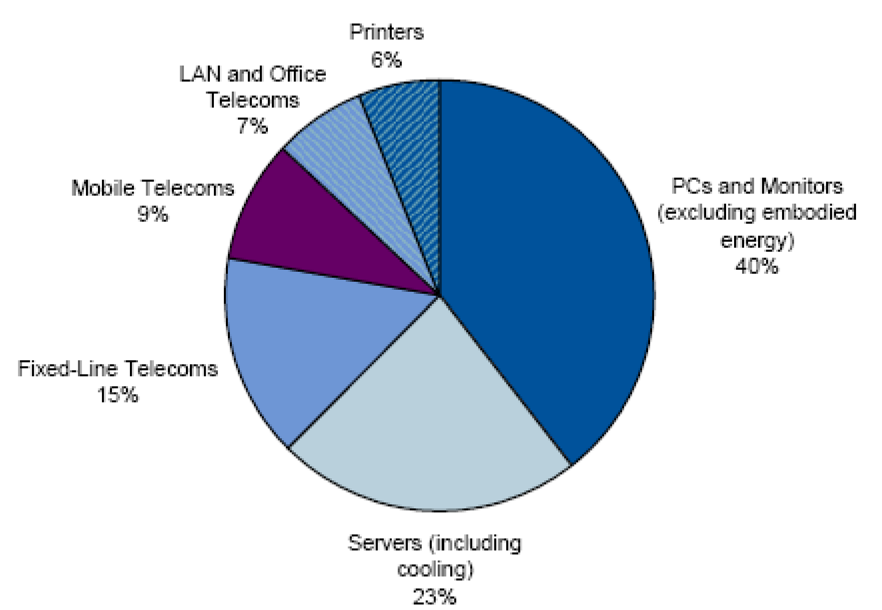


Figure 3: Estimated distribution of global CO_2 emissions from ICTs

Note: This analysis does not include radio-broadcasting equipment or TV sets. It is based on a global estimate of 0.9 Gigatonnes of CO_2 equivalent.

Source: Kumar, Rakesh and Mieritz, Lars (2007) "Conceptualizing "Green IT" and data centre power and cooling issues", Gartner Research Paper No. G00150322.

- As these ICT devices acquire more processing power, their requirements for power and for cooling, also rise. For instance third generation (3G) mobile phones operate at higher frequencies and need more power than 2G ones (for instance, for Internet access, digital signal processing, polyphonic ringtones etc). Therefore more power is required to keep them charged.

- An increasing percentage of ICT usage might be regarded as "unnecessary", in the sense that it is spam email, SMS and voice calls, or the storage rather than deletion of old material.

ICT use will only grow over time, and it is important therefore that the industry takes steps now to curtail and ultimately reduce its carbon emissions.

3 ICT USE IN MONITORING CLIMATE CHANGE

The science of climate change, which has developed over the last century or so[12], has benefited greatly from the parallel development of ICTs. ITU work in this area focuses on the use of ICTs (including radio and telecommunication technologies, standards and equipment) for weather and climate change monitoring, for instance in predicting, detecting and mitigating the effects of typhoons, thunderstorms, earthquakes, tsunamis (see Figure 4), man-made disasters, etc. The role of ICTs in weather and climate monitoring is clearly shown in the structure of the World Meteorological Organization's (WMO) World Weather Watch (WWW).

The WWW is composed of three integrated core system components:

- The Global Observing System (GOS) 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 (see Figure 5). The GOS mainly acts as 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.

Box 1: XV World Meteorological Congress, May 2007, of the World Meteorological Organization (WMO), in Resolution 3:

- Re-affirmed the crucial importance of radiofrequency (RF) bands for meteorological and related environmental operations and research, and for disaster risk reduction;
- Stressed that some RF bands are a unique natural resource for passive sensing that deserve absolute protection;
- Urged all Members to do their utmost at national, regional and international levels to ensure the availability and protection of suitable RF bands;
- Appealed to ITU and its Administrations to ensure the absolute protection of the passive sensing RF bands, and to give due consideration to the WMO requirements for RF allocations and regulatory provisions;
- …

- The Global Telecommunication System (GTS) 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, processes an enormous volume of meteorological observational data and generates meteorological products such as analysis, warnings and forecasts.

All three layers of the WWW are based on the use of different ICT components and applications.

All ITU Sectors are very active in developing ITU standards and other publications devoted to the use of telecommunications and radio technologies for climate, weather monitoring and forecasts, as well as Earth observation activities, and organizing different forums (symposia, seminars, workshops, etc.) relevant to climate and weather monitoring systems and equipment. However, taking into account the importance of the radio frequency spectrum (see Box 1) the Radiocommunication Sector contribution is especially valuable for the development and functioning of the Global Observing System (see Figure 5). ITU-R Study Group 7 ("Science services") has developed the RS ("Remote Sensing") Series of ITU-R Recommendations and Reports for the implementation of radiocommunication systems for monitoring climate change.

The work of the ITU Radiocommunication Sector (ITU-R) in this area focuses on the use of ICT (different radio technologies and equipment including 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. The studies carried out by the ITU-R Study Groups, the Radiocommunication Assembly and the World Radiocommunication Conference (whose decisions have international treaty status) provide necessary support for the development and utilization of different ICT systems such as:

- 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, without which the current and planned accuracy of weather predictions would be seriously compromised; and
- broadcast sound and television systems and different mobile radiocommunication systems that warn the public of dangerous weather events, and aircraft pilots of storms and turbulence;
- satellite systems that are also used for dissemination of information concerning different

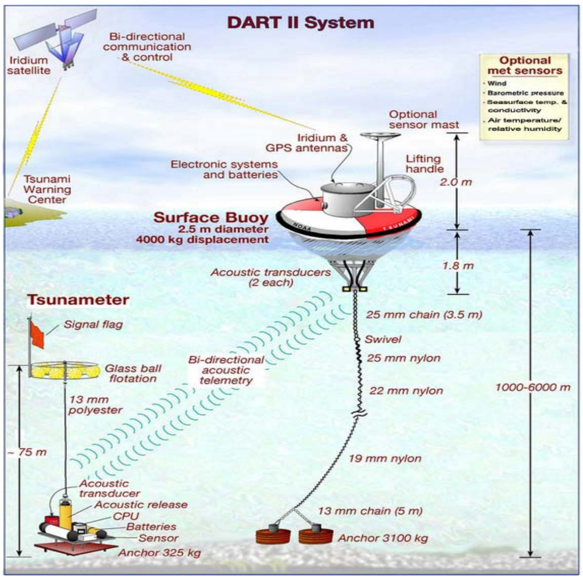


Figure 4: Deep-ocean assessment and report of tsunami (DART) system
Source: US National Oceanic and Atmospheric Administration (NOAA).

natural and man-made disasters.

All these systems are part of the Global Observing System (GOS), see Figure 5, employed by the majority of countries. These systems save thousands of lives every year and the World Meteorological Organization (WMO) and ITU, together with other UN Agencies, Administrations and different organizations around the World contribute to further development of such systems.

Recognizing that the radio frequency spectrum is a critical resource for remote sensing employed in the GOS (see Resolution 673 "Radiocommunications use for Earth observation applications"[13]) the World Radiocommunication Conference[14] 2007 (WRC-07, Geneva):

- considered (with positive results) four main issues directly related to remote sensing (including extension of bands for some active sensors);
- approved five new Resolutions concerning new studies relevant to remote sensing;
- included four items in the draft agenda of WRC-11 on the use and further development of remote sensing systems.

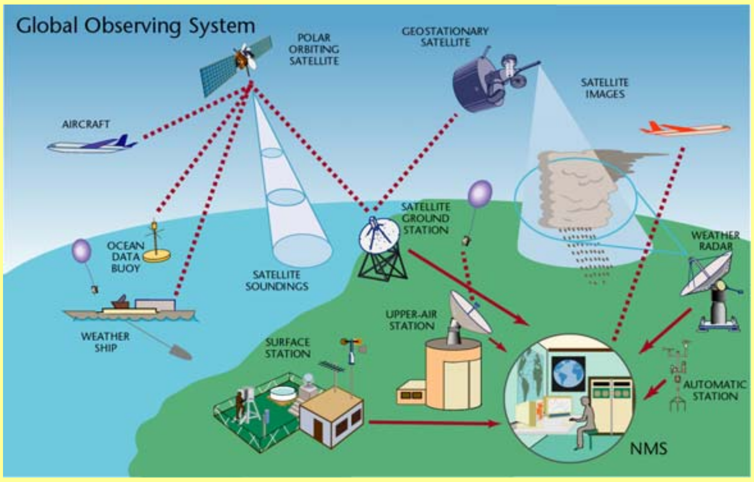


Figure 5: WMO Global Observing System
Source: WMO and ITU Handbook "Use of Radio Spectrum for Meteorology
Note: NMS = National Meteorological Service.

