FINAL REPORT

ITU-D STUDY GROUP 2

QUESTION 24/2

ICT AND CLIMATE CHANGE

5TH STUDY PERIOD 2010-2014

Telecommunication Development Sector

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QUESTION 24/2:

ICT and climate change

ITU-D Study Groups

In support of the knowledge sharing and capacity building agenda of the Telecommunication Development Bureau, ITU-D Study Groups support countries in achieving their development goals. By acting as a catalyst by creating, sharing and applying knowledge in ICTs to poverty reduction and economic and social development, ITU-D Study Groups contribute to stimulating the conditions for Member States to utilize knowledge for better achieving their development goals.

Knowledge Platform

Outputs agreed on in the ITU-D Study Groups and related reference material are used as input for the implementation of policies, strategies, projects and special initiatives in the 193 ITU Member States. These activities also serve to strengthen the shared knowledge base of the membership.

Information Exchange & Knowledge Sharing Hub

Sharing of topics of common interest is carried out through face-to-face meetings, e-Forum and remote participation in an atmosphere that encourages open debate and exchange of information.

Information Repository

Reports, Guidelines, Best Practices and Recommendations are developed based on input received for review by members of the Groups. Information is gathered through surveys, contributions and case studies and is made available for easy access by the membership using content management and web publication tools.

Study Group 2

Study Group 2 was entrusted by WTDC-10 with the study of nine Questions in the areas of information and communication infrastructure and technology development, emergency telecommunications and climate-change adaptation. The work focused on studying methods and approaches that are the most suitable and successful for service provision in planning, developing, implementing, operating, maintaining and sustaining telecommunication services which optimize their value to users. This work included specific emphasis on broadband networks, mobile radiocommunication and telecommunications/ICTs for rural and remote areas, the needs of developing countries in spectrum management, the use of ICTs in mitigating the impact of climate change on developing countries, telecommunications/ICTs for natural disaster mitigation and relief, conformance and interoperability testing and e-applications, with particular focus and emphasis on applications supported by telecommunications/ICTs. The work also looked at the implementation of information and communication technology, taking into account the results of the studies carried out by ITU-T and ITU-R, and the priorities of developing countries.

Study Group 2, together with ITU-R Study Group 1, also deals with Resolution 9 (Rev. WTDC-10) on the "Participation of countries, particularly developing countries, in spectrum management".

This report has been prepared by many experts from different administrations and companies. The mention of specific companies or products does not imply any endorsement or recommendation by ITU.

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0 Introduction

The earth's climate has always changed, flowing through series of warming and cooling cycles, with paleoclimatology enabling us to determine major climate variations through the ages. However, recent large-scale anthropogenic influences have led to dramatic changes and the Earth has entered into a warming cycle of unprecedented speed. Climate change is therefore a reality and is probably one of the biggest long term challenges in the history of humankind, as it challenges our ability to achieve economic and social objectives in support of sustainable development. The adverse effects of climate change are likely to fall disproportionately on developing countries, given their limited resources.

What is climate change?

Basically, it refers to a statistically significant variation in either the mean state of the climate or in its variability, persisting for an extended period (typically decades or longer). Climate change may be due to natural internal processes or to persistent anthropogenic changes in the composition of the atmosphere or in land use. The United Nations Framework Convention on Climate Change (**UNFCCC**), in its Article 1, defines "climate change" as: "a change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods".

What are ICTs?

ICTs cover a wide range of technologies for gathering, storing, retrieving, processing, analysing and transmitting information in digital form. ITU is committed to working, together with other organizations, to combat climate change, and plays a leading role, within the United Nations, in developing an integrated approach to examining the relation between ICTs and climate change. On the one hand, ICTs contribute to climate change, and, on the other hand, ITU studies serve to show that new technologies can be energy efficient and to highlight the beneficial role that ICTs can play in combating global warming.

Earth observation from space enables us to monitor the planet and plays a crucial role in helping us understand the current state of the climate and how it may evolve. ICT and radiocommunications are vital tools to combat against climate change, they contribute to the operational monitoring of the climate and detection of global climate changes. The continued observations of geophysical parameters in the atmosphere, oceans and land surface are essential to monitor the climate on our planet. The availability of accurate climate information collected over decades will benefit mankind at all levels and will, in a wide range of areas, assist regional and national planners to better assess the potential impacts of climate change and thereby select the most appropriate options for their infrastructure planning.

What is the link between ICT and Climate change?

ICTs make a valuable contribution to mitigating, and adapting to, climate change. ITU-D assists countries in combating climate change using ICTs, facilitating the mobilization of technical, human and financial resources needed for their implementation and promoting access to ICTs. Recent studies have shown that ICTs make a positive contribution to reducing greenhouse gas (GHG) emissions, saving about one to four times their own emissions over the rest of the economy. At the same time, while ICTs make a positive contribution to reducing GHG emissions, they are themselves large energy consumers. Today, consumption by all ICTs (computers, televisions, phones and chargers, Internet boxes, servers and data centres) amounts in some countries to around 2 per cent of global carbon emissions in 2008[1] or 7.15 world power electricity consumption. These figures could climb even higher in the coming years if current growth rates are maintained. In 2020, the world power electricity consumption dedicated to ICT would become 14.6 %[2]. This report examines the links between ICTs, climate change and development, as these three spheres become increasingly interlocked due to the magnifying effect of climate change on existing development challenges and vulnerabilities.

1 Climate change

The Earth's climate has changed over the last century with various factors tending to indicate that most of the warming observed over the past 50 years is essentially attributable to human activities. Indeed, primarily through those activities, the human being is modifying the composition of the atmosphere, and it is now being said that humankind has entered the Anthropocene era.

Moreover, computer models were already predicting that temperatures would continue to rise over the twenty-first century. This was revealed by the Third Assessment Report of the Intergovernmental Panel on Climate Change (IPCC)[3], the elaboration of which involved several hundred scientists from many countries.

The IPCC Report (2007) states as follows.

"Warming of the climate system is unequivocal, as is now evident from observations of increases in global average air and ocean temperatures, widespread melting of snow and ice and rising global average sea level. Eleven of the last twelve years (1995-2006) rank among the twelve warmest years in the instrumental record of global surface temperature (since 1850). The 100-year linear trend (1906-2005) of 0.74 [0.56 to 0.92] ° C is larger than the corresponding trend of 0.6 [0.4 to 0.8]°C (1901-2000). The linear warming trend over the 50 years from 1956 to 2005 (0.13 [0.10 to 0.16] ° C per decade) is nearly twice that for the 100 years from 1906 to 2005."

To complete with the main findings of the the 2012 IPCC report: explain the various scenari envisaged by IPCC.

According to the **State of the Climate in 2010** report, published by the National Oceanic and Atmospheric Administration (NOAA), the air temperature above land in 2010 was the second warmest on record. The Arctic is continuing to warm at about twice the rate of regions in lower latitudes. Locally and regionally, changes in temperature can influence the distribution of expected weather, alter precipitation patterns, and affect trends in many other climate indicators. Those indicators continue to capture the underlying march of long-term trends, such as the steady increase in GHG concentrations and the loss of Greenland's ice sheet.
The **State of the Climate in 2011**[4] report, published by the National Oceanic and Atmospheric Administration (NOAA), indicates that the annual global combined land and ocean surface temperature was 0.51°C above the 20th century average of 13.9°C. 2011 is the 35th consecutive year, since 1976, that the yearly global temperature was above average. Only one year during the 20th century, 1998, was warmer than 2011.The warmest years on record were 2010 and 2005, which were 0.64°C above average. Separately, the 2011 global average land surface temperature was 0.8°C above the 20th century average of 8.5°C and ranked as the eighth warmest on record. The 2011 global average ocean temperature was

[1] www.gartner.com/it/page.jsp?id=503867

[2] Overall ICT Footprint and Green Communication Technologies, Proceedings of the 4th International Symposium on Communications, Control and Signal Processing, ISCCSP 2010, Limassol, Cyprus, 3-5 March 2010

[3] www.ipcc.ch/publications_and_data/publications_ipcc_fourth_assessment_report_synthesis_report.htm

[4] State of the climate in 2011, NOAA

0.40°C above the 20th century average of 16.1°C and ranked as the 11th warmest on record. In addition, La Niña contributed to weather and climate patterns around the world in 2011: when compared to previous La Niña years, the 2011 global surface temperature was the warmest observed during such a year. Many extreme events occurred at regional and local levels and la Niña contributed to some but not all of these events. Regarding the arctic ice, it is to be mentioned that in September 2011, the sea ice extent was the second smallest since the satellite era began. In Greenland the ice sheet, due to the above-average air temperatures and declining albedo (reflectivity), had shown an extreme level of melting and mass loss as well.

According to **NASA** (Goddard Institute for Space Studies or GISS)[5], 2012 was the ninth warmest of any year since 1880, continuing a long-term trend of rising global temperatures. With the exception of 1988, the nine warmest years in the 132-year record all have occurred since 2000, with 2010 and 2005 ranking as the hottest years on record. GISS, which monitors global surface temperatures on an ongoing basis, released an analysis that compares temperatures around the globe in 2012 to the average global temperature from the mid-20th century. The comparison shows how Earth continues to experience warmer temperatures than several decades ago. The record dates back to 1880 because that is when there were enough meteorological stations around the world to provide global temperature data. The average temperature in 2012 was about 14.6°C, which is 0.6°C warmer than the mid-20th century baseline. The average global temperature has risen about 0.8°C since 1880, according to this analysis.
Scientists emphasize that weather patterns always will cause fluctuations in average temperature from year to year, but the continued increase in greenhouse gas levels in Earth's atmosphere assures a long-term rise in global temperatures. Each successive year will not necessarily be warmer than the year before, but on the current course of greenhouse gas increases, scientists expect each successive decade to be warmer than the previous decade. What matters is this decade is warmer than the last decade, and that decade was warmer than the decade before. The planet is warming. The main reason it's warming is because human mankind is pumping increasing amounts of carbon dioxide into the atmosphere. Carbon dioxide is a greenhouse gas that traps heat and largely controls Earth's climate. It occurs naturally and also is emitted by the burning of fossil fuels for energy. Driven by increasing man-made emissions, the level of carbon dioxide in Earth's atmosphere has been rising consistently for decades. In 1880, the CO_2 concentration in the atmosphere was about 285 parts per million by volume. In 1960, it reached 315 parts per million, as measured by the U.S. National Oceanic and Atmospheric Agency (NOAA). Today, this concentration exceeds 390 parts per million. This is the highest level reached in at least 800,000 years.

The **State of the Climate in 2012**[6] report, published by the National Oceanic and Atmospheric Administration (NOAA), indicates that the year 2012 was the 10th warmest year since records began in 1880. The annual global combined land and ocean surface temperature was 0.57°C above the 20th century average of 13.9°C. This marks the 36th consecutive year (since 1976) that the yearly global temperature was above average. Currently, the warmest year on record is 2010, which was 0.66°C above average. Including 2012, all 12 years to date in the 21st century (2001–2012) rank among the 14 warmest in the 133-year period of record. Only one year during the 20th century—1998—was warmer than 2012.

The 2012 global average land surface temperature was 0.90°C above the 20th century average of 8.5°C and ranked as the seventh warmest year on record. La Niña, which is defined by cooler-than-normal waters in the eastern and central equatorial Pacific Ocean that affect weather patterns around the globe, was present during the first three months of 2012. The weak-to-moderate La Niña dissipated in the spring and was replaced by ENSO-neutral conditions for the remainder of the year. When compared to previous La Niña years, the 2012 global surface temperature was the warmest observed during such a year; 2011 was the previous warmest La Niña year on record. The 2012 global average ocean temperature was 0.45°C above the 20th century average of 16.1°C and ranked as the 10th warmest year on record. It was

[5] www.giss.nasa.gov/research/news/20130115/

[6] www.ncdc.noaa.gov/sotc/global/2012/13

also the warmest year on record among all La Niña years. The three warmest annual ocean surface temperatures occurred in 2003, 1998, and 2010—all warm phase El Niño years.

1.1 Scientific factors

There are numerous causes of climate change, many of them natural (such as variations in solar radiation, and volcanic activity). However, it is man-made climate change that is of greatest concern because it appears to be leading to a progressive and accelerating warming of the planet, as a result of the release of GHG, primarily carbon-based, emissions. The work of IPCC shows that global GHG emissions have risen by 70 per cent since 1970.

The reports of the World Meteorological Organization (WMO)/United Nations Environment Programme (UNEP), drawn up with the assistance of IPCC, are essential to the accumulation and dissemination of greater knowledge about man-made climate change, and to laying the foundations for the measures that are needed to counteract such change.

The scientific factors whose convergence is giving rise to global warming are as follows[7]:

1. Air temperatures are increasing. Since 1970, satellite measurements have been added to those taken by ground-based meteorological stations, enabling seamless coverage of the entire planet.
2. The oceans are warming up. Since the 1980s, the surface temperatures of the oceans have been regularly measured by satellites, in addition to which several hundred drifting buoys have been deployed in all the world's seas. Temperature profiles down to depths of 2000m are periodically effected to determine the temperature and salinity of the entire water column.
3. Mountain ice is receding, it being a well-known fact that mountain glaciers enable researchers to conduct lengthy series of measurements.
4. The polar ice caps are sliding more rapidly towards the sea. Greenland and the Antarctic are between them reported to have been shrinking by some 500 billion tons of ice per year over the past ten years or so, with the annual loss increasing by some 36 billion tons.
5. The sea level is rising. Sea-level gauges have revealed an annual 1.6 to 1.8 mm rise in sea level during the last century. Since the 1990s, altimetry satellites have been in use, showing that from 1993 to 2010, the oceans have been rising by an average 3.3 mm per year, i.e. twice as rapidly as the rise recorded by sea-level gauges during the twentieth century. This acceleration is confirmed by recent measurements using sea-level gauges.
6. Sea ice is disappearing. Since 1978, satellites have detected a reduction in the ice coverage of the Arctic Ocean, from 8 million km^2 in 1980 to 4.33 million km^2 in 2011.
7. In the northern hemisphere, terrestrial species are moving northwards.
8. The permafrost is warming.

Changes in climate are the result both of internal variability within the climate system and of external factors (both natural and anthropogenic). Anthropogenic emissions are significantly modifying the concentrations of some gases in the atmosphere. Some of these gases are expected to affect the climate by changing the Earth's radiative balance, measured in terms of radiative forcing. GHGs, which have a global effect, tend to warm the Earth’s surface by absorbing some of the infrared radiation it emits. The principal anthropogenic GHG is carbon dioxide (CO_2), the concentration of which has increased by 31 per cent since 1750 to a level that has probably not been exceeded for 20 million years. This increase is predominantly due to fossil fuel burning, but also to changes in land use, especially deforestation. The

[7] La Recherche : ce que mesurent les spécialistes, 01/11/2011 par Lise Barnéoud dans mensuel n°457

global atmospheric concentration of CO_2 has increased from pre-industrial values of about 280 ppm (parts per million, an atmospheric measurement based on carbon molecules) to 385 ppm in 2008. With an annual growth of 2 ppm per year, it exceeds by far the variations observed over the last 650 000 years (180 to 300 ppm)[8]. IPCC has set the climate-warning threshold at 450 ppm, while some scientists advocate an upper limit of 350 ppm to avoid exceeding that threshold. The other significant anthropogenic GHGs are methane (CH_4) (151 per cent increase since 1750, one-third of CO_2's radiative forcing), halocarbons such as CFCs and their substitutes (100 per cent anthropogenic, one quarter of CO_2's radiative forcing) and nitrous oxide (N_2O) (17 per cent increase since 1750, one-tenth of CO_2's radiative forcing).

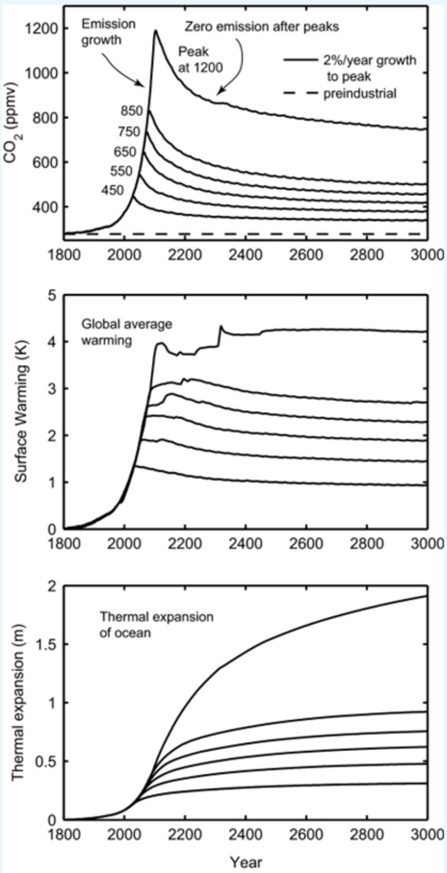
Some scientists[9] are pointing the issue of the potential for irreversibility. They claim that climate change that takes place due to increases in carbon dioxide concentration, is largely irreversible for 1,000 years after emissions stop. Following cessation of emissions, removal of atmospheric carbon dioxide decreases radiative forcing, but is largely compensated by slower loss of heat to the ocean, so that atmospheric temperatures do not drop significantly for at least 1,000 years. Among illustrative irreversible impacts that should be expected if atmospheric carbon dioxide concentrations increase from current levels around 390 parts per million (ppm) to a peak of 450–600 ppm over the coming century are irreversible dry-season rainfall reductions in several regions comparable to those of the “dust bowl” era and inexorable sea level rise. Thermal expansion of the warming ocean provides a conservative lower limit to irreversible global average sea level rise of at least 0.4–1.0 m if 21st century CO_2 concentrations exceed 600 ppm and 0.6–1.9 m for peak CO_2 concentrations exceeding ≈1,000 ppm. Additional contributions from glaciers and ice sheet contributions to future sea level rise are uncertain but may equal or exceed several meters over the next millennium or longer.

The following figure illustrate the consequences on parameters such as surface warming and thermal expansion if CO_2 emissions increase at a rate of 2%/year to peak CO_2 values of 450, 550, 650, 750, 850, and 1200 ppmv, followed by zero emissions (in 2100, the concentration would equal 735 ppm). The rate of global fossil fuel CO_2 emission grew at ≈1%/year from 1980 to 2000 and >3%/year in the period from 2000 to 2005 (13). Results have been smoothed using an 11-year running mean. Warming over land is expected to be larger than these global averaged values, with the greatest warming expected in the Arctic. Sea level rise (meters) from thermal expansion only (not including loss of glaciers, ice caps, or ice sheets).

[8] Que sais-je ? Le réchauffement climatique, le grand risque, n° 3650, §1 La transformation de l’atmosphère planétaire

[9] Irreversible climate change due to carbon dioxide emissions Proc Natl Acad Sci U S A. 2009 Published online 2009 January 28. Environmental Sciences

Figure 1: Correlation between carbon dioxide concentration and global warming phenomena and its irreversibility during 1000 years



According to IPCC, temperatures are expected to increase by 1.8 to 4°C by the end of the twenty-first century by comparison with the period 1980-1999.

Climate change is liable to affect millions of people, particularly in terms of water shortages, not to mention sea-level rises and the extreme impact they will have on many coastal cities worldwide.

1.2 Extreme phenomena and climate change

Based on observations collected from 1950, there is evidence that the extremes change, because of anthropogenic influences, including increases in greenhouse gas emissions in the atmosphere.

Throughout the world, the increasing occurrence of extreme climate phenomena caused by climate change is having a decisive impact on the manner in which people initiate and maintain development.

Although most people do not feel the increase in average temperature, two studies published in the February 2011 edition of Nature express the conclusion that global warming is already causing extreme climate phenomena[10] that are affecting the lives of millions of people. The research establishes a direct link between the increase in GHG levels and the growing intensity of precipitation in the form of rain and snow in the northern hemisphere, coupled with a higher risk of flooding. Scientists are convinced that

[10] www.sciencemag.org/content/309/5742/1844.full

estimates of internal climate variability cannot explain the increased precipitation intensity observed during the second half of the twentieth century. For over ten years now, it has been acknowledged that the number of extreme rainfall episodes has been on the increase in certain parts of the northern hemisphere. However, scientists have now for the first time been able to successfully and clearly establish the anthropogenic contribution to this phenomenon.

The 2007 IPCC report states the following.

"Some extreme weather events have changed in frequency and/or intensity over the last 50 years:

– It is very likely that cold days, cold nights and frosts have become less frequent over most land areas, while hot days and hot nights have become more frequent.

– It is likely that heat waves have become more frequent over most land areas.

– It is likely that the frequency of heavy precipitation events (or proportion of total rainfall from heavy falls) has increased over most areas.

– It is likely that the incidence of extreme high sea level has increased at a broad range of sites worldwide since 1975.

There is observational evidence of an increase in intense tropical cyclone activity in the North Atlantic since about 1970, and suggestions of increased intense tropical cyclone activity in some other regions where concerns over data quality are greater. Multi-decadal variability and the quality of the tropical cyclone records prior to routine satellite observations in about 1970 complicate the detection of longterm trends in tropical cyclone activity."

In addition, an IPCC report in 2012[11] on extreme events states the following.

"There is evidence that some extremes have changed as a result of anthropogenic influences, including increases in atmospheric concentrations of greenhouse gases"

In general[12], models of 21st-century climate tend to reduce the number of tropical cyclones observed by 0-10% for every °C of global warming. The average intensity is projected to increase by 1-4% per 1°C, with destructive power (the cube of the wind speed) growing by 3-12% per 1°C.

Calculations based on the expected global increase in water vapor show a potential 7% rise per 1°C in the amount of rain falling within 100 kilometers of a tropical cyclone's center. Although most tropical oceans are expected to warm, a strong case has been made that it is the *relative* amount of warming among oceans that affects where hurricanes increase or decrease in number. Because of the circulation pattern of rising and sinking air driven by relatively warm and cool tropical waters, respectively, regions with warmer sea surface temperatures will tend to generate more cyclones at the expense of regions where less warming occurs. While the tropical Atlantic has warmed more rapidly than the other tropical oceans over the past few decades, models provide no consensus that this will continue into the future.As already explained before, we know that when the atmosphere has one degree Celsius more, it contains about 7% more moisture[13],. This scientific fact may explain the increased precipitation during extreme phenomena that are observed in North America, Central and South-East Asia. This is an undisputed fact: as the temperature increases, the hydrological cycle intensifies[14] encouraging heavier precipitation globally. The overall higher temperatures tend to increased levels of evaporation and water vapour in the atmosphere that explain these higher precipitation levels –sometimes replacing snowfalls.

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[11] IPCC, 2012: Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation.

[12] Warming world : impact by degree. Based on the National Research Council report, Climate Stabilization Targets: Emissions, Concentrations, and Impacts over Decades to Millennia (2011)

[13] La Recherche, Février 2013, réchauffement climatique 1, page 38

[14] Space Technologies and climate change, OECD 2008, see chapter 1 page 22

Another type of unexpected extreme event[15] that may occur is in connection with the melting of glaciers in the mountains, especially in the Himalayas. When a natural dam bursts with erosion due to water pressure or when earthquakes, tons of ice and stones descend and can cause tsunamis. At least 50 tsunamis of this type have occurred in the last century in the Himalayas and this phenomenon may well increase with rising temperatures. Many lakes in some areas in the Himalayas created due to the melting of the glaciers, are considered hazardous and therefore can cause serious risks to people living in those areas.

1.3 Sources of climate change

Since the early eighteenth century, human (anthropogenic) activities have been disturbing the carbon cycle on account of anthropogenic emissions of CO_2 into the atmosphere (use of fossil fuels) and deforestation.

The Earth's climate is influenced by many factors, such as the amount of GHGs and aerosols in the atmosphere, the amount of energy coming from the sun and the properties the Earth's surface. Changes in those factors, caused by human-related or natural processes, have a warming or a cooling effect on the planet because they alter how much of this solar energy is retained or reflected back into space.

The atmospheric concentrations of GHGs such as carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O) have all increased markedly since 1750, and now far exceed their pre-industrial levels.

Carbon dioxide is the most important anthropogenic GHG. Its concentration in the atmosphere (379 ppm in 2005) is now far higher than the natural range over the last 650 000 years (180 to 300 ppm) and has been growing faster than ever since the beginning of its continuous direct measurement in 1960, mainly on account of fossil fuel use and, to a lesser extent, changes in land use. In almost one million years, the Earth's atmosphere has never experienced such high concentrations of CO_2. For instance, CO_2 emissions from fossil fuel use increased from 6.4 Gt per year in the 1990s to 7.2 Gt per year over the period 2000-2005. Atmospheric concentrations of methane and nitrous oxide have also greatly increased since pre-industrial times, those increases being mostly attributable to human activities such as agriculture and fossil fuel use.[16]

The effect of carbon dioxide on the temperature has been examined[17]. The human contribution to global warming is due to increases in the concentration of greenhouse gases and aerosol particles, which alter the Earth's energy budget. In the special case of the greenhouse gas carbon dioxide, cumulativeemissions are also an important metric or measure of the effect of humans on the climate system. The best estimate is that 1,000 gigatonnes of human-emitted carbon emissions leads to about 1.75°C increase in global average temperature. Cumulative carbon emissions to date (2010) are about 500 gigatonnes, and the rate of global emissions is increasing. Based on current understanding, this warming is expected to be nearly irreversible for more than 1,000 years. The higher the total or cumulative carbon dioxide emitted and the higher the resulting atmospheric concentration, the higher the warming will be for the next thousand years. Higher emissions would lead to more warming over many thousands of years, allowing more time for key but slow components of the Earth system to act as amplifiers of climate change. For example, warming of the deep ocean over many centuries will release additional carbon stored in deep-sea sediments, and the Greenland ice sheet could shrink or even disappear if global warming remained in the range of 3.5°-5.0°C for several thousand years, raising global sea level by about 4-7.5 meters.