In addition to monitoring the effects of climate change, ICTs have also proved invaluable in computer modeling of the Earth's atmosphere, beginning with the work of computer pioneer von Neumann in the late 1940s. Meteorological services are among the most demanding users of the world's fastest supercomputers, and produce progressively more sophisticated general circulation models of climate. For instance, the Hadley Centre for Climate Change in the United Kingdom runs a variety of climate models on a suite of NEC SX-6 supercomputers which have processing power equivalent to 1'000 times that of a top-of-the-range desktop PC. The numerical climate models are linked via Bracknell, one of 15 regional and three global telecommunication hubs of the GOS[15] (see Figure 5). In addition, by using the unused processing cycles of thousands of linked computers[16], it is possible for scientists, and even amateurs, to conduct climate modeling experiments. Sophisticated computer systems also help run the system of tradable permits for carbon emissions which are one of the main implementation tools of the Kyoto Protocol.

Figure 6: Retreat of the Trift Glacier, Switzerland
Source: Swiss Academy of Sciences.
Note: The glacier retreated by around 200m between 2004 and 2005.

The typical locations for climate research—such as the polar ice caps, glaciers, volcanoes, the ocean bed or the upper layers of the atmosphere—are inhospitable, and remote monitoring and data collection using ICT-equipped sensors (telemetry) is essential for research. Even more useful has been the development of aerial photography, satellite imagery, grid technology and in particular the use of global positioning by satellite (GPS) for tracking slow, long-term movement, for instance of glaciers or ice floes (see Figure 6). The World Glacier Monitoring Service uses an integrative multi-level approach to document glacier changes that links satellite remote sensing and GPS data with aerial photography, in-situ measurements and computer modeling of glacial mass balance, with research spread over many decades.

The technology of Ubiquitous Sensor Networks (USN) is also proving useful in the field of environmental monitoring[17]. USNs combine a network of sensors with computer processing power for data collection and analysis. Standardization work for USNs is currently being undertaken by a number of bodies, including ITU-T. Applications of USNs for environmental monitoring include SEAMONSTER[18] (the South East Alaska Monitoring Network for Science, Telecommunications, Education and Research), a NASA-sponsored smart sensor web project with near real-time recovery of environmental data, initially focusing on the Lemon Creek watershed in Juneau, Alaska.

4 MITIGATING THE IMPACT OF ICTS ON CLIMATE CHANGE

The key to combatting global warming is to stabilize and eventually reduce the emission of GHG. International success has been achieved with a reduction in ozone depleting substances (such as chlorofluorocarbon (CFC) gases) to 20 per cent of their 1990 levels by 2004, thanks to the 1987 Montreal Protocol. However, emissions of carbon dioxide have grown by around 80 per cent since 1970 and, despite the 1997 Kyoto Protocol, which set aggregate targets for a limitation/reduction by 5 per cent of 1990 levels by 2008-2012 for the so-called "Annex 1 countries" (developed countries and economies in transition), there seems little sign of this rate of growth slowing. Furthermore, growth in CO_2 emissions outside the Annex 1 countries has grown enormously, as countries like China and India industrialize their economies rapidly.

The IPCC 4th assessment report has proposed a reduction of GHG emissions of 25-40 per cent below 1990 levels by the year 2020 for Annex 1 countries. This could be sufficient to keep the average global temperature rise below 2° C. At the UN Climate Change Conference, held in Bali from 3-14 December 2007[19], the IPCC 4th assessment report was formally adopted as the scientific basis for further work within the UN Framework Convention on Climate Change (UNFCCC). Furthermore, a schedule of future meetings was adopted with a view to adopting a successor agreement to the Kyoto Protocol by 2012. However, crucially and controversially, the targets for limitation of GHG emissions and global average temperature rise were not included in the text of the document (the so-called Bali Roadmap[20]). The negotiations process will be led by a new subsidiary body of the UNFCCC called the Ad-hoc Working Group on Long-term Cooperative Action (LCA), which holds its first meeting in Bangkok, 31 March – 4 April 2008[21]. The critical future meetings will be the next UN Climate Change Conferences due to take place in Poznan, Poland, December 2008 and Copenhagen, Denmark, December 2009, as well as the WMO Climate Conference, in Geneva, October 2009.

Reducing carbon emissions will require changes in lifestyle and behaviour, but changes in management practices can also have a positive impact. New energy infrastructure investments are urgently required to move towards cleaner energy production, but there is also much that can be done in reducing energy consumption, in changing agricultural practices and through land-use change. Other longer-term, more high-tech solutions include ocean fertilization, creating a global sunshade and carbon sequestration. It is clear that any mitigation strategy must have multiple elements and ICTs can help with this, either:

- **Directly,** by reducing the ICT sector's own energy requirements. For instance, a major focus of ITU's work in recent years has been on **Next-Generation Networks** (NGN), which are expected by some commentators (Dittberner Associates[22]) to reduce energy consumption by 40 per cent compared to today's PSTN (see Box 2 on NGN).
- **Indirectly,** through using ICTs for carbon displacement (see Box 3 on the ETNO/WWF initiative).
- **In a systemic way**, by providing the technology to implement and monitor carbon reductions in other sectors of the economy (see Box 5 on ICTs and intelligent transport systems).

The credibility of the ICT industry in offering solutions for other sectors in reducing their carbon footprint will be much greater if the ICT itself shows that it is taking steps to put its own house in order. Some examples below show how this is already taking place:

- BT plc, the incumbent telecommunications provider in the UK and the host of the second of the two ITU symposia on ICTs and Climate Change, has made a public commitment to reduce carbon emissions to 80 per cent of 1996 levels by 2016 (it has already achieved a 60 per cent reduction by 2007; an annual saving of almost one million tonnes of CO_2). Furthermore, BT also sources almost all its electricity from low-carbon sources, and plans to self-provide some 25 per cent of its electricity requirements from its own wind farms by 2016.[28] BT has made a number of other pledges to engage its suppliers, its customers and its employees in climate change commitments. In this context, BT's CEO, Dr Ben Verwaayen, personally chaired a task force of the Confederation of British Industry (CBI) on "Climate Change – everyone's business", published in November 2007. The 18 member companies made a series of pledges, including empowering households to halve their carbon emissions by 2020 and enable their employees to make an aggregate reduction of one million tonnes of CO_2 within three years.[29]

- BT is one of the members of the European Telecommunication Networks Operators' association (ETNO), who signed an environmental charter in 1996 on sustainability. Between 2001 and 2003, 25 ETNO member Telcos succeeded in reducing their overall carbon emissions by 7 per cent and their carbon intensity (per unit of turnover) by 14 per cent (see Figure 7 and Box 3).

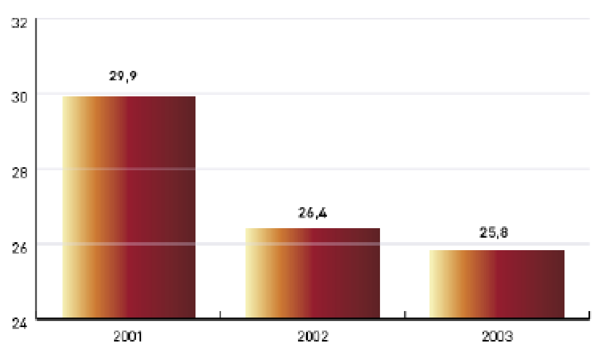


Figure 7: Reduction in grams of CO_2 per unit of turnover for selected European Telcos

Source: ETNO. *Note:* Based on survey of 25 ETNO Members.

- The Japanese incumbent operator, NTT, has also taken a number of similar measures as part of its "Total Power Revolution" campaign, which enabled it to save some 124 million kWh of electricity during 2007. It is also taking part in wider Japanese initiatives, such as at the "CoolBiz" and "WarmBiz" initiatives promoted by the Ministry of the Environment to encourage employees to dress seasonably for reducing heating and air-conditioning requirements. NTT is also converting its vehicle fleet to low-emission vehicles and, in a particularly "green" initiative, is experimenting with growing sweet potatoes on the roofs of its offices in order to reduce heat loss in winter and reduce heat absorption in summer.[30]

The 2008 McKinsey report, carried out for the Climate Group and the Global eSustainability Initiative (GeSI), finds that there is scope for reducing the carbon footprint of the ICT sector by some 36 per cent by

Box 2: Next-generation energy consumption for next-generation networks

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

- 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;
- More tolerant climatic range specifications for NGN switching locations, which are raised from 35 degrees (between 5 and 40°C) to 50 degrees (between -5 and 45°C). As a result, the switching sites can be fresh-air cooled in most countries rather than requiring special air conditioning.
- NGNs may make use of more recent standards, such as VDSL2 (ITU-T G.993.2), which specifies three power modes (full, low-power and sleep), whereas VDSL has only a single power mode (full power).

However, a particular concern relates to computer data centres, which have very demanding requirements for air-conditioning, electricity supply back-up etc. It is estimated that the five leading search companies use some two million servers. The total power required to run and cool these data centres amounts to around 5 GW and represents some 30 per cent of their total costs. Projects to reduce power consumption by data centres include the "Green grid" consortium involving AMD, Intel, Dell, Sun HP, IBM and others. Other initiatives to reduce power consumption include the "WattWatt" community website established by the IEC for sharing ideas on energy efficiency and the "GridWise" initiative of the US Dept of Energy which allows remote control of virtual thermostats via a web interface.

Sources: Adapted from various sources including Young (2007)[23], Schiwy (2005)[24], AMD[25], GridWise[26] and IEC[27].

Box 3: Saving the climate @ the speed of light

A joint initiative between the European Telecommunication Network Operators' association (ETNO) and the World Wide Fund for nature (WWF), called "Saving the climate @ the speed of light", is designed to show how ICTs can be used to displace carbon emissions within the European Union. The initiative sprang out of the World Summit on the Information Society (WSIS), following a conference on Telecommunications and Sustainability held in Budapest, 25-26 November 2004[32]. The partners have developed a two part roadmap:

- The first target is to reduce EU carbon emissions by 50 million CO_2 equivalent tonnes annually by 2010 through the strategic use of ICTs;
- The second would be a more ambitious target for 2020, to be set before 2010.

A number of areas in which ICTs can reduce carbon emissions have been identified:

- By reducing the need for travel through video- and audio-conferencing, and by facilitating remote participation in meetings. It is estimated that each 1 per cent reduction in business travel in the EU, amounting to around 50 million audio/video-conference calls, would save around one million tonnes of CO_2 emissions annually.
- Through flexible working patterns, such as telecommuting, facilitated by ICTs. Each one million EU telecommuters would save around one million tonnes of CO_2 emissions annually. A similar study in the United States, where commuting distances tend to be longer, found that today's 3.9 million telecommuters save between 10-14 million tonnes of CO_2 equivalent[33].
- By promoting sustainable consumption and development, through "dematerialization" (replacing atoms with bits), for instance through online phone billing (to save on paper bills), online submission of tax forms, by using IPTV to replace trips to the DVD store, by using e-commerce to reduce shopping trips etc.

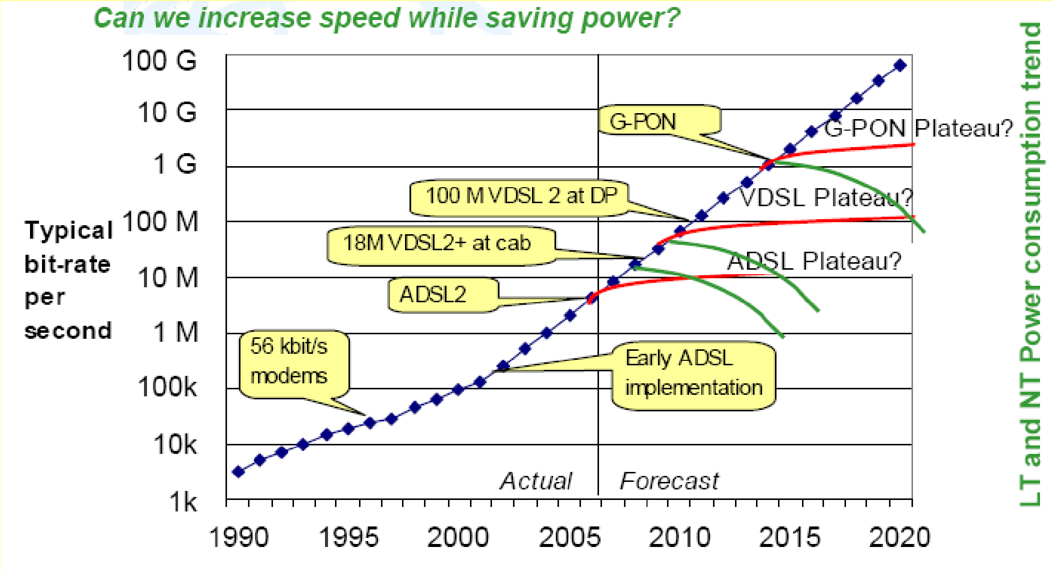
Source: ETNO and WWF.[34]

2020 (equivalent to 770 Megatonnes of CO2 equivalent) by using existing technologies, with the greatest cuts being possible in data centres. For example, Google's data centre at The Dalles, consumes enough electricity to power a town of 200'000 inhabitants. Google chose to locate this data centre next to the Columbia River, in Oregon USA, to make use of cheaper and less polluting hydro-electricity. Other savings can be made in the way that data centres are structured, by using fewer, more powerful processors, and by changing the way that servers are networked together.[31]

The application of ITU Recommendations, especially those that relate to energy-saving in ICT equipment, can go a long way to generating savings of greenhouse gas emissions in the ICT sector. At its December 2007 meeting, the ITU-T Telecommunication Standardization Advisory Group (TSAG) has invited all ITU Study Groups to conduct a systematic investigation of their existing and future Recommendations in the light of climate change.[35] Within ITU-T Study Group 15, Working Party 1 (Optical access networks), an energy-saving checklist for standards development has been elaborated, and was approved by SG-15 at its February 2008 meeting[36]. The document presents a questionnaire that enables standards-developers to carry out a systematic check of the implications for global warming. This was further discussed in a series of tutorials on power-saving held 13-15 February 2008[37].

The Telecommunication Development Sector (ITU-D), for its part, is contributing to this effort by providing information and guidance on available energy-efficient ICTs and their use through its assistance to member states, its training materials and dissemination of information via a dedicated website[38] on e-environment and e-sustainability, and through its collaboration with partners such as GeSI. An important focus is on greater use of **recycling** and the safe disposal of waste, which can assist in reducing global warming and the release of GHG. One area of study within ITU-T is "Environmental and Safety Procedures for Outside Plant" (ITU-T Study Group 6). Environmental protection procedures now in place in many countries will affect the selection of materials and mode of installation in outside plant. Study items include environmental aspects resulting from outside plant material recycling. Recommendations are being developed to implement these considerations while recycling copper and optical cables materials

Figure 8: Relationship between bit-rate and power consumption over time



Source: Faulkner, David, et al (2008) "ITU-T SG15 WP/1 access network transport, energy-saving checklist, available at: http://www.itu.int/dms_pub/itu-t/oth/09/05/T09050000010007PDFE.pdf.

Note: LT = Line termination; NT = Network termination.

Part of the concern over the global warming effect of ICTs is coming from the seemingly inexorable rise in the **power requirements of ICT devices**, driven by the high transmission capacity. As shown in Figure 7, the transmission capacity of different generations of access network technology is doubling approximately every year. The speed plateau of Asymmetric Digital Subscriber Line (ADSL) technology is likely to be reached at around 10 Mbit/s, but Very high-speed Digital Subscriber Line (VDSL) technology will raise this to 100 Mbit/s and Gigabit Passive Optical Networks (G-PON) will extend it above 1 Gbit/s. All other things being equal, as transmission capacity rises, so too will power consumption, for both devices and networks. The challenge is to achieve continually rising transmission capacity while stabilising, or reducing, the power requirements.

There are technical solutions to this problem. For instance, continuing with the example of broadband access technologies, the following options offer solutions to reducing power requirements in VDSL:

- Adaptive start-up: reduce power requirements when data rate and margin requirements are met;
- Offer low-power and low-transmission rate options in the standards for VDSL2/2+;
- Offer a sleep state (hibernation) in the standards;
- Adapt VDSL profiles to different markets and applications so as to optimise them for spectrum management and loop-length requirements in different domains[39].