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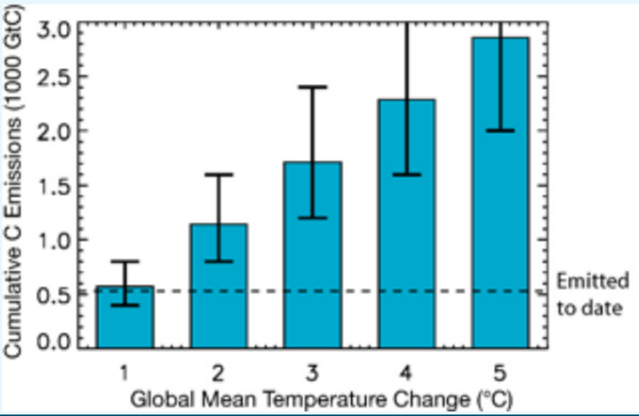
[15] www.7sur7.be/7s7/fr/2665/Rechauffement-Climatique/article/detail/1654151/2013/06/20/L-Himalaya-menace-par-les-tsunamis.dhtml

[16] http://co2now.org/

[17] Warming world : impact by degree. Based on the National Research Council report, Climate Stabilization Targets: Emissions, Concentrations, and Impacts over Decades to Millennia (2011)

Figure 2: Cumulative emissions and increases in global mean temperature



The previous figure illustrates that recent studies show that cumulative carbon dioxide emission is a useful metric for linking emissions to impacts. Error bars reflect uncertainty in carbon cycle and climate responses to carbon dioxide emissions due to observational constraints and the range of model results. Cumulative carbon emissions are in teratonnes of carbon (trillion metric tonnes or 1000 gigatonnes)

1.4 United Nations conferences on climate change

1.4.1 United Nations Framework Convention on Climate Change (UNFCCC)

The United Nations Framework Convention on Climate Change (UNFCCC)[18], was adopted on 9 May 1992, in New York and opened for signature at the 'Rio Earth Summit' in Rio de Janeiro in June 1992. Entering into force in March 1994, it has achieved near universal ratification as of September 2011 with ratification by 194 Parties (194 States and 1 regional economic integration organization)[19]. The signatory States initially committed themselves to a list of measures (national inventories, change mitigation programmes, application and diffusion of appropriate technologies, preparations for dealing with consequences, etc.).

These were used to create the 1990 benchmark levels for accession of Annex I countries to the Kyoto Protocol and for the commitment of those countries to GHG reductions.

The ultimate objective of the Convention and any related legal instruments that the Conference of the Parties may adopt is to achieve, in accordance with the relevant provisions of the Convention stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system (Article 4).

The secretariat (Climate Change Secretariat) whose mandate is laid out in Article 8 of the Convention has been located in Bonn, Germany since August 1996 from its prior location of Geneva, Switzerland[20]. IPCC plays a key role as the entity providing scientific support to the secretariat.

In particular, Article 2 of the convention reads as follows:

"The ultimate objective of this Convention and any related legal instruments that the Conference of the Parties may adopt is to achieve, in accordance with the relevant provisions of the Convention, stabilization of GHG concentrations in the atmosphere at a level that would prevent dangerous

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[18] http://unfccc.int/essential_background/convention/background/items/2853.php

[19] http://unfccc.int/essential_background/convention/status_of_ratification/items/2631.php

[20] https://unfccc.int/secretariat/history_of_the_secretariat/items/1218.php

anthropogenic interference with the climate system. Such a level should be achieved within a time-frame sufficient to allow ecosystems to adapt naturally to climate change, to ensure that food production is not threatened and to enable economic development to proceed in a sustainable manner."

Since 2007, the Parties to UNFCCC have been working to elaborate an adaptation framework intended to enhance international cooperation and action on adaptation. Expectations are that this will facilitate in reducing vulnerability and build resilience in all countries, in particular developing countries, and especially those that are particularly vulnerable to the harmful effects of climate change. Recognizing that the effectiveness of cooperation and of adaptation measures depends on the commitment of all concerned, the Parties invited competent multilateral, international, regional and national organizations, the public and private sectors, civil society and other relevant players to commit themselves to, and support action in favour of, coherent and integrated adaptation.

1.4.2 ITU participation in the Framework Convention process

Outside UNFCCC, seven symposia organized by ITU on the subject of "ICTs and climate change", the most recent of which was held in Montreal in May 2012, have served to highlight the important role that ICTs can play in reducing total GHG emissions. This report reflects many of the conclusions and contributions from those symposia.

The Union has also played an active part in the Framework Convention process, including at the 16th Conference of the Parties (COP-16), held in Cancún (Mexico) from 29 November to 10 December 2010, and the one held in Durban in December 2011. ITU organized several events on the sidelines of this conference, attracting numerous participants.

The United Nations conference on climate change held in Cancún (Mexico) ended with the adoption of the Cancún Agreements, which many consider to be a balanced compromise. Those agreements provide for the following:

- Within the framework of the multilateral process, it is officially recognized that industrialized countries have objectives and that those countries must elaborate low-carbon development plans and strategies, determine how best to implement them, including through market-based mechanisms, and submit annual inventories.
- Within the framework of the multilateral process, it is officially recognized that developing countries are to take measures to reduce emissions. A register must be established for recording mitigation measures taken by developing countries and for ensuring that the appropriate level of financial and technological support for those measures is provided by industrialized countries. Developing countries must publish biennial progress reports.
- The Conference of the Parties, acting as the meeting of the Parties to the Kyoto Protocol, decided to continue with the negotiations in order to complete its work and avoid any hiatus between the first and second commitment periods. This point will be examined at the next session of the Conference of the Parties, to be held in Durban.
- The Clean Development Mechanism foreseen under the Kyoto Protocol has been strengthened to ensure that ecologically rational and sustainable emission reduction projects attract more investment and make more use of technologies.
- The Parties have created a body of initiatives and institutions to protect vulnerable populations against climate change and allocate the financial and technological resources needed by developing countries to plan and construct their own sustainable future.
- The decisions provide for a total of USD 30 billion in fast-start finance from industrialized countries to support climate action in the developing world up to 2012, and a commitment to raise USD 100 billion in long-term funds by 2020.
- Where managing the financing of measures to combat climate change is concerned, a mechanism has been put in place for the design of a Green Climate Fund under the authority of the Conference of the Parties and administered by a board comprising developing countries and developed countries in equal number.

- A new "Cancun Adaptation Framework" has been adopted to ensure the more effective planning and implementation of adaptation projects in developing countries through the strengthening of financial and technical assistance, with a clear mechanism for ongoing work in relation to loss and damage.
- Governments have agreed to boost action to curb emissions from deforestation and forest degradation in developing countries through technological and financial support.
- The Parties have established a technology mechanism with a Technology Executive Committee and Climate Technology Centre and Network to increase technology cooperation and support action on adaptation and mitigation.

The decisions adopted by the Conference of the Parties at its 16th session (COP-16) and by the Conference of the Parties serving as the Meeting of the Parties to the Kyoto Protocol (CMP) at its sixth session (CMP-6) are available at: www.unfccc.int.

ITU continues to actively support the negotiations of the Conference of Parties (COP) to the UNFCCC and promote ICTs as an integral part of the solution. Particularly, ITU participated in the 2012 United Nations Climate Change Conference (COP18-CMP8), which took place in Doha, Qatar, in December 2012. Within this event ITU, together with ictQatar, Ericsson and the Broadband Commission organized the side event "The broadband bridge: linking ICTs with climate change for a low carbon future", which gathered relevant stakeholders working around the issue of low carbon technologies. ITU will continue to send official delegations to attend future COP events and to promote the use of ICTs more effectively to tackle climate change related challenges.

1.4.3 Outcomes of the various conferences

1.4.3.1 Kyoto Protocol

The Kyoto protocol, which was negotiated between 1995 and 1997 and entered into force in 2005, provides that countries must meet their targets primarily through national measures. The objective negotiated Kyoto was a 5.2 per cent reduction in GHG emissions by 2012 with respect to the level achieved in 1990. The choice of the 1990 main base year remains in Kyoto, as it does in the original Framework Convention. The treaty came into force 16th February 2005. The reduction quotas are distributed among 38 industrialized countries and should lead, if they are respected between 2008 and 2012, an overall decrease of 5.2% of greenhouse gas emissions in industrialized countries.

However, the Kyoto Protocol offers them additional means of meeting their targets through the use of three market-based mechanisms. The Kyoto mechanisms are:

- Emissions trading – known as "the carbon market". Each State receives a certain emission volume, calculated on the basis of an authorized emission ceiling. The principle is that States allocate to industries a quantity of rights to emit GHGs, expressed in tonnes of CO_2 equivalent. Such rights may be exchanged.
- Joint implementation. A company in one signatory country making an investment in another signatory country obtains quotas (or avoided emissions) thus created and resells them on the emissions market.
- The Clean Development Mechanism (CDM). This mechanism is identical to the preceding one, but applies between a company in a wealthy signatory country and a poor country.

The mechanisms help stimulate green investment and help Parties meet their emission targets in a cost-effective way.

One of the original features of the Kyoto Protocol lies in the possibility of subtracting, in the calculation of the emission balance of industrialized countries, the portion of CO_2 that is stored in the form of carbon by growing forests, referred to as "carbon sinks". It is to be noted that discussion as to the effectiveness of such sinks is ongoing.

Under the Protocol, countries' emissions must be monitored and all exchanges scrupulously recorded. The recording systems register and record transactions effected by the Parties under the mechanisms. The UNFCCC secretariat, located in Bonn (Germany), maintains an International Transaction Log to ensure that transactions are in conformity with the rules established under the Protocol.

The Parties meet their accountability obligation by submitting annual emission inventories and regular national reports under the Protocol.

A system exists to ensure that Parties are meeting their commitments and, should they encounter problems in so doing, to assist them in staying on track.

Where adaptation is concerned, and as provided for in the convention, the Kyoto Protocol also seeks to assist countries in adapting to the harmful effects of climate change by facilitating the elaboration and implementation of technologies capable of increasing resilience to its effects.

1.4.3.2 Copenhagen Agreement

The Copenhagen conference was the 15th UNFCCC Conference of the Parties (COP-15). It was held in Copenhagen (Denmark) from 7 to 18 December 2009. In accordance with the roadmap adopted in 2007 at COP-13, it was the occasion for the 192 countries having ratified the convention to renegotiate an international climate agreement to replace the Kyoto Protocol, initiated at COP-3 in 1997 and whose first phase comes to an end in 2012. COP-15 was also MOP-5, i.e. the fifth annual meeting since the entry into force of the Kyoto Protocol in 2005.

COP-15, the 15th edition of the annual summit of representatives of the countries having ratified UNFCCC, produced the "first genuinely global agreement" aimed at halving GHG emissions by 2050 with respect to those of 1990, in order not to exceed an average increase of 2°C in 2100 with respect to the preindustrial era.

This agreement is not legally binding, since it does not extend the Kyoto protocol, due to expire in 2013. Nor does it specify deadlines or quantitative objectives, whereas in order to stabilize the temperature rise to two degrees with respect to the preindustrial era, industrialized countries should reduce their GHG emissions by 40 per cent by 2020. Each country has committed itself to formulating, by end January 2010, its GHG reduction targets for 2015-2020. Some developing countries nevertheless agreed to implement mitigation measures to combat deforestation at the national level and to publish a biennial progress report on those efforts, while rich countries agreed to devote an annual (from 2020 to 2100) USD 100 billion to developing countries.

1.4.3.3 Cancun Agreements

The objective of the 16th Conference of the Parties (COP-16) was to achieve a "balanced package". The Cancun Agreement recognized that the average temperature increase must be kept below 2°C. However, the Parties to the Convention agreed to review the 2°C target in order to increase the level of commitment to achieving 1.5°C by 2015 in the light of, among other things, the IPCC report to be published in 2014. The Parties agreed on use of the expression "historical responsibility" in the final decision of the conference, but that expression appears only in the part relating to emission reductions by developed countries.

Adaptation to the consequences of climate change is also one of the main concerns of developing countries, especially the most vulnerable countries that are no longer mentioned in the Cancun Agreement. At previous conferences, the vulnerability of African countries and of small island developing states (SIDS) was highlighted; however, owing to a major disagreement among developing countries as to the definition of vulnerability, the reference to Africa and SIDS simply vanished from the text on adaptation.

The Cancun text includes a decision on the establishment of an Adaptation Committee to "promote the implementation of enhanced action on adaptation in a coherent manner", with a new institution being thus created.

The question of loss and damage resulting from climate change – in other words, the implementation of a global insurance system for damage caused by major climate events – was addressed. However, despite the serious climate events experienced during 2010, the parties did not manage to reach agreement on the matter, deciding merely to set up a work programme to that end.

One of the key demands of developing countries was that a global fund be established for adaptation and reduction of emissions in those countries. They also called for equitable representation between developed and developing countries in the fund's administrative board. The Cancun Agreement provides for, among other things, the establishment of a Green Climate Fund.

Regarding the second commitment period under the Kyoto Protocol, which was one of the priorities of COP-16 at Cancun, no agreement on the matter was reached at Cancun.

Concerning protection for carbon sinks, the climate negotiations revolved around two distinct mechanisms, namely LULUCF and REDD.

LULUCF (Land use, land-use change and forestry) is a mechanism which takes into account the absorption of CO_2 through the "breathing" of forests (and by other sinks such as humid areas) in developed countries. The level of absorption is then taken into account in the emission reductions of Annex I countries (industrialized countries).

This mechanism thus measures the natural action of forests in capturing CO_2. It is, however, an extremely complex tool which can unfortunately be used to hide a country's emissions. According to some estimates by NGOs, inadequate LULUCF rules make it possible to "hide" approximately 400 Mt of CO_2 (equivalent to the annual emissions of Spain) each year.

The Cancun negotiations did not bring delegates to an agreement on this issue. The five different options for rules governing LULUCF remain on the negotiating table and will continue to be discussed during the course of this year.