A further example of reductions in CO_2 emissions are provided by **fibre-to-the-home** (FTTH) technologies. A study conducted by FTTH Council Europe and Price Waterhouse Coopers, published in February 2008, finds that the net environmental impact of an investment in fibre can be positive over a 15 year period, with a reduction in CO_2 emissions equivalent to 330kg per user; the equivalent to a car travelling 2'000 km. In the next 15 years, these savings would be approximately doubled as the main environmental impact is in the production and deployment phase.[40]

However, in order to be effective, it might be necessary to back up technical solutions with regulatory pressure or incentives. Within the European Union, codes of conduct for power saving have been developed for digital TV set-top boxes, external power supplies, uninterruptible power supplies (UPS) and broadband equipment and a further code of conduct is under development for data centres. The stated aim is to halve power consumption. For instance, for broadband equipment, it is estimated that current trends will foresee a

Box 4: Digital broadcasting Plan GE06 will reduce transmission power and may reduce number of powerful transmitters employed for TV and sound broadcasting

The Regional Radiocommunication Conference 2006 (RRC-06), which involved 120 countries, developed a new digital broadcasting Plan GE06 that envisages significant reduction (~7 dB) of transmitter power due to the use of digital modulation. Moreover the number of transmitters (there are tens of thousands of transmitters around the world with power of up to 100-150 kW each) may be reduced due to the possibility of transmitting several TV and sound programmes in one channel (instead of 1 TV programme per channel). ITU-R BT and ITU-T H series Recommendations are used as the technical bases for switching from analogue to digital broadcasting.

level of demand of up to 50 Terawatt hours by 2015, but this could be halved by implementation of the broadband code of conduct.[41]

A final example from the ICT sector is provided by the introduction of **new radio technologies**—such as digital modulation for broadcasting, ultra-wideband (UWB) technology employing extremely low power, smart antennas, etc—which is reducing power requirements (see Box 4). All ITU-R Study Groups are concentrating their studies not only on increasing service quality and the efficient use of the radio spectrum, but also on energy saving and reduction of power consumption.

Overall, while the main potential contribution of the ICT sector to combatting climate change is likely to be in the application of ICTs in other sectors of the economy (the topic of the next section) and changing behaviour of end-users; it is important first that the ICT sector put its own house in order.

5 USING ICTS TO REDUCE GREENHOUSE GAS EMISSIONS

Although ICTs account for only around 2.5 per cent of total greenhouse gas emissions, they have the capacity to be used in reducing the other 97.5 per cent in other sectors of the economy, notably in smart buildings, reduced travel, improved energy efficiency etc. They can do this primarily by creating opportunities for the abatement (or displacement) of existing applications that generate carbon dioxide (CO_2).

A number of studies have been carried out of the carbon abatement opportunities offered by ICTs of which the three most recent are:

- The study, entitled "Saving the planet @ the speed of light", carried out in 2007 by the European

Figure 9: Telecommunications-based carbon abatement opportunities in Australia

Carbon-Opportunity (in order of size)	$MtCO_2$-e saving	Percentage of national emissions
Increased Renewable Energy	10.1	1.81
Personalised Public Transport	3.9	0.70
De-centralised Business District	3.1	0.55
Presence-Based Power	3.0	0.53
Real-time Freight Management	2.9	0.52
'On-Live' High Definition Video Conferencing	2.4	0.43
Remote Appliance Power Management	1.8	0.33
Total	27.3	4.88

Source: Climate Risk pty (2007) "Towards a high-bandwidth, low-carbon future".

Telecommunication Network Operators association (ETNO) and the WorldWide Fund for nature (WWF), which is billed as the "First roadmap for reduced CO2 emissions in the EU and beyond". This study is profiled in Box 3.

- The study, entitled "Towards a high-bandwidth, low-carbon future", carried out also in 2007 by ClimateRisk pty on behalf of the incumbent Australian carrier, Telstra. [42] The report identifies seven specific telecoms-based opportunities for carbon abatement, as shown in the Figure 8. If implemented in full, it would account for almost 5 per cent of Australia's national emissions. Telstra itself is using high-performance video-conferencing, or "Telepresence", to reduce its own internal travel requirements. During 2007, Telstra held some 7'500 video conferences, lasting nearly 20'000 hours and generating an estimated reduction in travel equivalent to 4'200 tonnes of carbon dioxide.

- The report "ICTs and e-Environment", carried out in 2007 on behalf of the International Telecommunication Union, reviewing some key ICT initiatives and providing recommendations for strengthening the capacity of developing countries to make beneficial use of ICTs to mitigate and adapt to environmental changes[47].
- The study, entitled "Impact of ICT on Global Emissions", carried out in 2008 by McKinsey on behalf for the Climate Group and GeSI. This report identifies carbon abatement opportunities in 15 different areas generating a total of 12.3 Gigatonnes of CO_2 equivalent. It explores four of these opportunities in more detail--smart buildings, industrial motor optimization, smart grid and efficient logistics and supply chain management—as these are identified as offering the best commercial opportunity for Telcos as well as having the best available data.

Probably the most obvious area for carbon abatement opportunities offered by ICTs is in **reducing, or substituting for, travel requirements** of people and goods. The ICT industry offers a number of different tools and services which can theoretically replace travel, especially business travel, which range from the mundane (e.g., email, phone calls, text messaging) to the sophisticated (high-performance video-

Box 5: ICTs and intelligent transport systems

In addition to reducing the direct effects of the ICT sector on climate change, and the indirect effects through using ICTs for abatement of carbon emissions, ICT-based technologies can also have a systemic impact on other sectors of the economy and of society, and can help in providing a basis for sustainable development. The potential systemic impact of ICTs is particularly apparent in the transport sector which, according to the Stern report[43], accounts for 14 per cent of total greenhouse gas emissions.

ICTs can be applied to transport through the deployment of Intelligent Transport Systems (ITS)[44]. Although the main focus of ITS is on the safety, management and efficiency of transport systems, ITS can also be used to reduce their environmental impact. For example:

- Parking guidance systems can lead motorists to the most appropriate parking space, and thereby reduce engine time;
- Similarly, GPS use for navigation or vehicle dispatch can reduce journey time;
- Road pricing schemes, such as the congestion charge in London, can encourage greater use of public transport and reduce congestion, thereby reducing journey times;
- Using cars as an environment monitoring tool. For instance, by feeding real-time data collected from vehicle on average speed, climatic conditions, hold ups etc into satellite navigation systems, it is possible to give other vehicles an updated picture of road conditions and to suggest alternative routings where appropriate.[45]
- In addition, so-called "eco-driving', whereby in-car systems provide advise to drivers to takes steps to maximize fuel efficiency, has been demonstrated to reduce carbon emissions by up to 20 per cent.[46]

Source: ITU-T Technology Watch Briefing Report #1 and ITU-R "Intelligent Transport System" - Handbook on Land Mobile (including wireless), Volume 4.

conferencing). Figure 9 presents a segmentation of the market opportunities provided by ICTs and a selection of the tools available. Supply chain, production and transportation efficiency can also be enhanced by using the full potential offered by ICTs. One example is represented in Box 6.

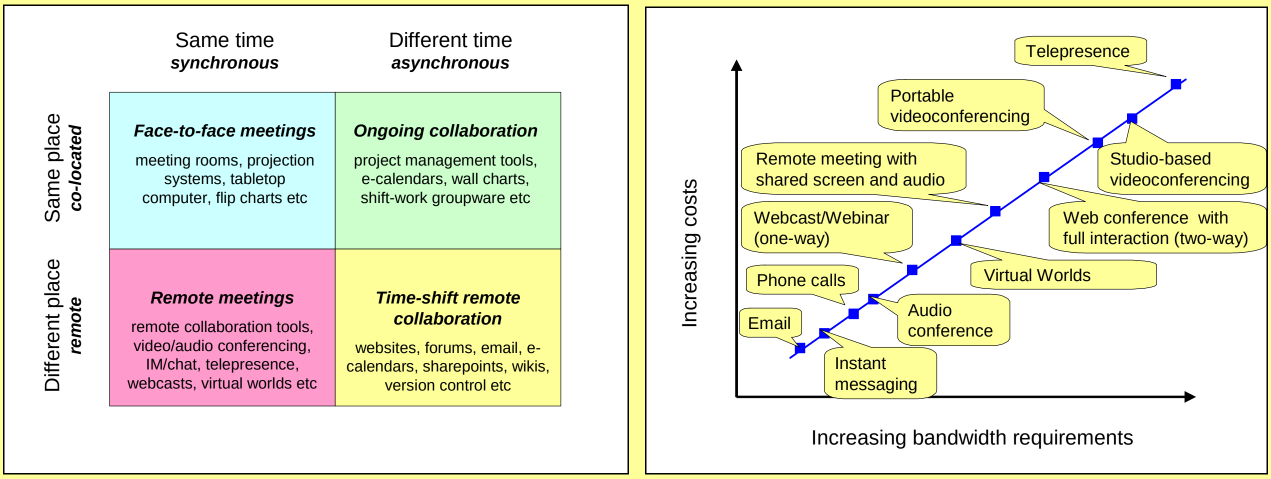
ITU-T has produced reports on both the low-end of this market (remote collaboration tools[48]) and the high-end (telepresence[49]), to examine the potential of using these tools for carbon abatement through travel avoidance. ITU-T is already making extensive use of remote collaboration tools and TSAG has sanctioned a pilot to test two commercially available products: *GoToMeeting* (Citrix) and *WebEx* (recently acquired by CISCO). The meetings of the steering committee for the two ITU Symposia have been conducted using GoToMeeting and the events will be broadcast to a worldwide audience using *GoToWebinar*.

A second area where ICTs have been extensively used for reducing CO_2 emissions caused by transport is in the use of **intelligent transport systems** (ITS), which is explored in more detail in Box 5. The three main elements of green ITS are the car, the infrastructure and the driver. Over time, considerable progress has been made in improving the fuel-efficiency of cars but relatively little progress has been made in infrastructure, and there has been little change in driver behaviour. If nothing changes, the usage of petroleum will double between 2007 and 2030 and this could be multiplied by three if all the world's citizens are to enjoy the same level of mobility currently experienced in the developed world. Ultimately, therefore, telematics and the application of ITS offer the best solution for improved fuel efficiency. A reasonable target would be to reach a level where all cars are using less than 130 g of CO_2 per km traveled by 2012. ITU's main efforts in this field are geared towards the annual "Fully Networked Car" workshops, organized jointly with ISO and IEC, the fourth of which was held in Geneva, 5-8 March 2008 with a particular a particular focus on ICTs and climate change.[50]

A third way in which ICTs can assist other sectors of the economy in reducing greenhouse gas emissions is through so-called "**dematerialization**", or the replacement of "atoms" with "bits". An example of this is the current shift underway in the market for pre-recorded movies and music away from physical distribution (e.g., DVDs, CDs) to online delivery.[51] ITU-T standards for digital compression (such as the H-series for multimedia, including MP3 and MP4) and ITU-T and ITU-R Recommendations for broadband access networks (such as the ITU-T G-series, including DSL standards, the ITU-R BO, M, S series for radio access) greatly assist with this process. ITU is also making its own modest contribution to dematerialization through the long-term shift away from paper-based to online publishing, which reached its culmination in 2007 with the decision of ITU Council to make all ITU-T Recommendations permanently free-of-charge online (see Box 6). Within the context of ITU-D's work relating to ICTs and environmental protection (including waste management and environmentally-friendly supply chain management), it provides information and guidance in these areas through its cooperation assistance to member states, its training materials and website on

Figure 9: Remote collaboration tools and other groupware

Segmented by time and place (left chart) and by bandwidth / cost (right chart)



Source: ITU-T Technology Watch Briefing Report #5; remote collaboration tools. Left chart, adapted from Wikipedia (http://en.wikipedia.org/wiki/Image:Cscwmatrix.jpg).

e-environment and e-sustainability, and through its collaboration with partners such as GeSI. These applications fall under Programme 3 of the Doha Action Plan of ITU-D, notably WTDC-06 Resolution 54.

Box 6: ITU-T Recommendations Online and the reduction of carbon emissions

In 1995, when ITU made its first steps in the transition to electronic publishing, ITU-T printed some 368'534 copies of Recommendations, of an average size of 42 pages each. A further one million unsold copies were in stock. In 2007, ITU-T distributed more than three million Recommendations through free download, but will print only just over 10'000 copies. If ITU-T were still printing (instead of distributing for free online) all its Recommendations, this would require logging around 23 Douglas Fir trees per year, at an annual loss to the environment through absorption ability of 25.3 tonnes of CO_2 over a 100-year period.

To this should be added the cost of transporting the printed Recommendations to customers. In 1995, the level of publication sales (159'669 printed ITU-T Recommendations were sold in that year), required some 108 tonnes of CO_2 emission. By 2007, this had been reduced to just 1.5 tonnes. However, in the absence of free Recommendations online, carbon emissions would have been multiplied over 20-fold rather than decreasing. Thus it can be seen that ITU-T's transition from paper to electronic publishing represents a major saving for the environment.

Source: ITU, based on analysis using the GHG protocol tool (see: www.GHGprotocol.org) and carbon absorption estimates at www.carbon-info.org.

6 ICTs FOR ADAPTING TO THE LOCAL EFFECTS OF CLIMATE CHANGE

The impact of global warming on the world's climate to date (see Figure 2) is relatively small compared with what can be expected in the future, even if the increase in GHG is stabilized. The IPCC, in its 4th assessment report, predicts a rise in average temperatures of 1.4-5.8°C[52] and a 3 per cent reduction in global GDP by 2030. However, the results are likely to be highly uneven in their distribution, with low-lying coastal areas (e.g., small island developing states, Bangladesh delta, Netherlands) at risk because of rising sea levels; sub-Saharan Africa at risk due to desertification; a growing number of environmental refugees and increased pressure on sources of fresh water and on vulnerable ecosystems such as coral reefs, tundra, coastal wetlands etc (see Figure 11).

At the Antalya ITU Plenipotentiary Conference in 2006, Member States adopted Resolution 136 on the "*Use of telecommunications/ICTs for monitoring and management in emergency and disaster situations for early warning, prevention, mitigation and relief*" which, *inter alia*, calls upon the Directors of the Bureaux to continue their technical studies and to support the development of early-warning, mitigation and relief systems.[53] ITU-T's work in this field includes standardization of call priority in emergency situations (e.g., Recommendation E.106 on the International Emergency Preference System for disaster relief). ITU-T also leads the Partnership Coordination Panel on

Figure 11: Countries most at risk from natural disasters related to climate change

Drought	Flood	Storm	Coastal (<1m)[a]	Coastal (<5m)[a]	Agriculture
Malawi	Bangladesh	Philippines	All low-lying island states	All low-lying island states	Sudan
Ethiopia	China	Bangladesh	Vietnam	Netherlands	Senegal
Zimbabwe	India	Madagascar	Egypt	Japan	Zimbabwe
India	Cambodia	Vietnam	Tunisia	Bangladesh	Mali
Mozambique	Mozambique	Moldova[b]	Indonesia	Philippines	Zambia
Niger	Lao PDR	Mongolia[b]	Mauritania	Egypt	Morocco
Mauritania	Pakistan	Haiti	China	Brazil	Niger
Eritrea	Sri Lanka	Samoa	Mexico	Venezuela	India
Sudan	Thailand	Tonga	Myanmar	Senegal	Malawi
Chad	Vietnam	China	Bangladesh	Fiji	Algeria
Kenya	Benin	Honduras	Senegal	Vietnam	Ethiopia
Iran	Rwanda	Fiji	Libya	Denmark	Pakistan

Notes: a. Metres above sea-level. B. Winter storms. Shaded countries are Least Developed Countries.
Source: World Bank, October 2007, IDA and climate change: Making climate action work for development.

Telecommunications for Disaster Relief (PCP-TDR), which falls under the responsibility of ITU-T Study Group 2[54]. Its terms of reference include monitoring and promoting technical standardization work in this area.