The other mechanism is known as REDD+ (Reducing emissions from deforestation and forest degradation). REDD+ concerns only developing countries, and particularly those with significant forest coverage (to be understood as humid forests).

The REDD mechanism is one of the issues on which most progress has been made in the negotiations. Some countries, such as Norway, have already given several billion dollars to Brazil and Indonesia – countries which were clearly seeking rapid implementation of the REDD mechanism. It is to be noted that REDD is essentially a forest management mechanism aimed at avoiding deforestation.

Regarding protection for carbon sinks, the parties drew up a lengthy and clear list that is contained in the COP decision. This list takes particular account of the right of indigenous peoples.

As to the question of the marketplace, no agreement would appear to have been reached. However, the COP decision states that the support provided by developed countries within the REDD framework must be “adequate and predictable”.

The parties agreed on the creation of a Technology Executive Committee, with the primary task of analysing and providing an overview of technological needs. The parties also agreed on the creation of a Climate Technology Centre and Network to assist countries in the development and deployment of existing technologies and identification of the technological needs at the regional and national levels.

1.4.3.4 Durban Agreement

The countries meeting in Durban (South Africa) in December 2011 put forward a response to the international community in relation to climate change, while recognizing the urgent need to set their collective sights on reducing GHG emissions in order to keep the average global temperature rise below 2°C.

In Durban, governments decided to adopt a universal legal agreement on climate change as soon as possible, but not later than 2015. Work to this end will commence immediately within the framework of a new group known as the Ad Hoc Working Group. They thus decided that the UN climate process must be ambitious, with one of the key elements being the publication of the next IPCC report. It is to be noted that the next major UNFCCC conference on climate change is to be held from 26 November to 7 December 2012 in Qatar.

The following key decisions emerged from COP-17 in Durban:

Green Climate Fund. A standing committee was created to have an overview of climate finance within the UNFCCC framework. It will comprise 20 members, with equal representation of developed and developing countries. A work programme focusing on long-term financing was agreed upon.

Adaptation. The 16-member Adaptation Committee will report to the Conference of the Parties on its efforts to improve the coordination of adaptation measures worldwide. The adaptation capacities of the poorest and most vulnerable in particular have to be strengthened. National adaptation plans will enable developing countries to assess and reduce their vulnerability to climate change. The most vulnerable countries are to receive better protection against loss and damage caused by extreme meteorological events associated with climate change.

Technology. The Technology Mechanism will become fully operational in 2012. Its operational arm will be the Climate Technology Centre and Network.

Support for developing-country action. Governments agreed a registry to record developing-country mitigation actions.

Other key decisions. A forum and work programme on unintended consequences of climate change actions and policies were established. Under the Kyoto Protocol's Clean Development Mechanism, governments adopted procedures to allow carbon-capture and storage projects. Governments agreed to develop a new market-based mechanism to assist developed countries in meeting part of their targets or commitments under the Convention. Details of this will be taken forward in 2012.

1.4.3.5 Doha Agreement

The 2012 UNFCCC climate negotiations in Doha, Qatar (COP 18) [21]concluded on finalizing the rules for the Kyoto Protocol's second commitment period. A series of decisions on transparency, finance, adaptation, and forests (REDD+) was taken. In addition, a work plan to negotiate a new legally binding international climate agreement by 2015 was approved. The goal of keeping global average temperature rise below two degrees C still remains a big challenge[22].

At COP 17 in Durban, the EU agreed to a second commitment period for the Kyoto Protocol (KP2), but there was no time to finalize all the rules. In Doha, the rules for that second commitment period were finally agreed upon, allowing it to move forward for another eight-year period (2013-2020). While countries who have joined this second commitment period (including the EU, Australia, Switzerland, and Norway) only contribute 15 percent of global emissions, this is an important step in that it maintains the only legally binding instrument under the UNFCCC.

With the new legal arrangement, these countries will be able to begin implementing their new commitments from January 1, 2013 without any gaps. KP2 also features an ambition trigger, which requests that KP2 Parties revisit and increase their commitments by 2014 (rather than 2015) in line with the 25-40 percent emissions reductions called for by the IPCC 4th Assessment Report. Indeed, IPCC estimates that industrialized countries need to decrease between 25 and 40% their green gas emissions by 2020 in order not to exceed elevation of temperature of 2° on average. This issue will be considered at a high-level ministerial roundtable in 2014. In addition, developing countries were granted an increase of

[21] http://unfccc.int/meetings/doha_nov_2012/meeting/6815.php#decisions

[22] http://insights.wri.org/news/2012/12/reflections-cop-18-doha-negotiators-made-only-incremental-progress

the “Share of Proceeds,” a means to use a percentage of the revenue generated by carbon market mechanisms to help developing countries meet the cost of climate change adaptation.

COP 18 also made decisions on two important adaptation matters: National Adaptation Plans and the Adaptation Committee.

COP 18 launched a new set of adaptation planning efforts by approving a set of technical guidelines to help Parties develop National Adaptation Plans (NAPs). NAPs are envisioned as long-term, flexible, and iterative planning processes to help build adaptive capacity and respond to climate change. This is a departure from the adaptation planning approach taken in the past under the National Adaptation Programs of Action (NAPAs), which were short-term, highly project-based, and limited in implementation to the LDC Parties. The COP called on the Global Environment Facility (GEF) to use the existing Least Developed Countries’ Fund (LDCF) to meet the full cost of preparing the NAPs for LDCs. It also asked bilateral and multilateral funders and the GEF Special Climate Change Fund to help non-LDC developing country Parties develop their NAPs.

COP 18 also approved the three-year work plan of the Adaptation Committee, which represents an important new effort to promote coherence among the many adaptation negotiation streams under the Convention. The Committee also aims to support synergies between the UNFCCC and the adaptation activities of organizations outside the Convention, and will provide technical support and guidance to the Parties. An annual forum held by the Committee in conjunction with COP will be an important vehicle for improving global exchange and lesson-learning on adaptation.

2 Climate change monitoring

Observation of the "Earth system" is the fundamental and unquestionable cornerstone for all scientific climate studies. Today, global climate observation relies on a network of operational satellites in polar and geostationary orbits, as well as on a global observation network using ground-based sensors.

2.1 Background

2.1.1 ITU-R

The use of Earth observation satellites provides systematic and homogeneous measurements in support of the scientific analysis. ITU-R is responsible for identifying the necessary radio-frequency spectrum for climate monitoring, disaster prediction and detection and relief operations, including through the establishment of cooperative arrangements with the World Meteorological Organization (WMO) in the field of remote-sensing applications.

ITU-R plays an important role in climate change monitoring through Resolutions 646 (WRC-03), 647 (WRC-07) and 673 (WRC-07) on use of radiocommunications for environmental monitoring, public protection and disaster relief. The Radio Sector manages the detailed coordination and recording procedures for space systems and earth stations, which are used for climate data collection and environmental monitoring.

ITU-R Study Group 7 (SG 7), in particular Working Party 7C (WP 7C), deals with radio-based devices called sensors (passive or active), which are the main tools for global monitoring of the geophysical parameters of the Earth and its atmosphere. Environmental information, including climate monitoring data, is currently being obtained through the measurements taken by sensors which analyse the characteristics of received radio waves. Space-based sensors are the only tools that provide environmental data on a long-term, repetitive, reliable and global scale.

WRC-07 adopted a number of resolutions on studies related to remote sensing, which is a vital component in the science of climate change. Resolution 673 (Rev. WRC-12), on the importance of Earth observation radiocommunication applications, comes under WRC-12 Agenda item 8.1 and calls for ITU-R studies on possible means to improve the recognition of the essential role and global importance of Earth observation radiocommunication applications and the knowledge and understanding of administrations regarding the utilization and benefits of these applications. These studies resulted in an ITU-R RS report (See ITU-R Report RS.2178: The essential role and global importance of radio spectrum use for Earth observations and for related applications).

Most of the data for the WMO Global Observing System (GOS) and Global Climate Observing System (GCOS) are provided by radiocommunication systems and radio-based applications operating in the Earth-exploration satellite, meteorological-aids and meteorological satellite services. These systems are described in a number of ITU-R Recommendations. In particular, WP 7C has developed a Recommendation on the use of remote sensing in the study of climate change and its effects (see new Recommendation ITU-R RS.1883: use of remote sensing systems in the study of climate change and the effects thereof). ITU-R Study Group 7 (Science services), in cooperation with the World Meteorological Organization, produced a WMO and ITU Handbook on Use of Radio spectrum for meteorology: weather, water and climate monitoring and prediction providing information on the development and proper use of radiocommunication systems and radio-based technologies for environmental observation, climate control, weather forecasting and natural and man-made disaster prediction, detection and mitigation.

In the ITU-R Report "The essential role and global importance of radio spectrum use for Earth observations and for related applications", it is stressed that information about climate, climate change, weather, precipitation, pollution or disasters is a critically important everyday issue for the global community. Earth observation activities provide us with such information, which is required for daily weather forecasting, climate change studies, environmental protection, economic development (transportation, energy, agriculture, construction) and for safety of life and property. In addition, it is noted that spaceborne remote sensing (passive and active) of the Earth's surface and atmosphere plays an essential and increasingly important role in meteorological research and operations, in particular for mitigating the impact of weather- and climate-related disasters, and in understanding, monitoring and predicting climate change and its impacts.

ITU-R has recently (2012) published a report entitled "Radio-based technologies in support of understanding, assessing and mitigating the effects of climate change" (available in English only). This report lays particular emphasis on the crucial importance of satellite observations, which are an indispensable means of understanding climate evolution thanks to the repetitiveness and homogeneity of their measurements, as detailed in the next paragraph. The report also establishes linkages with decisions taken by WRC-12. In addition to revising Resolution 673, it will be recalled that the 2012 Radiocommunication Assembly (RA-12) adopted a resolution entitled "Reduction of energy consumption for environmental protection and mitigating climate change by use of ICT/radiocommunication technologies and systems", in which ITU-R study groups are invited to develop Recommendations, Reports or handbooks on practices in place to reduce energy consumption within ICT systems, and in which mention is also made of the need for effective systems for monitoring the environment and monitoring and predicting climate change. The text of the Resolution is reproduced in Annex 8.

2.1.2 ITU-T

ITU-T Resolution 73 on ICTs, the Environment and Climate Change Revised and consented at World Telecommunication Standardization Assembly (Dubai, 2012) proposes the following.

Resolves to promote the use of ICTs as cross-cutting tool to assess and reduce GHG emissions, optimize energy and water consumption, minimize e-waste and improve its management;

Supports studies on, inter alia, green data centers, smart buildings, green ICT procurement, cloud computing, energy efficiency, smart transportation, smart logistics, smart grids, water management, adaptation to climate change and disaster preparedness, and reduction of GHG emissions;

Encourages internal and external collaboration to move forward the environmental global agenda.

ITU-T developed a New Resolution 79 on E-Waste Consented at World Telecommunication Standardization Assembly (Dubai, 2012) urging ITU-T to:

Contribute to alleviate the negative impact of e-waste on the environment and health;

Pursue and strengthen the development of ITU activities in regard to handling and controlling e-waste from ICT equipment and methods of treating it:

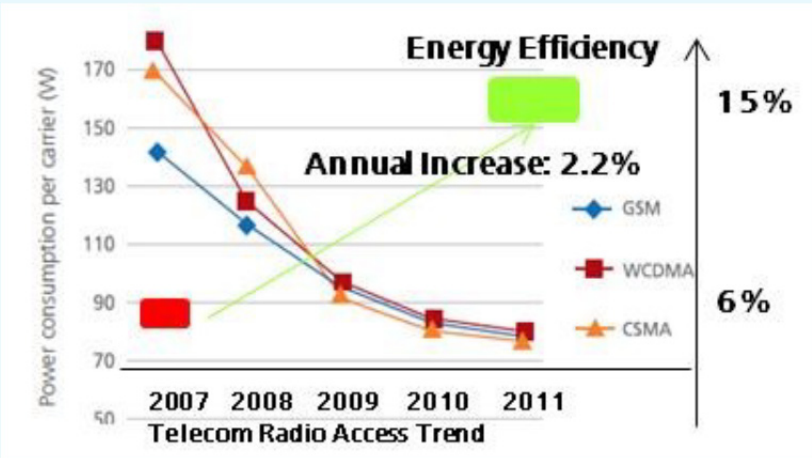
To adopt Best practices, Recommendations, methodologies and other publications and Guidance for policy makers;

To assist developing countries, which are the countries that suffer most from the hazards of e-waste without being the most responsible;

To colaborate with all relevant stakeholders.

In the field of Energy efficiency metrics and measurement for telecommunication equipment, ITU-T developped Recommendation ITU-T L.1310: it contains the definition of energy efficiency metrics, the related test procedures, methodologies and measurement profiles required to assess the energy efficiency of telecommunication equipment. It includes wired as well as wireless broadband access; optical transport technologies; routers; switches; mobile core network equipment; and small networking equipment used in homes and small enterprises. These metrics evaluate ICT equipment's energy efficiency through a comparison between its technical performance (useful work) and its energy consumption.

Figure 3: Power consumption for future radion systems



In the field of Methodologies, ITU-T developed a common set of methodologies for the assessment of ICT carbon footprint. Without such a methodology, it will be impossible to provide meaningful comparisons and, it helps to establish the business case to go green

An Energy-Aware Survey on ICT Device Power Supplie reports the results of a wide analysis performed on a large set of commercially available external power supplies (more than 300 devices verified and more than 200 electrically measured) to assist the standardization activities within ITU-T Study Group 5 (SG5) (Recommendation ITU-T L.1001). Mechanical, electrical and environmental characteristics have been evaluated; correlation and statistics have also been developed.