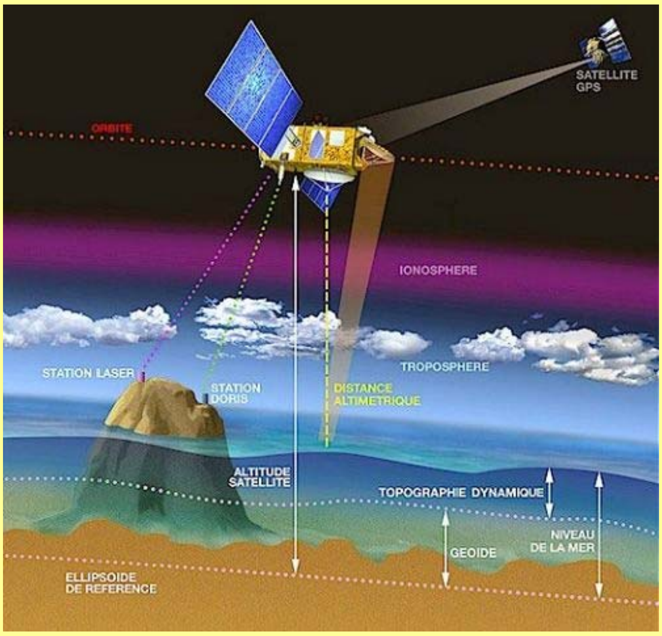


Figure 12: Use of satellites and radio-frequency remote sensing (altimeters) for ice and ocean studies: Can identify a change in sea level with a precision of 2-3 cm.
Source: ITU-R Study Group 7 ("Science Services") and CNES

One of the outcomes of ITU-T Study Group 2's work is the assignment of a special E.164 country code (888) to the United Nations Office for the Coordination of Humanitarian Affairs (OCHA) for the purpose of facilitating the provision of an international system of naming and addressing for terminals involved in disaster relief activities. This might be used in an area of a country that has been cut off from the national telecommunications system of that country, or for natural disasters covering many countries, such as a tsunami (see Box 7). A number of regional and sub-regional workshops have been held on telecommunications/ICTs for disaster relief, and a Global Forum on 10-12 December 2007 in Geneva. More information on ITU's activities in this area is provided in the Annex.

ITU's mission, from the very earliest days, has included telecommunications (including radiocommunications) for disaster relief and for emergency services, which are particularly important in mitigating the effects of climate change, for instance from flooding due to rising sea levels (see Figure 11), or increased incidence of violent storms and hurricanes. Virtually all ITU-T Study Groups are active in this area, notably Study Group 2 which has the lead on telecommunications for disaster relief/early warning. Similarly all ITU-R Study Groups carry out studies and develop ITU-R Recommendation/Reports/ Handbooks on the use of different radiocommunication services (amateur, broadcasting, satellite-broadcasting, Earth-exploration satellite, meteorological and meteorological-satellite, fixed and fixed-satellite, mobile and mobile-satellite, radiodetermination, etc.) for early warning the public of impending disasters, for planning and relief operations and for emergency situations (see also section 3 above).

Box 7: Tsunami early warning systems: Message sent, but was it received?

A good example of the use of ICTs for disaster relief is the establishment of a tsunami early-warning and mitigation system for the Indian Ocean, following the tsunami of 26 December 2004, operating under the aegis of UNESCO's International Oceanographic Commission. A similar system has existed in the Pacific Ocean since 1965 and the Indian Ocean system is based on 25 seismic stations, 26 national tsunami centres and three deep ocean sensors, with messages sent by satellite phone. It became operational in June 2006. However, when it was needed for real the following month (see map), as a result of the Java earthquake, no message was relayed to coastal areas of Indonesia and hundreds of people were killed by the ensuing tidal wave. In a test conducted on 24 January 2007, the average delay between a message being sent (by SMS and email) and a response received back ranged between a minimum of two minutes (seven countries) and 31 hours (Indonesia), with three countries failing to respond at all. UNESCO has admitted that more coordination among governments is needed.

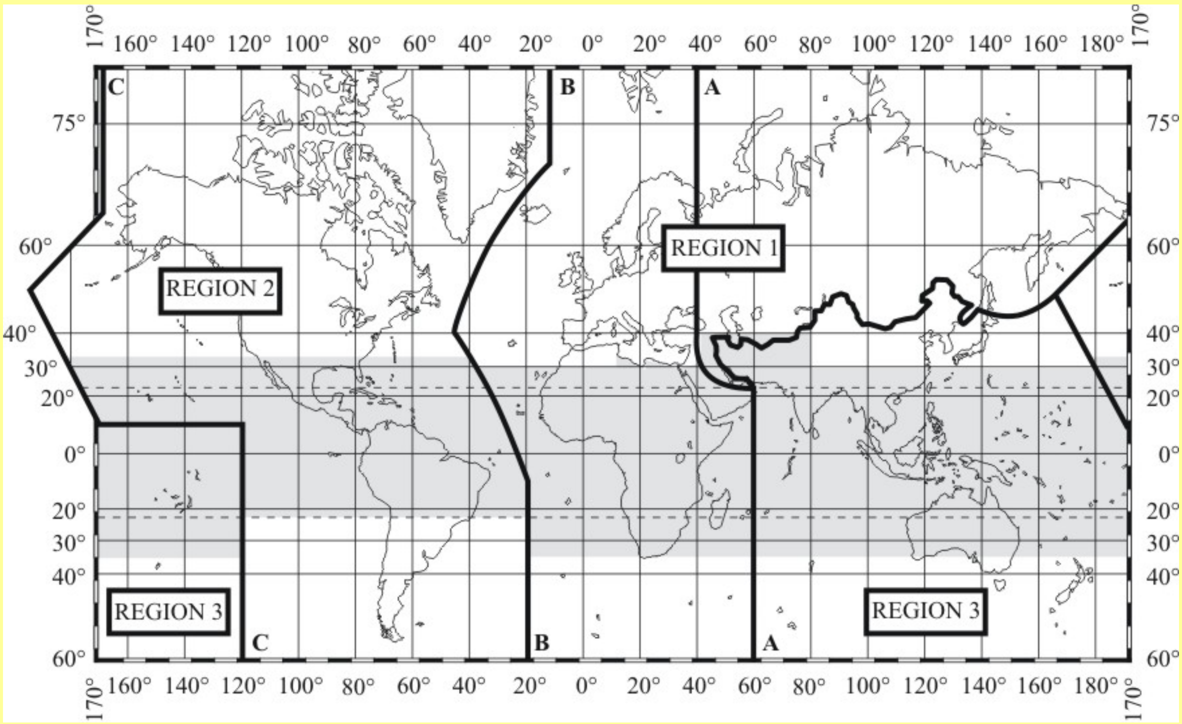
Source: Adapted from IOC/UNESCO[55] and BBC[56].

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). ITU-R’s Study Groups have developed Recommendations, Reports and Handbooks related to the use of radiocommunication services at different phases of disaster: prediction, detection, alerting and relief.[57]

The 2003 World Radiocommunication Conference, in Resolution 646 strongly recommends use of the following regionally harmonized bands for public protection and disaster relief in emergency situations for different ITU Regions (see Figure 13):

- **Region 1**: 380-470 MHz as the frequency range within which the band 380-385/390-395 MHz is a preferred core harmonized band for permanent public protection activities within certain countries of Region 1;
- **Region 2**: 746-806 MHz, 806-869 MHz, 4 940-4 990 MHz;
- **Region 3**: 406.1-430 MHz, 440-470 MHz, 806-824/851-869 MHz, 4 940-4 990 MHz and 5 850-5 925 MHz.

Figure 13: ITU Regions, as defined in the Radio Regulations



Source: ITU.

The Radiocommunication Assembly 2007 (RA-07) approved Resolutions ITU-R 53 and 55 instructing all ITU-R Study Groups to carry out studies on the use of radiocommunication in disaster prediction, detection, response, mitigation and relief. WRC-07 further advocated the development of spectrum management guidelines for radiocommunication in emergency and disaster relief, as well as the identification and maintenance of available frequencies for use in the very early stages of humanitarian assistance intervention in the aftermath of disaster. ITU is developing a database for frequency management in disaster situations (Resolution 647 (WRC-07)).

Finally, greater use of **recycling** and the safe disposal of waste can assist in reducing global warming and the release of GHG. One area of study within ITU-T is “Environmental and Safety Procedures for Outside Plant” (ITU-T Study Group 6). Environmental protection procedures now in place in many countries will affect the selection of materials and mode of installation in outside plant. Study items include environmental aspects resulting from outside plant material recycling. Recommendations are being developed to implement these considerations while recycling copper and optical cables materials.

7 CONCLUSIONS

This report, prepared especially for the two ITU symposia on ICTs and Climate Change, in Kyoto, Japan, 15-16 April, and in London, UK 17-18 June 2008, has examined the way in which ICTs contribute to global warming, but also how they can be used to monitor, mitigate and adapt to climate change. As with other sectors of the economy, the ICT sector faces a moral challenge to change the way it does business in order to contribute to the wider global struggle to assure our future environment. Although the humanitarian imperative is the primary driving factor, it is clear that there are also important commercial incentives to support such a change of behaviour: energy efficiency reduces costs; improved traffic management reduces delays; corporate social responsibility improves brand image; carbon abatement creates new market opportunities; sustainable development creates jobs etc.

In short, the world's looming climate crisis represents a major opportunity for the ICT industry, and one in which international leadership, and the application of international standards will be paramount. This report has presented some of the ways in which ITU and its membership and partners are already responding to this challenge (more details of ITU activities are presented in the annex). But the actions of the ICT industry have to be a coordinated part of a wider, global initiative, and that is why the outcomes of the ITU symposia will feed into the 2008 G8 meeting (in Hokkaido, Japan) and the ongoing work of the UNFCCC. Technology-based solutions have to be backed up by political will and a genuine desire to change the direction in which humanity is heading, in order to avoid a planetary crisis caused by climate change.

ANNEX: AN INVENTORY OF ITU ACTIVITIES RELATED TO ICTS AND CLIMATE CHANGE

Activities relevant to combatting climate change are already taking place throughout ITU, both in the regular work programmes and in special initiatives. These activities respond to many of the issues discussed in the main report. The following inventory includes current and planned climate change-activities and is intended to be indicative, not exhaustive.

Telecommunication Development Sector

- The World Telecommunication Development Conference 2006 (WTDC-06) reviewed key technological developments in the information and communication technology (ICT) sector and adopted, *inter alia*, Resolution 54 on ICT applications, including e-environment[58]. In this regard, activities of Programme 3 of the Doha Action Plan include providing technical cooperation assistance to ITU member states, developing tools and training material, and collaborating with partners.
- The ITU-D website on e-environment and e-sustainability[59], developed under Programme 3 of the Doha Action Plan (DAP), contains ITU internal and external relevant resources and links, including resources on topics such as the use of ICTs for environmental protection and the environmentally safe disposal of e-Waste.
- ITU-D Programme 3, jointly with UNEP, supports the Global eSustainability Initiative (GeSI), a global partnership of major players of the ICT sector that promotes technologies for sustainable development.
- Under Programme 3, an e-Environment scoping study has been commissioned to guide future work (available in March 2008). The programme of work for 2008-2009 includes developing an e-environment toolkit aimed at national policy-makers.
- Programme 3 provided input to ITU-T's briefing paper on climate change as well as to the ITU Symposia on ICTs and Climate Change in Kyoto (15-16 April 2008) and London (17-18 June 2008).
- Programme 6 provides assistance on disaster communications/emergency telecommunications to ITU Member States while paying special attention to the needs of least developed countries and Small Island Developing States that are the most vulnerable to the effects of climate change and global warming. Undertakes studies and deliver assistance in the use of active and passive space-based sensing systems as they apply to disaster prediction, detection, monitoring, and mitigation.
- Under Programme 6, design National Emergency Telecommunications Plans (NETPs) and develop Standard Operating Procedures (SOPs) on the application and use of ICT for early warning, response/relief, and reconstruction.
- Programme 6, assist countries in developing National Adaptation Programmes (NAPs) while ensuring that ICT is at the core of such initiatives.
- Programme 6, working with other OCHA, WHO, FAO, WFP, UNHCR, etc. under the United Nations Working Group on Emergency Telecommunications develop Minimum Operating Procedures for disaster relief and other measures in response to climate change and disasters.
- Programme 6, carries out infrastructure damage assessments after disasters and carries out network rehabilitation activities.
- Programme 6 has organized a number of regional and sub-regional workshops on telecommunications/ICTs for disaster management, and a Global Forum on 10-12 December 2007 in Geneva. A "Workshop on remote sensing in disaster management", was held 10-11 December 2007, which included presentations from BR on the use of satellites in measuring and monitoring climate change and in assisting with emergency response to disasters.
- Programme 6 with the International Strategy for Disaster Reduction (ISDR) implements the conclusions of the World Conference on Disaster Reduction for the decade 2005-2015 under the Hyogo Framework.
- The Jakarta area office led the ITU delegation to the Bali UN Climate Change Conference, in Dec. 2007, with participation also from TSB. Daily mission reports are available.

- The Cairo office organized an ITU Regional Seminar on "The role of ICT in protecting Man and Environment: How to limit the impact of its use" in cooperation with the Secretariat of the Council of Arab Ministers responsible for environmental affairs in the League of Arab States in October 2004.

Radiocommunication Sector

- The World Radiocommunication Conferences (WRCs) analyze the spectrum requirements and allocate the necessary radio frequency spectrum for radiocommunication systems and radio based applications employed for environment and climate monitoring including weather forecasting, natural disaster prediction, detection and mitigation.
- WRC-07 and Radiocommunication Assembly (RA-07) adopted a number of Resolutions on remote-sensing, which is a vital component in the science of climate change.
- ITU-R Study Groups have adopted ITU-R Recommendations on the development and use of radiocommunication systems and radio-based applications operating in Earth-exploration satellite, meteorological-aids and meteorological satellite services, which today provide most of data for the Global Observing System (GOS). These data are also used in the Global Climate Observing System (GCOS).
- ITU-R Study Group 7 "Science services" in cooperation with the World Meteorological Organization produced WMO and ITU Handbook "Use of Radio Spectrum for Meteorology providing information on development and a proper use radiocommunication systems and radio-based technologies for environment observation, climate control, weather forecasting and natural and man-made disaster prediction, detection and mitigation.
- ITU-R Recommendations, Reports and Handbooks standardizing the use of new radio technologies such as digital modulation, error protection coding techniques, etc. allow:
  - significantly reduced power consumption of radio equipment[60];
  - reduced atmosphere/ionosphere heating by very high power transmitters (several MW).

  An interesting example of the new technological achievements is the new ultra-wideband (UWB) technology employing extremely low power, smart antennas, etc. All ITU-R Study Groups are concentrating their studies not only on increasing service quality and the efficient use of the radio spectrum, but also on energy saving and reduction of power consumption.
- The Radiocommunication Sector has been working on the spectrum requirements of intelligent transport systems (ITS) since the early-1980s. ITS can assist in reducing carbon emissions through more efficient traffic management, reduction of congestion etc. ITU-R Study Group 5 "Terrestrial services" (SG 8 before 2008) produced ITU-R "Intelligent Transport System" - Handbook on Land Mobile (including wireless) in Land Mobile series.[61]
- Mitigation of the negative effects of climate change is another area of the Radiocommunication Sector activities. 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). ITU-R's Study Groups have developed Recommendations, Reports and Handbooks related to the use of radiocommunications for relief operations.
- **Telecommunication Standardization Sector**
- The World Telecommunication Standardization Assembly 2008 (WTSA-08) will be presented with a draft Resolution to require all new ITU-T standards (Recommendations) to be checked against energy saving and environmental criteria. The WTSA will also consider the adoption of a Resolution on a target percentage reduction on ICT/telecom energy requirements over the following 4 year study period.
- ITU-T is coordinating the organization of two ITU Symposia on ICTs and Climate Change, which will take place in Kyoto, 15-16 April and in London 17-18 June 2008, with the results feeding into relevant meetings such as the OECD ministerial, the G8 summit in Japan, the UNFCCC and in particular WTSA-08. A call for papers/speakers has been issued, a resources website developed, and the first coordination meeting (by teleconference) was held on 21 Jan.