ITU-T also developed a rport on boosting Energy Efficiency through Smart Grids: this report discusses the role of ICT in the smart grid with a view of energy efficiency, with the ultimate goal of hindering climate changes. Eventually, ITU-T is also developing a manual on the life cycles of equipment.

2.2 Remote sensing: means for monitoring climate change

2.2.1 Active and passive remote sensing by satellite

Satellite systems are very effective since they provide a repetitive series of precise and reliable measurements of various geophysical parameters such as: ocean salinity, soil humidity, temperature at all atmospheric levels, ocean temperature, average sea level, and so on. For example, space and meteorological agencies (e.g. CNES, NASA, NOAA, EUMETSAT, ESA, ISRO, JAXA, …) work collaboratively in satellite Earth observation programmes (Jason, SMOS, Megha-tropique, …). All of these satellite systems, providing a wide range of indicators that are essential to the study of climate change, are fully operational, and the data they provide are constantly being examined and analysed by space and meteorological agency experts.

The purpose of satellite altimetry is to observe the evolution of the mean sea level and monitor the quantities of ice on the Earth's surface. By storing and comparing data from all altimeter missions, scientists can follow and explain, and therefore anticipate, a range of impacts related to global warming. Mean sea level is the average, taken over all the oceans, of sea surface height with respect to a reference. However, regional variations are observed, and it is advised to go to reference[23] for further details and explanations (see also §2.2.2).

2.2.2 A concrete example: monitoring the rise in sea level

Sea levels change according to a range of temporal and spatial scales. The total volume of the ocean can change as a result of changes in ocean mass (addition of water to the ocean from the land) or expansion/contraction of the ocean water as it warms/cools.

Furthermore, the ocean is not like a bathtub - that is, the level does not change uniformly as water is added or taken away. There can be large regions of ocean with a decreasing sea level, even when the overall global mean sea level is rising. Obviously, there must be regions of ocean with trends correspondingly greater than the mean to balance out the regions with trends less than the mean.

The current increase in global sea level is about 3 mm/year, with thermal expansion producing about half of this rate. This contribution has increased from around 0.5 mm/year over the second half of the twentieth century to around 1.6 mm/year over the last 12 to 14 years, and is expected to continue at at least this level over the next century or more owing to GHG-induced warming of the atmosphere and ocean. When the surface temperature increases by 0.1°C, the sea level rises by 1 cm. Thus, with a 0.6°C increase by comparison with 1900, the sea level has risen by 6 cm.

Owing to the very patchy and sparse (especially as we go back in time) body of ocean temperature data that is available to estimate longer-term contributions, the contribution over most of the twentieth century is hard to estimate reliably.

The main causes of recent sea level rises are the melting of glaciers and contributions from the Greenland (both surface melting and iceberg calving) and Antarctic ice sheets. This is believed to produce about one-third or more of the current 3 mm/year annual increase in global sea level. The contribution from the ice sheets is poorly understood at the moment and is an active area of research. The melting of the Greenland ice sheet alone could increase global mean sea level by around 7 metres. This would probably take around 1 000 years, but it is believed that ice melt from Greenland could nevertheless contribute significantly to sea level rises over the next 50 to 100 years.

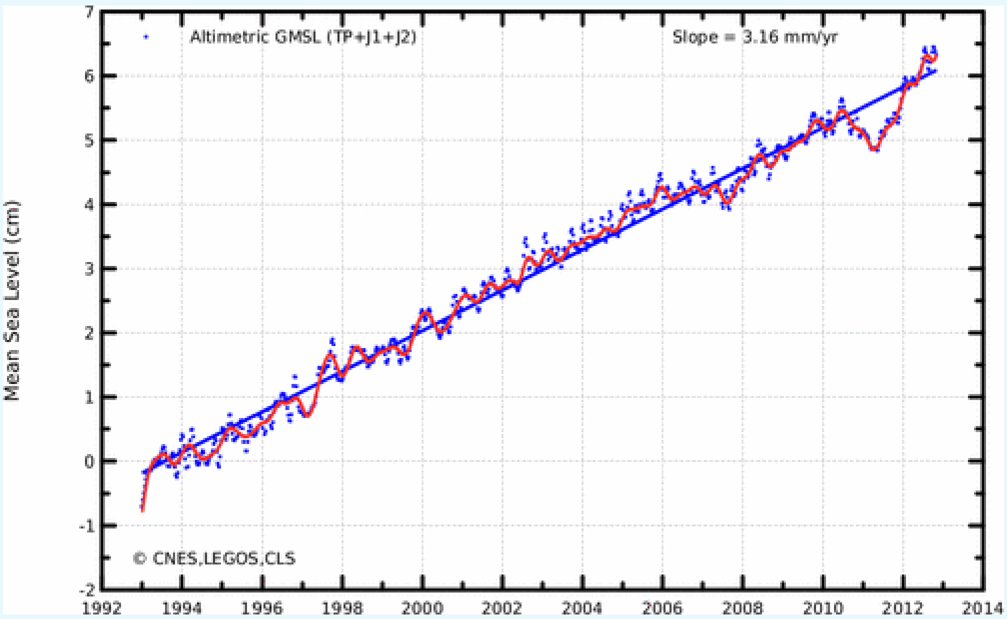
The global mean level of the oceans is one of the most important indicators of climate change. It incorporates the reactions from several different components of the climate system. Precise monitoring of changes in the mean level of the oceans, particularly through the use of altimetry satellites, is vitally

[23] www.aviso.oceanobs.com/en/applications/ocean.html

important for understanding not just the climate but also the socioeconomic consequences of any rise in sea level.

During the twentieth century, the sea level was measured by means of tide gauges located along certain continental coasts and on a number of islands. Analysis of the data obtained indicates that, during the course of the last century, the sea level rose at an average rate of some 1.7 mm per year. Thanks to satellite altimetry missions, the global mean sea level (GMSL) has been calculated on a continual basis since January 1993. Precise verifications[24] have been conducted for a better coherence between all the satellites launched (Topex/Poseidon, Jason-1, Jason-2, and other missions such as Envisat, ERS-1 and ERS-2) by precisely determining any bias between them, in order to compute mean sea level at high latitudes (above 66°N and S), and also to improve spatial resolution by combining all these missions. Sea-level measurements using satellite altimetry have the advantage of producing an "absolute" measurement that is independent of movements in the Earth's crust, unlike tide-gauge measurement, which measures the sea level with respect to the ground.

Figure 4: Altimetric global mean sea level

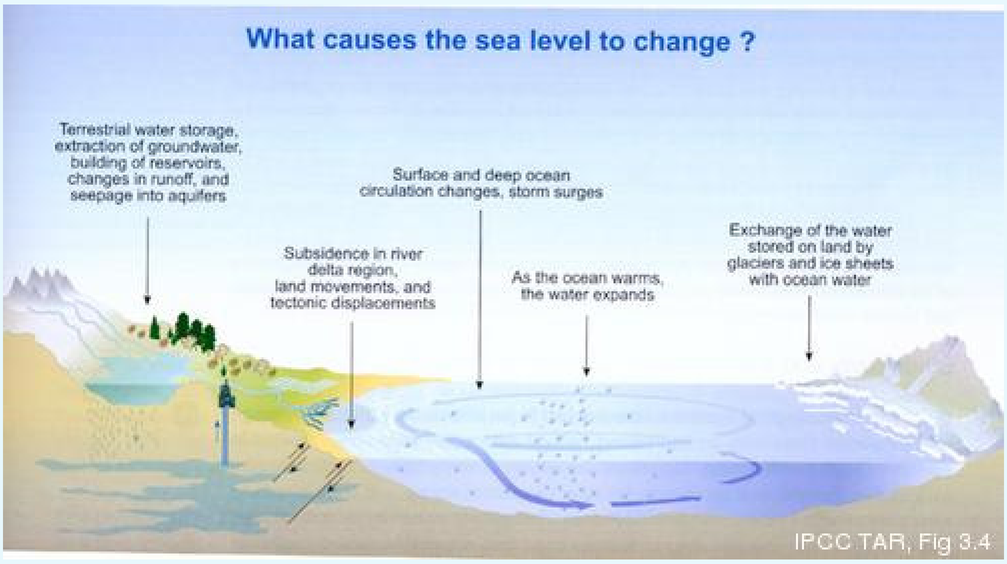


The slope describes a mean increase of 3.16 mm/year, with an uncertainty of 0.5 mm per year. It is to be noted that, over the past two decades, the rise in sea level has not been uniform, and that in certain regions it has been occurring three times faster than the global mean rise, for example in the western Pacific.

The following figure shows the main physical phenomena responsible for causing the sea level to rise.

24 www.aviso.oceanobs.com/en/news/ocean-indicators/mean-sea-level/

Figure 5: Main physical phenomena responsible for causing the sea level to rise



With the aid of sensors located on buoys, it has been found that the ocean has undergone significant warming, particularly since the 1970s. In the period 1993-2003, thermal expansion – which has slowed a little since 2003 – explains 50 per cent of the observed rise in sea level (a warmer sea has more volume than a colder sea). On average, over the period 1993-2010, it was responsible for one-third of the observed rise in sea level, equivalent to around 1 mm/year.

It is, moreover, known that warming is not geographically uniform, and that in certain areas the salinity level also contributes to warming through the associated density variations. The part played by continental ice masses is significant, it being estimated that over the period 1993-2010 the melting of mountain glaciers accounted for a further third of the rise in sea level. The contribution made by polar ice caps (Greenland, Antarctic) to sea level rises over the period 1993-2010 is in the order of 25 per cent. Where inland waters are concerned, measurements (particularly those carried out by means of the GRACE satellite) show them as having contributed less than five per cent to sea level rises in recent years.

2.2.3 Terrestrial, airborne and other systems

Airborne systems are used mainly for testing prototypes of payloads to be carried on future satellites, in order to validate future operational systems, bearing in mind that climate change analysis requires an ongoing series of reliable, repetitive and mutually compatible measurements.

Terrestrial (fixed and mobile) systems are also used, since they are able to compensate for the types of measurement that satellites are unable to perform. In addition, they are essential when it comes to calibrating the data obtained from satellites.

Submarine systems are very useful since, for example, satellites are able to measure ocean salinity only on the surface and not at depth. Other facilities have to be used to obtain those geophysical parameters that cannot be obtained through the use of satellites.

The experts use physical models that are constantly updated by means of terrestrial and satellite measurements – the phenomenon known as simulation, whereby data obtained from terrestrial sensors are enriched with satellite data. Comparison with a model is, moreover, necessary in order to validate the order of magnitude of the data obtained, bearing in mind that data can in some cases be erroneous on account of incorrect measurement or some disturbance. In such cases, the erroneous measurement can be eliminated thanks to the model.

3 ICTs

3.1 Definition and role of ICTs

Information and communication technologies (ICTs) encompass a very broad range of items, including computers, televisions, telephones and chargers, Internet boxes, servers and data centres. A document from the European commission (DG INFSO) provides a working definition [25] that may be relevant for Q24/2.

ITU-D is currently making an attempt to get an acceptable definition for ICT. The current working definition is as follows: "Technologies and equipment that handle (e.g. access, create, collect, store, transmit, receive, disseminate) information and communications".

It is to be noted this definition is preliminary since it has not been officially approved by the council and may be subject to further improvements.

Although it is difficult to produce an exhaustive inventory of all the ways in which ICTs help in combating and monitoring these dramatic climate changes, from the practical standpoint, ICTs are useful in the following areas: teleworking and teleconferencing, optimization of transportation usage and daily commuting, e-commerce, computerization of administrative procedures and minimization of energy consumption in buildings. ICTs offer an incredible number of opportunities for meeting the ambitious goal of reducing energy consumption.

Although ICTs themselves require energy resources, they also provide many opportunities for advancing environmental research, planning and action at the global level. This includes monitoring and protecting the environment as well as adapting to and mitigating climate change. It is important to know how best to use ICTs in order to minimize their impact on the environment. One issue developed in the Question is: *"To elaborate a methodology for the implementation of this Question, in particular gather evidence and information regarding current best practices being taken to reduce overall global greenhouse gas (GHG) emissions taking into consideration progress achieved by the ITU-T and ITU-R in this regard".* A particular basis for Question 24/2 is Resolution 66, on information and communication technologies and climate change, adopted by the World Telecommunication Development Conference (Hyderabad, 2010), which highlights the usage and benefits of ICTs.

In addition, ICTs have contributed to the economic growth experienced by many industrial sectors over the last two decades. In the economy and society in general, ICTs have had a particularly major impact in the areas of health, security, training and social integration.

In its latest Opinion on the Radio Spectrum Policy Programme, the European Union's Radio Spectrum Policy Group (RSPG) expressly states that: one of the key objectives of EU spectrum policy is to enhance the quality of life of European citizens; that efficient and effective use of spectrum technologies could also stimulate carbon reduction in other sectors; that the sector can also reduce its own greenhouse emissions with the help of greener ICTs; and that, in rural and remote areas, infrastructure and network sharing can reduce the environmental impact.