- Through its Technology Watch function, ITU-T has issued a series of briefing papers relevant to climate change, on the topics of: ICTs and climate change; telepresence (high-performance videoconferencing); and intelligent transportation systems (ITS). The climate change paper was reviewed by TSAG at its Dec 2007 meeting and adopted as a basis for launching a work programme in this area.
- At its Dec 2007 meeting, TSAG approved a Liaison Statement to all ITU-T Study Groups (TSAG-LS-30), which invites them to assess all existing and new ITU-T Recommendations in the light of climate change.
- On-going standardization work on Next-Generation Networks (NGN) is being conducted through the NGN Global Standards Initiative.[62] A study has estimated that NGNs could reduce energy requirements by up to 40 per cent compared with today's networks through a combination of reduced number of switching centres, more modern equipment with multiple power modes (e.g., VDSL2+), reduced requirements for air-conditioning, support for advance services, and more efficient routing of traffic.[63]
- ITU-T has organized a series of "Fully Networked Car" workshops, the third of which was held at the Geneva Motor Show, 5-7 March 2008, with environment as its theme. A number of potential standardization activities in the field of Intelligent transport Systems (ITS) that could mitigate emission levels were identified.
- The ITU-T Director represented ITU at the International Conference to Combat Desertification, in Beijing, January 2008, giving a presentation on the contribution ITU is making in this area.
- ITU-T SG 2 (Operational aspects of service provision, networks and performance) is working on the standardization of call priority in emergency situations (e.g., Recommendation E.106 on the International Emergency Preference System for disaster relief). One of the outcomes of this work is the assignment of a special E.164 country code (888) to the United Nations Office for the Coordination of Humanitarian Affairs (OCHA) for the purpose of facilitating the provision of an international system of naming and addressing for terminals involved in disaster relief activities. Work has started for the coordination of the assignment of channel numbers for cell broadcast alert messages in mobile networks. ITU-T, under the leadership of SG 2, coordinates the Partnership Coordination Panel on Telecommunications for Disaster Relief (PCP-TDR).[64]
- ITU-T SG 6 (Outside plant and related indoor installations) develops Recommendations on, *inter alia*, environmental and safety procedures for outside plant, including the recycling of copper and optical cables materials.
- ITU-T SG 15 (Optical and other transport network infrastructures) has prepared a technical paper ("*Energy-saving checklist for standardization activities*") investigating ways to reduce the power consumption of telecommunications equipment. The widespread availability of broadband access is facilitating the wider use of telecommuting. The paper was adopted at the Feb 2008 meeting, where a series of very well attended tutorials on energy-saving were held, from 13-15 February. SG15 has also pioneered the use of questionnaire surveys as a prompt to standards-developers for increasing energy-efficiency.
- ITU-T SG 16 (Multimedia terminals, systems and applications) is of particular importance in terms of standards for remote collaboration, such as the H series of ITU-T Recommendations on audiovisual and multimedia systems, including video-conferencing, which provide a means for people to collaborate at a distance without needing to travel.
- ITU-T Study Group 17 (Security, languages and telecommunications software) has developed a new Recommendation X.1303, jointly with OASIS, which provides the basis for a common alerting protocol for use in advance of impending threats, such as tsunamis, typhoons or earthquakes.

General Secretariat

- Through the SPM, ITU has been actively participating in the work of the Chief Executives Board (CEB) and its subsidiary bodies on developing a unified and collaborative UN strategy to combat climate change, including a matrix on activities of each agency and program. This work has included providing comments and taking part in negotiations on CEB documents, including the UN Sec-Gen's paper to the

Bali climate change conference, providing an ITU input document to that conference and press release, and representing ITU in the UN Environmental Group.

- SPM is monitoring ongoing negotiations under the Bali roadmap and coordinating ITU participation in upcoming international events on climate change, e.g. the Poznan Conference in 2008 and the WMO Conference in 2009.
- SPM is coordinating efforts to make the ITU climate neutral, pursuant to a policy established at the CEB, including a carbon audit. The Building Division has taken a number of practical steps to improve energy efficiency and to reduce heat-loss, including in the design of the Montbrillant Building.
- Efforts are underway to move increasingly to paperless meetings and the IS Department has been providing tools to facilitate remote participation in ITU meetings (see below).

Remote collaboration tools

For those participating in, or organizing ITU meetings, there are a number of tools that can be used to substitute for face-to-face meetings, or to facilitate remote participation in meetings (e.g., for developing countries). These tools include:

- TIES (Telecom Information Exchange Services) (see: http://itu.int/TIES), which includes electronic access to restricted documents, email account, electronic forum etc;
- Other electronic working methods, including informal FTP area and correspondence groups (see: http://itu.int/ITU-T/tsag/edh/ifa-structure.html).
- Free access to ITU-T Recommendations online. Following a decision by the 2007 ITU Council, all ITU-T Recommendations (of which more than 3'100 are in force), are now available free of charge online (see: http://itu.int/ITU-T/publications/recs.html). It is estimated that the move away from printed to electronic Recommendations has reduced shipping requirements equivalent to a saving of 100 tonnes of CO_2 per year. Over three million ITU-T Recommendations were downloaded in 2007.
- Internet Broadcast System (IBS). Many ITU meetings are now broadcast over the web, either with or without restrictions on access, and many have sound and or video archives available for consultation. For instance, the archives for the September 2007 workshop on multimedia in NGN are available online at: http://itu.int/ibs/ITU-T/200709multimedia.
- E-learning. ITU conducts many different courses each year through e-learning, organized both by the HQ in Geneva and the regional offices (see: http://itu.int/ITU-D/hrd/elearning).
- Remote participation tools. ITU is currently evaluating two popular remote participation or groupware packages, and these are available to meeting organizers (e.g., for organizing meetings of rapporteurs, offering webinars etc). These include GoToMeeting (see: www.gotomeeting.com) and WebEx (see: www.webex.com), For more information see the TSAG liaison statement on remote participation tools (TSAG-LS-32).

Information dissemination tools

ITU offers a number of information dissemination tools to its members, including websites, bulletin boards, email reflectors, forum discussions, newslogs, interactive calendars etc. One recent innovation is the use of a *wiki* created by the ITU-T Focus Group on Identity Management (see: http://www.ituwiki.com/) and subsequently used for other purposes.

GLOSSARY OF ABBREVIATIONS AND ACRONYMS

21CN	Twenty-first Century Network
2G	Second Generation mobile communications
3G	Third Generation mobile communications
BOINC	Berkeley Open Infrastructure for Networked Computing
C	Centigrade
CALM	Continuous Air Interface for Long and Medium Range communications
CDM	Clean Development Mechanism
CFC	Chlorofluorocarbon gases
CO_2	Carbon dioxide
CS	ITU Constitution
DVD	Digital Versatile Disc
ETNO	European Telecommunication Network Operators' association
EU	European Union
GEO	Group on Earth Observations
GDP	Gross Domestic Product
GeSI	Global eSustainability Initiative
GHG	Greenhouse Gases
GOS	Global Observing System
G-PON	Gigabit Passive Optical Network
GPS	Global Positioning by Satellite
$GtCo_2$-eq	Gigatonnes of Carbon Dioxide equivalent
GTS	Global Telecommunication System
GW	GigaWatts
ICTs	Information and Communication Technologies
IEC	International Electrotechnical Commission
IOC	International Oceanographic Commission
IPCC	Intergovernmental Panel on Climate Change
IPTV	Internet Protocol Television
ISO	International Organization for Standardization
ITS	Intelligent Transport Systems
ITU	International Telecommunication Union
ITU-D	ITU Telecommunication Development Sector
ITU-R	ITU Radiocommunication Sector
ITU-T	ITU Telecommunication Standardization Sector
NGN	Next-Generation Network
NMS	National Meteorological Service
OCHA	Office for the Coordination of Humanitarian Affairs
PC	Personal Computer
PCP-TDR	Partnership Coordination Panel on Telecommunications for Disaster Relief
RA	Radiocommunication Assembly
RFID	Radio Frequency Identification
SG	Study Group
SMS	Short Message Service
TSAG	Telecommunication Standardization Advisory Group (in ITU-T)
UN	United Nations
UNEP	United Nations Environment Programme
UNESCO	United Nations Educational Scientific and Cultural Organization
UNFCCC	United Nations Framework Convention on Climate Change
USN	Ubiquitous Sensor Network
VDSL	Very high speed Digital Subscriber Line
WG	Working Group
WMO	World Meteorological Organization
WRC	World Radiocommunication Conference

WSIS	World Summit on the Information Society
WTDC	World Telecommunication Development Conference
WTSA	World Telecommunication Standardization Assembly
WWF`	World Wide Fund for nature
WWW`	World Weather Watch System

REFERENCES AND SOURCES OF FURTHER INFORMATION

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12 For an account of the history of the science of climate change, see Spencer Weart’s website at: http://www.aip.org/history/climate/index.html.

13 Resolution 673 (WRC-07, Geneva), “Radiocommunications use for Earth observation applications”, is available in the Provisional Final Acts (as Resolution COM 6/23) at: http://www.itu.int/md/R07-WRC07-R-0001/en.

14 WRC-07 was the biggest Radiocommunication meeting in ITU history with participation of more than 2’800 participants from 164 ITU Member States and 104 observer organizations. The World Radiocommunication Conferences are empowered to modify the Radio Regulations – an international treaty.

15 The World Weather Watch programme is described at: http://www.wmo.int/pages/prog/www/index_en.html and the global observing system at: http://www.wmo.int/pages/prog/www/OSY/GOS.html.

16 See for instance http://www.climateprediction.net/index.php which claims to be the world’s largest experiment on climate modeling and uses a programme called BOINC (Berkeley Open Infrastructure for Networked Computing) for distributed computing.

17 Ubiquitous Sensor Networks are the subject of the 4th ITU Technology Watch Briefing Report (February 2008), available at: http://www.itu.int/dms_pub/itu-t/oth/23/01/T23010000040001PDFE.pdf.

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