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[25] Impact of Information and Communication technologies on Energy Efficiency, final report, September 2008 (see §1.1.3 for the ICT working definition)

3.2 The global ICT footprint

Accurate, consistent and internationally comparable data on GHG emissions are essential for the international community to be able to take the most appropriate action to mitigate the effects of climate change and ultimately achieve the objective of the Convention. Communicating relevant information on the most effective ways of reducing emissions and adapting to the adverse effects of climate change also contributes towards sustainable development worldwide.

A new "socially-networked" generation around the world continues to drive unprecedented global demand for ICT hardware, software and services providing mobile and instant access to information.

To help, rather than hinder, the fight against climate change, the ICT sector must manage its own growing impact and continue to reduce emissions from data centres, telecommunication networks and the manufacture and use of its products.

Already in 2008, the ICT sector was generating a turnover in excess of EUR 2 700 billion, or 6.5 per cent of world GDP. It is not unreasonable to think that the ICT sector – as the potential vector for a new form of economic organization, referred to by some as the quaternary economy – will, in ten years from now, represent 20 per cent of the global economy. Some experts consider the carbon footprint from ICT equipment, including radio applications (TV and radio sets, video and DVD players and recorders, terrestrial and satellite set-top boxes, etc.) and systems to be significantly higher than 2 to 2.5 per cent, i.e. a little under one gigatonne of CO_2 equivalent. For example, in its report to the European Parliament, the European Commission stated that *"ICTs are now embedded in almost all parts of the European economy. As a result of its own success, use of ICT products and services represents about 7.8% of electricity consumption in the EU and may grow to 10.5% by 2020".*

The main constituent (40 per cent) of this is the energy requirements of personal computers and data monitors, with data centres contributing a further 23 per cent. Fixed and mobile telecommunications contribute some 24 per cent of the total. As the ICT industry is growing faster than the rest of the economy, this share may well increase over time. However, ICTs have the potential to assist in finding solutions for reducing the remaining 97.5 per cent of global emissions from other sectors of the economy.

Under these conditions, the remaining 97.5 per cent therefore constitute a tremendous opportunity for pursuing the fundamental goal of reducing GHG emissions.

From ITU-D's standpoint, one of the key areas in which ICTs could help to mitigate the impacts of climate change is that of adaptation measures. ICTs have a critical role to play in combating climate change through the reduction of GHG emissions, and although their increasing use adds to global warming (one has only to think of the hundreds of millions of computers and more than one billion television sets that are never fully turned off at night in offices and homes), ICTs can nevertheless also be part of the solution on account of the role they play in monitoring climate change and adapting to and mitigating its effects.

In France, for example, the ICT share of electricity consumption now exceeds 13 per cent and could even climb towards 20 per cent in the coming years if current growth rates are maintained.

In any case, ICT use will continue to expand, making it important for the industry to take measures as of now to curb, and ultimately reduce, its carbon emissions.

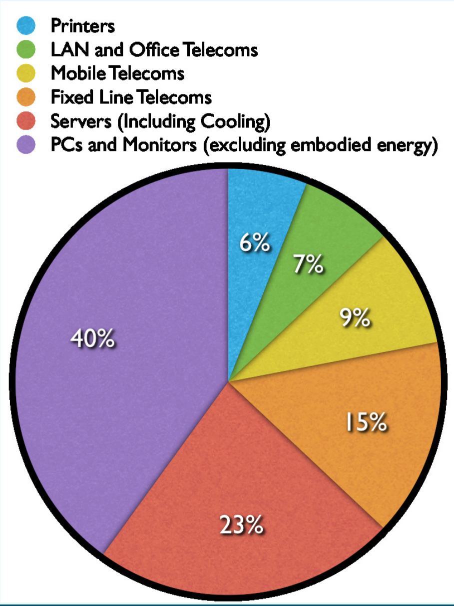
It is to be noted that ICTs are contributing to global warming in a number of ways:

- The proliferation of ICT users (for example, the number of mobile phone users rose from 145 million in 1996 to over 3 billion in August 2007, reaching 4 billion by the end of 2008).
- Many ICT users own multiple devices.

- Constant increases in processing and transmission power (for example, third-generation (3G) mobile phones operate at higher frequencies and consume more power than 2G phones).
- Users tend to keep their devices turned on at all times and to store rather than delete older data.

The following figure[26] shows the estimated distribution of global CO_2 emissions from various types of ICT ICTs.

Figure 6: Estimated distribution of global CO_2 emission from ICT



Energy efficient computing is a central feature of smarter digital electronic products. We are close to a world where these chips can measure, manage, and control the environmental performance of a range of products, improving performance and reducing the carbon footprint for some of the products that we all use every day, including computer servers and mobile phones. The technology can also be applied in different industrial sectors, such as transportation, energy, and infrastructure. It can help reduce the carbon footprint of ICT infrastructure itself.

Current research in emerging aspects of this trend includes work by the Carbon Trust[27], which is conducting research into the reduction of global energy consumption and the carbon reduction potential of new computer systems. The efficiencies to be gained from remote sensing and monitoring can help reduce the environmental impact. Technical examples for everyday office activity include sensors that turn off lights when no-one is around, more efficient motors in air-conditioning and lifts, or remote controls for PCs to make sure they are turned off at night. Smart appliances and smart networks can help in this process, and can help provide more energy efficient processing and thus a more sustainable future for us all.

Energy efficiency and low cost will also be the two crucial elements in developing the next generation of computer systems. These elements will be instrumental in providing affordable, efficient and sustainable technology which can help to bridge the digital divide.

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[26] http://css.escwa.org.lb/ictd/1248/25.pdf

[27] www.carbontrust.com/

3.3 ICTs for reducing GHG emissions

In its report 'SMARTer 2020[28] GeSI, international consortium for the promotion of ICTs and practices that promote sustainable development and growth, highlighted the potential benefits of new technologies on reducing greenhouse gas emissions. Carbon emissions of ICT can be largely offset by the large-scale development of new technologies applied to the dematerialization (replacing travel by means of electronic communication, electronic invoicing removing the paper, etc.), improved transport efficiency, industries, agriculture, networks and so-called intelligent buildings.

Knowing that the ICT sector would have spent in 2011 a volume of 0.91 billion tons of carbon dioxide and that these costs are expected to reach 1.27 billion in 2020 tonnes of CO^2, ICT would be able to generate equivalent reductions to 7 times their own carbon footprint (manufacturing, IT infrastructure and usage), or 9.1 billion tons of CO^2 always 2020 and 16.5% of the total volume of greenhouse gas emissions. These reductions break down by sector as follows:

- Transport: 2.0 billion tonnes of CO_2
- Energy: 1.7 billion tonnes of CO_2
- Building: 1.6 billion tonnes of CO_2
- Agriculture: 1.6 billion tonnes of CO_2
- Industry: 1.5 billion tonnes of CO_2
- Services: 0.7 billion tonnes of CO_2

It can be seen that the biggest reduction would affect transportation (currently, transportation accounts for 25 per cent of CO_2 emissions).

It is also in terms of growth opportunities for the ICT sector and gains at the level of the global economy that GeSi also valued its various scenarios with some key estimates for 2020 worldwide:

- Jobs created: 29500000
- Savings generated: 1 900 billion U.S. dollars

ICT enabled applications have demonstrated a strong link between increased efficiency and cost savings resulting in the overall net reduction of GHG emissions. These are key motivation factors that encourage Governments and the private sector alike to introduce increased usage of ICT in a multitude of applications and services.

The central Government role in achieving energy efficiency savings is best demonstrated through leadership resulting in “leading by example” initiatives. Governments tend to be the largest landlord, fleet operator and purchaser of goods and services and therefore offer in the first instance the greatest opportunity to achieve GHG emission reductions. The study by C2ES[29] provides a number of case studies describing the use of ICT solutions to reduce energy consumption. Several studies estimated that if widely implemented would have the potential to reduce energy consumption across the US economy by 12 – 22% (the GeSi group proposes an overall estimate of 16.5 % reducing factor as explained above). Some of the studies addressed cloud computing and Data Centre consolidation, fleet management using new tools to advance sustainability and efficiency and testing of new building technologies.

[28] http://gesi.org/SMARTer2020

[29] Leading by example: Using Information and Communication Technologies to Achieve Federal Sustainability Goals - www.c2es.org/publications/leading-by-example-federal-sustainability-and-ict

Broadband reinforces a significant range of other technological developments, all of which provide the opportunity to change the way we live and to enable a low carbon economy. Greater deployment of broadband is therefore essential to act as the catalyst for ICT enabling solutions. The technology sector has a unique capability for virtualisation. Virtualisation has been described as the de-materialisation of physical processes through the application of technology. The benefit of virtualisation is that traditional, high impact and high energy processes are replaced by low impact, low carbon technologies. The virtual replacement (or proxy) for a physical process usually uses far less energy (often several orders of magnitude) but still enables people to achieve the same ends.

Some virtualisation technologies, such as broadband, have been so successful and are now so pervasive that they have changed fundamental behaviour and led to the creation of new business models.

Travel replacement technologies are one of the most important quoted application of virtualization. This isn't surprising considering that transport contributes typically 25% of CO_2 emissions in developed Countries. Favouring videoconferencing over travelling is one clear example to to reduce CHG emissions.

Energy use [30] in buildings accounted for around half the UK's 150 million tonnes of carbon dioxide emissions in 2004, and the energy used to heat, light and run UK homes accounts for over half of that. The UK government is taking a leading role in this area.

Besides implementing the Energy Performance of Buildings Directive (which requires all publicly owned buildings to display actual energy usage), all new homes being built will comply with low and zero carbon standards. The objective is to foster technologies and innovation that will help drive down emissions from existing building stock. The government is introducing a combination of economic incentives and regulatory controls to help achieve this and aims to be the first country to set a timetable for delivering zero carbon homes.

There is scope for ICT and associated technologies to play a major role in achieving these aims through the application of smart building technologies. These include building and energy management systems, metering technologies, environmental sensors, lighting control systems, energy auditing and optimisation software, and communication network.

Annex 8 provides the text of Resolution ITU-R 60 about the Reduction of energy consumption for environmental protection and mitigating climate change by use of ICT/radiocommunication technologies and systems.

3.4 Managing energy consumption of telecommunication networks

Until recently, establishing a mobile network in underserved locations has been an expensive proposition, typically relying on diesel generator powered stations that are costly to maintain and add to the network's carbon footprint. The deployment of new wireless base station sites or retrofitting of existing ones can now leverage on efficient alternative energy hardware configurations such as hybrid genset battery systems, solar systems or mixed solar-wind systems. Beyond this, the total energy required to power the global telecom network can also be optimized by leveraging ad-hoc energy supervision and management systems. These new telecom deployment trends are particularly important in developing countries as they combine social, economic and environment targets. Annexes 5 and 6 (case study 1) provides details on specific issues such as poor-grid or off-grid configurations, alternative energy usage and global energy optimization for telecom networks.

[30] High Tech: Low Carbon: The role of technology in tackling climate change - www.greenbiz.com/sites/default/files/document/CustomO16C45F97277.pdf

3.5 Rebound effect

The rebound effect means that interventions to improve energy efficiency often lead an increase in power consumption rather than a reduction thereof.

The impact of the so-called rebound effect (or take–back effect), well known in the economic and energy spheres, needs to be taken into consideration. It generally refers to the introduction of new technologies, or other measures taken to reduce resource use. These responses tend to offset the beneficial effects of the new technology or other measures taken. While the literature on the rebound effect generally focuses on the effect of technological improvements on energy consumption, the theory can also be applied to the use of any natural resource.

The rebound effect[31] denotes increased consumption resulting from actions that increase efficiency and reduce consumer costs. It is an extension of the "law of demand", a basic principle of economics, which states that if prices (costs perceived by consumers) decline, consumption usually increases. A programme or technology that reduces consumer costs tends to increase consumption. This is not to suggest that the rebound effect *eliminates* the benefits derived from efficiency gains. The rebound effect is normally followed by energy savings or a net reduction in congestion. In addition, consumers benefit directly from increased efficiency or the introduction of a better technology. However, the rebound effect can significantly change the nature of the benefits derived from a given policy or project. To ensure an accurate assessment of that policy or project, it is therefore important to factor in the rebound effect.

Some strategies[32] to reduce GHGs can have a rebound effect. In the long term, emissions will be lower than predicted estimates. Thus, measurement leads to improved fuel efficiency may, in a first step, reduce emissions. For the transportation sector for instance, higher energy efficiency reduces the cost kilometer, which often causes a surge in demand for mobility. Part of emission reductions is negated by an increase in the number of kilometers traveled. The question of the best method of modeling rebound effects is central to any modeling strategies for reducing GHG emissions.

On the whole, this theory is an interesting one that can also be applied to the use of any natural resource. While administrations have not yet examined the impact of technological improvements on energy consumption, they can nevertheless see that it may be necessary, in the interests of enhanced accuracy, to take account of the theory when assessing a given policy or draft decision. Annex 9 sets out the main conclusions to be found in the Global e-Sustainability Initiative (GESI)[33] report entitled "*Evaluating* the *carbon-reducing impacts of ICT"*.

- For example, unpublished studies [34] by the research Department of Electricité de France (EDF) show that when prices fall, low-income households are likely to increase the temperature in their homes. Generally, when a good or service becomes cheaper, they tend to consume a larger amount without any question. Finally, the ecological benefit expected from green technologies is reduced, or may become negative in some cases. Several methods are used to directly measure the rebound effect. In electricity, for example, if consumption increases by 2% due to lower rates of 10%, the resulting rebound effect equals 20% of over electricity consumption. In the field of transport, technological innovation tends to increase mileage and increase overall fuel consumption (20 to 30% in the United Estates according to one estimate).

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31 www.developpementdurable.gouv.fr/IMG/pdf/CAS_Synthese_consommation_durable_janv_2011.pdf

32 http://internationaltransportforum.org/Pub/pdf/02GreenhouseF.pdf

33 www.GeSI.org

34 Economiser plus pour polluer plus, Manière de voir 115, Février-Mars 2011, Le Monde diplomatique

- The second type of rebound effect is indirect. Unlike the previous case, the consumer believes that it has reached a satisfactory level of consumption of the service the price of which has become lower. However, he will spend the money saved, which will increase the flow of materials into society.
- Finally, the diffusion of ICTs opens a third type of effect rebond. When the efficiency of the way a used ressource is increased, the cost of this ressource decreases, therefore promoting socio-economic activities that will make intensive use of this given ressource.

4 Adaptation to climate change and impact reduction measures

4.1 Background

People will have to adapt to changes in the weather as they have always done. One of the difficulties in adapting to climate change is we must prepare for multiple impacts. In addition, the adaptation and emission reduction are inseparable because they use the same ways of action.

The Stern review aimed to be the most comprehensive ever into the economics of climate change. It aimed to examine the costs and benefits of mitigation actions as well as the potential costs of future technological developpements. The conclusion is that climate change presents a unique challenge to global economics but that the benefits of strong, early action change readily outweigh the costs. Early action on climate change is economically justifiable, is used to back arguments for mitigation, including technological solutions (renewable energy sources, halting forest destruction, usage of alternative or creative means to reduce costs and energy consumption…).

The STERN report[35] states the following.

"*Using the results from formal economic models, the Review estimates that if we don't act, the overall costs and risks of climate change will be equivalent to losing at least 5% of global GDP each year, now and forever. If a wider range of risks and impacts is taken into account, the estimates of damage could rise to 20% of GDP or more. In contrast, the costs of action – reducing greenhouse gas emissions to avoid the worst impacts of climate change – can be limited to around 1% of global GDP each year.*

The investment that takes place in the next 10-20 years will have a profound effect on the climate in the second half of this century and in the next. Our actions now and over the coming decades could create risks of major disruption to economic and social activity, on a scale similar to those associated with the great wars and the economic depression of the first half of the 20th century. And it will be difficult or impossible to reverse these changes.

So prompt and strong action is clearly warranted. Because climate change is a global problem, the response to it must be international. It must be based on a shared vision of long-term goals and agreement on frameworks that will accelerate action over the next decade, and it must build on mutually reinforcing approaches at national, regional and international level.

If no action is taken to reduce emissions, the concentration of greenhouse gases in the atmosphere could reach double its pre-industrial level as early as 2035, virtually committing us to a global average temperature rise of over 2°C. In the longer term, there would be more than a 50% chance that the temperature rise would exceed 5°C. This rise would be very dangerous indeed; it is equivalent to the change in average temperatures from the last ice age to today. Such a radical change in the physical geography of the world must lead to major changes in the human geography – where people live and how they live their lives."

[35] Stern Review: The Economics of Climate Change

The impact of rise of 4°C is fully developped in a Report[36] which states the following.

"This report spells out what the world would be like if it warmed by 4 degrees Celsius, which is what scientists are nearly unanimously predicting by the end of the century, without serious policy changes. The 4°C scenarios are devastating: the inundation of coastal cities; increasing risks for food production potentially leading to higher malnutrition rates; many dry regions becoming dryer, wet regions wetter; unprecedented heat waves in many regions, especially in the tropics; substantially exacerbated water scarcity in many regions; increased frequency of high-intensity tropical cyclones; and irreversible loss of biodiversity, including coral reef systems.

And most importantly, a 4°C world is so different from the current one that it comes with high uncertainty and new risks that threaten our ability to anticipate and plan for future adaptation needs. The lack of action on climate change not only risks putting prosperity out of reach of millions of people in the developing world, it threatens to roll back decades of sustainable development.

It is clear that we already know a great deal about the threat before us. The science is unequivocal that humans are the cause of global warming, and major changes are already being observed: global mean warming is 0.8°C above pre industrial levels; oceans have warmed by 0.09°C since the 1950s and are acidifying; sea levels rose by about 20 cm since pre-industrial times and are now rising at 3.2 cm per decade; an exceptional number of extreme heat waves occurred in the last decade; major food crop growing areas are increasingly affected by drought."

Mitigation and adaptation are not exclusive. Climate change is a global problem that requires collective global action. It does not make any difference where the greenhouse gases are emitted into the atmosphere. Adaptation is not only about government action. Significant scope remains for people to act for themselves and take responsibility for preparing for the impact of climate change.

4.2 ICTs and adaptive measures

Adaptation consists in:

- the adoption of policies aimed at integrating ICTs into disaster management strategies, including identification of local vulnerabilities to climate change, to ensure the efficient transmission of warning messages to people living in vulnerable areas, while also encouraging the use of ICTs in the interests of transparency and of the exercise of responsibilities in regard to the allocation of the resources to be used for the purpose of adapting to climate change and for disaster management;
- the adoption of policies and measures to provide regulatory incentives, based on international standards, designed to commit States and public entities and encourage the private sector and consumers to reduce their GHG emissions and energy consumption to a minimum and make the most rational possible use of renewable energies, including through the use of ICTs;
- the promotion of measures to reduce the ecological impact of energy consumption to a minimum through the use of smart grids (see Annex 7).

Annex 6 provides a case study concerning climate change adaptation and mitigation for the state of Ghana.

[36] Turn Down the Heat: Why a 4°C Warmer World Must Be Avoided, 2012 International Bank for Reconstruction and Development / The World Bank

4.3 Life cycle of ICT equipment, recycling and e-waste

Electronic waste generally poses a significant threat to the environment. For example, a computer monitor may contain over six per cent of its weight in lead! Each year, 14 million tonnes of electronic goods are produced worldwide, of which only 20 per cent are adequately recycled and processed. Electrical and electronic devices (TV sets, computers, etc.) contain a large number of recoverable metals such as copper and iron, and heavy metals such as lead, mercury, zinc, arsenic and cadmium. All of these metals ultimately end up in urban waste flows. However, high levels of heavy metals complicate both the operation of municipal solid waste incinerators and the treatment and recycling of combustion residues. A large proportion of the recoverable metals from electrical and electronic appliances is lost during incineration, or can be recovered only at great expense.

It is also worth noting that the electrical and electronic appliances produced worldwide in 2011 contained some 320 tonnes of gold, equivalent to 7.7 per cent of the global production of this metal, and 7 500 tonnes of silver. However, less than 15 per cent of these quantities will be recycled, according to estimates published by the United Nations University (UNU). It is essential that attention be drawn to the wastage of precious resources such as gold and silver. Computers, mobile telephones, tablets and other electronic devices manufactured around the world in 2011 contained gold worth around EUR 13 billion and silver worth around EUR 4 billion, not to mention cobalt and palladium.

The reason for the low level of recycling of these metals lies in two opposing phenomena: the industrialized countries have the advanced technologies needed to perform such recycling, but the WEEE (Waste Electrical and Electronic Equipment) collection rate is relatively low, whereas in developing countries this rate is much higher (in the order of 80 to 90 per cent), owing to the informal recovery sector, but preference is given to the recycling of metals that are easier to extract, such as copper, aluminium and steel, for the most part in conditions that are disastrous for the environment and the health of those involved in the work.

France, for example, collects some 8 kg of WEEE per inhabitant per year. However, while this level of performance is considered good, it amounts to no more than between one-third and half of the total estimated quantity. According to UNU, improving the recycling rate for precious metals contained in WEEE calls for everyone concerned to be made aware of the value of such wastes.

All in all, it is clear that WEEE can be considered an opportunity rather than a burden, and that the notion of waste management needs to be replaced by that of resource management.

The separate collection and environmentally sound disposal of end-of-life electrical and electronic appliances reduces inputs of heavy metals into unsorted municipal waste. Iron, copper and other metals are recovered. Problematic components (mercury switches, PCB capacitors, etc.) are dismantled and disposed of separately. Non-recyclable organic chemical wastes (e.g. mixed plastics) can be appropriately incinerated.

Reducing ICT-engendered pollution has to be at the forefront of administrations' concerns.

In this spirit, numerous administrations have developed "green ICT" strategies to address the following challenges:

- Development of technical means for optimizing energy and resource consumption, smart technologies or possibilities for substitution.
- Development of sustainable practices to be integrated t into everyday activities (see Swiss paper)
- Boosting resource efficiency in the area of ICTs.
- Encouraging traders to take back and dispose of electrical and electronic appliances.
- Ensuring that systems have adequate capacity for measuring the volume of WEEE, with the aid of indicators to be defined by the Partnership on Measuring ICT for Development.
- Fostering, at the ICT design stage, an approach conducive to longer life cycles (eco-design), in the interests of reducing the volume of WEEE and encouraging programmes its recovery.

4.4 Actions by WTO

WTO (World Trade Organization) took actions within the environment-related activities in the framework of the Committee on Trade and Environment (CTE), which is responsible for matters related to climate change.

We can note the establishment, in 1998, of an Environmental Database, which has since been regularly updated. In the 1994 Marrakesh Agreement establishing the WTO, Members established a clear link between sustainable development and disciplined trade liberalization. In order to ensure that market opening goes hand in hand with environmental and social objectives, the CTE was set up by the Ministerial Decision on Trade and Environment, which gave it the following mandate:

– to identify the relationship between trade measures and environmental measures, in order to promote sustainable development;
– to make appropriate recommendations on whether any modifications of the provisions of the multilateral trading system are required, compatible with the open, equitable and non-discriminatory nature of the system.

With its broad mandate, the CTE has contributed to identifying and understanding the relationship between trade measures and environmental measures in order to promote sustainable development.

The work programme of the CTE is as follows:

Items 1 and 5: Trade Rules, environment agreements, and disputes

The relationship between the rules of the multilateral trading system and the trade measures contained in multilateral environmental agreements (MEAs), and between their dispute settlement mechanisms.

Item 2: Environmental protection and the trading system

The relationship between environmental policies relevant to trade and environmental measures with significant trade effects and the provisions of the multilateral trading system.

Item 3: How taxes and other environmental requirements fit in

The relationship between the provisions of the multilateral trading system and: a) charges and taxes for environmental purposes; and b) requirements for environmental purposes relating to products, such as standards and technical regulations, and packaging, labelling and recycling requirements.

Item 4: Transparency of environmental trade measures

The provisions of the multilateral trading system dealing with the transparency of trade measures used for environmental purposes. An Environmental Database (EDB) (documents WT/CTE/EDB/* and documents WT/CTE/W/46, 77, 118, 143 and 195) was established in 1998 for the WTO Secretariat to compile and update annually all measures related to the environment that governments have notified to the WTO or that have been noted in trade policy reviews.

Item 6: Environment and trade liberalization

How environmental measures affect market access, especially in relation to developing countries and least developed countries; and the environmental benefits of removing trade restrictions and distortions.

Item 7: Domestically prohibited goods

The issue of exports of domestically prohibited goods (DPGs), in particular hazardous waste.

Item 8: Intellectual property

The relevant provisions of the Trade-Related Aspects of Intellectual Property Rights (TRIPS) Agreement.

Item 9: Services

The work programme envisaged in the Decision on Trade in Services and the Environment.

Item 10: The WTO and other organizations

Input to the relevant WTO bodies on appropriate arrangements for relations with intergovernmental and non-governmental organizations (NGOs).

WTO regional trade and environment seminars are available for developing countries and economies in transition. They have been organized by the Secretariat since 1998.

The goal is to raise awareness of the links between trade, the environment and sustainable development, to intensify the dialogue between trade and environment policy makers, and to facilitate the exchange of data among members of a given region.

5 Questionnaire: analysis and recommendations

5.1 Questions contained in the questionnaire

Annex 3 contains the full questionnaire.

5.2 Analysis and summary of responses received

The information contained in this part of the annex was provided by administrations. Out of the 193 Member States of ITU, a total of 66 completed questionnaires were returned, 50 of them by administrations.

Q1 Does your government (or company) have any policy regarding climate change?

Most of the countries (70 per cent) stated that they have a policy on climate change. The following examples were given for the ways in which administrations use ICTs to combat climate change:

- Some administrations monitor climate change on a continual basis using modern technological means such as satellites.
- Apart from the use of those ICTs that are essential for climate monitoring, the use of ICTs in the context of climate change falls essentially into the following three categories:

1. ICT applications for adaptation to climate change.
2. ICT applications to mitigate the effects of climate change: preferred use of electronic media (e-mail, telephone, Internet, videoconferencing instead of expenditure on travel and printed documents).
3. Development of a sustainable ICT sector (green economy): ICT recycling (equipment and accessories), low-power equipment.

Some countries have launched a *National strategy for sustainable development 2010-2013*. This does not relate specifically to climate change but concerns all aspects of sustainable development.

General principles such as the use of ICTs to avoid physical travel have been adopted. A global strategy on ICTs and sustainable development is foreseen, involving a range of actions:

- Reducing the energy consumption of data centres by promoting best practices..
- Encouraging the manufacture and use of electronic components that consume less energy and mark them with energy efficient labels.
- Promoting ecologically responsible purchases via the Internet (while taking care to ensure that this does not jeopardize e-commerce).

- Widespread development of smart grids and intelligent transport systems and support for R&D in these spheres to prepare the way for future technology generations.
- Defining indicators for evaluating the energy and environmental performance of the digital sectors (in line with the regulatory obligations concerning evaluation of GHG emissions and with the work being undertaken within the framework of the Digital Agenda for Europe).
- Ensuring that public authorities (the State, local authorities and public institutions) have exemplary practices in place in the interests of making savings.
- Developing the requisite competencies.

Q2 Does your government (or company) have current actions in terms of adaptation to climate change?

Adaptation involves taking action to cope with the effects of climate change at the local or country level. ICTs can greatly support this action. Examples include remote sensing to gather climate data, dissemination of information such as sea-level forecasts, and impact minimization measures such as building on higher ground with respect to the sea level. ICT infrastructure is already used to warn of natural disasters such as earthquakes and tidal waves. Additional or new ICT infrastructure and services may be needed to help deal with problems such as water and food shortage, etc., arising from extreme climate conditions.

It is to be noted that 80 per cent of the administrations stated that they have adaptation policies.

One administration laid emphasis on the following actions:

1. Preparation for natural disaster alerts in terms of protective and civil defence measures within the country.
2. Preparation and publication of studies aimed at production of the requisite information for planning and promotion of actions against natural disasters.
3. Development of scientific, technological and innovative capacities to ensure the ongoing improvement of natural disaster warnings.
4. Development and implementation of systems for the monitoring of natural disasters.
5. Development and implementation of IT models for natural disasters.
6. Operation of IT systems for the preparation of natural disaster warnings.
7. Fostering of activities to strengthen training capacities.
8. Natural disaster warnings.

Administrations also mention meteorology centres for the forecasting and monitoring of climate changes.

a) Have you implemented measures to extend the lifespan of ICT equipment?

Sixty-three per cent of replies advocate extending ICT lifetime.

A number of replies refer to a charter for voluntary commitment of the telecommunication sector to sustainable development. Signed in 2010, the charter promotes extension by the customer of the useful lifetime of equipment, products and terminals.

b) Have you implemented recycling of ICT equipment in your country?

Incentive measures for the recovery of used telephones have been implemented:

- The main operators collect used telephones.
- Since early 2010, each operator offers, over and above ecological and social incentives, a financial incentive to customers returning their used mobile (valued according to age and condition: from EUR 2 to EUR 280 for a recent high-end mobile.

- Once collected, the terminals are all reused or recycled, in a process that includes the creation of jobs for players in the social and solidarity economy.

c) Do you have a policy in the management of electronic waste?

A number of European directives establish a general framework for the management of electronic wastes:

- Directive 2002/96/EC, known as the WEEE (waste electrical and electronic equipment) Directive is aimed at fostering the recycling of electrical and electronic equipment (EEE). It requires EEE manufacturers and importers to cover the costs of collecting and processing WEEE.
- Directive 2002/95/EC, known as the RoHS (restriction of hazardous substances) Directive, complements the WEEE Directive. It stipulates that, as from 1 July 2006, electrical and electronic equipment covered by the European directive, whether imported into or manufactured in the European Union, must be marketed free from six hazardous substances, namely:
  - lead (used in soldering…)
  - mercury (used in batteries…)
  - cadmium (used in batteries, integrated circuits…)
  - hexavalent chromium (used in connector contacts…)
  - PBBs (used in microprocessors…)
  - PBDEs (used in computer casings…).

Q3 Have you estimated the global ICT footprint in your country, in terms of greenhouse gas (GHG) emissions?

The ICT industry has for a long time been focused on delivering productivity enhancements in and through its products and solutions. Energy efficiency has only recently become a critical issue: in some countries, energy consumption of ICT is now more than 13 per cent. It is estimated that the ICT industry accounts for approximately 2.5 per cent of global CO_2 emissions.

An IDATE-BCG study conducted in 2009 established that the consumption of the ICT sector as a whole in 2008 represented 7.3 per cent of electricity consumption in France, i.e. 35.3 TWh/year. Despite the growth in usage, this consumption could be reduced to 34.3 TWh/year by 2012, and to 33.9 TWh/year by 2020.

In overall terms, this constitutes some 5 per cent of CO_2 output in France, estimated at 554 Mt.

Numerous replies refer to the establishment of a national observatory for monitoring the ICT footprint.

A further measure in favour of the environment involves identification of the potential role of ICTs in achieving energy efficiency and reducing GHG emissions in built-up areas.

Q4 Are you aware of “green” ICT initiative which would provide better design and energy consumption?

In French law, energy efficiency stands at the forefront of Act No. 2005-781 of 13 July 2005, establishing the directions of the energy policy. Article 3 thereof increases the annual rate of reduction in the final energy intensity to 2 per cent as from 2015, and to 2.5 per cent between now and 2030. To this end, the State is mobilizing all public policy instruments, starting with regulation, both French and community, relating to energy efficiency. Article L224-1 of the Environment Code stipulates that Conseil d’Etat decrees may oblige manufacturers and users to verify the energy consumption levels and emissions of pollutant substances contained in their goods, by their own efforts and at their own expense.

Q5 Are you aware of the so-called rebound effect that would offset the beneficial aspects of green ICT or any ICT consuming less energy?

Only 45 per cent of replies demonstrated awareness of the rebound effect.

The rebound effect (or take–back effect) is well-known in economy and in energy saving. It generally refers to the introduction of new technologies, or other measures taken to reduce resource use. Such responses tend to offset the beneficial effects of the new technology or other measures taken. While the literature on the rebound effect generally focuses on the effect of technological improvements on energy consumption, the theory can also be applied to the use of any natural resource.

This concept may be very attractive and beneficial in the realm of climate change since the basic idea is very similar. It generally refers to the introduction of new technologies (in our case, green ICTs) or of other measures designed to reduce resource utilization (in our case, electricity). Such responses tend to offset the beneficial effects of the new technology or other measures taken. France has not yet examined the effect of technological improvements on energy consumption, but is of the view that this theory has to be used in order to evaluate accurately a policy or draft decision.

Q6 What severe weather conditions are typical in your rural/remote regions?

We find examples of countries with the following conditions: summer temperatures in the vicinity of 40°C; a high humidity rate (up to 80 per cent); a low humidity rate (20 to 30 per cent); violent summer storms with a high level of electrical activity; in some cases, harsh winters followed by very hot summers (significant annual temperature range); regions with an aggressive industrial atmosphere; sea areas with high salinity levels).

Q7 Is your administration using any Systems and Applications of ICT to adapt to climate change?

Adaptation to climate change was demonstrated in 58 per cent of replies.

The key areas in which adaptation is observed are the following:

1. Water supply (see ITU-T tech watch report on smart water and ICT)
2. Food supply (see ITU-T tech watch report on this issue)
3. Health
4. Maintenance of infrastructure
5. Electricity
6. Gas
7. Road
8. Rail
9. Airport

Q8 What ICT services would enable communities to better adapt to climate change? (One example could be automated text messages to communities about water shortage and emergency water supply, etc.)

Use of social networks to train and inform groups on the ways in which society should apply greener technologies. Awareness-building campaigns are an essential means of providing the public at large with a better understanding of the close linkage between water resource management, for example, and adaptation to climate change.

Q9 What specific technologies or standards for ICT equipment are used by your administration to gather data to monitor climate change? Please select.

All manner of means and technologies are available for gathering the main geophysical parameters representing the climate change phenomenon.

- Satellite systems are highly effective since they provide a repetitive series of accurate and reliable measurements for a number of geophysical parameters, such as: ocean salinity, ground humidity, temperature at all atmospheric levels, ocean temperature, average sea level, and so on. For example, the French space agency (CNES), in collaboration with NASA, NOAA, EUMETSAT, ESA, ISRO and JAXA (among others), is involved in the following programmes: Jason, SMOS, Megha-Tropiques (…). All of these satellite systems, which provide numerous essential indicators in regard to climate change, are fully operational, and the data obtained are being constantly examined and analysed by experts from the space and meteorological agencies.

- Airborne systems are essentially used for testing prototypes of future payloads to be carried on future satellites in order to validate future operational systems. Indeed, it has constantly to be borne in mind that the analysis of climate change calls for an ongoing series of reliable, repetitive and mutually-compatible measurements.
- Terrestrial systems (fixed and mobile) are likewise used, since they compensate for the inability of satellites to provide all categories of measurement. They are also essential for calibrating the data obtained by means of satellites.
- Subsea systems are very useful since, for example, satellites are able to provide ocean salinity data only at the surface, and not at depth. Other arrangements are necessary for obtaining geophysical parameters which cannot be obtained by means of a satellite.

If others, please specify: Experts use physical models that are constantly updated by means of terrestrial and satellite measurements: this is the so-called assimilation phenomenon, where data obtained from terrestrial sensors are enriched with satellite data. Comparison with a model is, moreover, necessary in order to validate the order of magnitude of the data obtained, bearing in mind that some data may be false on account of mismeasurement or some disturbance, and that in such cases the mismeasurement can be eliminated by means of the model.

Q10 What technologies and/or standards could enhance the gathering of data/information about climate change for your administration?

The ICT sector can improve the gathering of data and information on climate change by:

- implementing appropriate systems for systematic observation, monitoring networks and institutional information systems for the oceans in support of decision-making. The primary systems would serve to identify vulnerable areas, populate databases, develop and implement resource protection measures and monitor compliance with urbanization rules;
- implementation of an air quality monitoring network including a number of stations to monitor CO_2 and CH4;
- implementation of a tide-gauge network;
- development and maintenance of the corresponding database, including networking with other institutions.

Collaboration with experts from space and meteorological agencies (including the World Meteorological Organization) in the interests of improving knowledge of climate evolution. Satellites and terrestrial measurement facilities are the main sources of information.

Q11 What information communication technologies and standards are used by your administration to disseminate information about climate change to those who need it (e.g. in broadcast, Satellite systems)? Examples include the following:

Communication technologies and standards rely on the following infrastructures:

- Terrestrial systems (public fixed)
- Terrestrial systems (public cellular)
- Terrestrial systems (private networks/private mobile radio networks
- Interactive voice systems.

The next IPCC report will be published very shortly, such a report being an important source of information for the public, the scientific community and decision-makers. In addition to this very comprehensive report, it is possible to find on the Internet such reliable sources of information as:

www.aviso.oceanobs.com
www.mercator-ocean.fr
www.esa.int/SPECIALS/Space_for_our_climate/index.html

Q12 What technologies and/or standards could enhance the dissemination of information about climate change to those who need it?

ICTs constitute a powerful support for the gathering, storage and dissemination of data relating to meteorological conditions and climate modelling, which are essential to the improvement of our knowledge of climate change. An effective mechanism for transmitting meteorological data to users is a fundamental requirement.

Q13 Access to information is important for communities needing to adapt to climate change. What are the challenges to deploying Telecommunication infrastructure in rural/remote areas in your region? Please indicate those that affect you most from the following examples:

1. Access to electricity
2. Cost of power backup
3. Terrain
4. Accessibility and transportation
5. Lack of skilled manpower
6. Installation and maintenance of networks
7. High operating costs
8. Low average revenue per user
9. Population sparse and scattered

Q14 What primary and backup energy sources are available in your rural/remote areas? Examples include the following:

Apart from solar and wind power, diesel is still used to a great extent in rural areas.

Q15 What types of telecom/mobile systems are needed to allow enhanced access to information concerning climate change or extreme weather events in rural/ remote regions?

Mobile radio services are used to a great extent.

Q16 What are the educational opportunities in rural/remote regions to train individuals in the use of ICTs for adaptation to climate change?

Videoconferencing should be encouraged.

Q17 Some systems are specifically developed for developing countries most of them have some features that are not essential enough to justify their cost and / or lack the required specification to meet the existing conditions in developing countries. What are the specifications and features that are essential in rural/remote regions in your country?

Videoconferencing is necessary, for example to foster education.

5.3 Proposed Recommendation

A Recommendation as an output of Q24/2, is proposed. It recommends the following.

Recommends

1. that countries elaborate guidelines/best practices and implement national policies and related measures to facilitate the use of ICT to combat climate change challenges;
2. that support is provided to help countries invest more in meteorology monitoring services in order to prevent extreme events that could be devastating as better prediction would costs relatively little and helps reduce the carnage caused by floods, droughts and tropical cyclones;
3. that in order to help countries invest in the technologies they need to know more about the climate change in general, and have better access to and understanding of meteorological data (satellite and terrestrial) that is supplied;
4. that countries elaborate training programs for a better usage of all the monitoring data;
5. that a program is developed based on real figures showing the effect of reduced energy consumption and the benefit of ICT;
6. that it is necessary to adopt innovative ICT-enabled strategies to tackle climate change adaptation and mitigation on the long-term;
7. that, as ICTs may need to operate in difficult meteorological conditions (hot weather, high humidity…), it becomes urgent to help countries develop more affordable green ICTs, as well as more robust and reliable;
8. that better cooperation between countries is to be established in areas related to the monitoring of meteorological data and for mitigating climate change using ICTs.

Recommends further

1. that appropriate steps be taken for the creation of an enabling environment at the national, regional, and international levels to encourage development and investment in the ICT sector, in meteorology and in prediction of extreme events by ITU Members;
2. that work on further developing the field of ICTs and climate change is continued and treated by countries as a priority and urgent task.

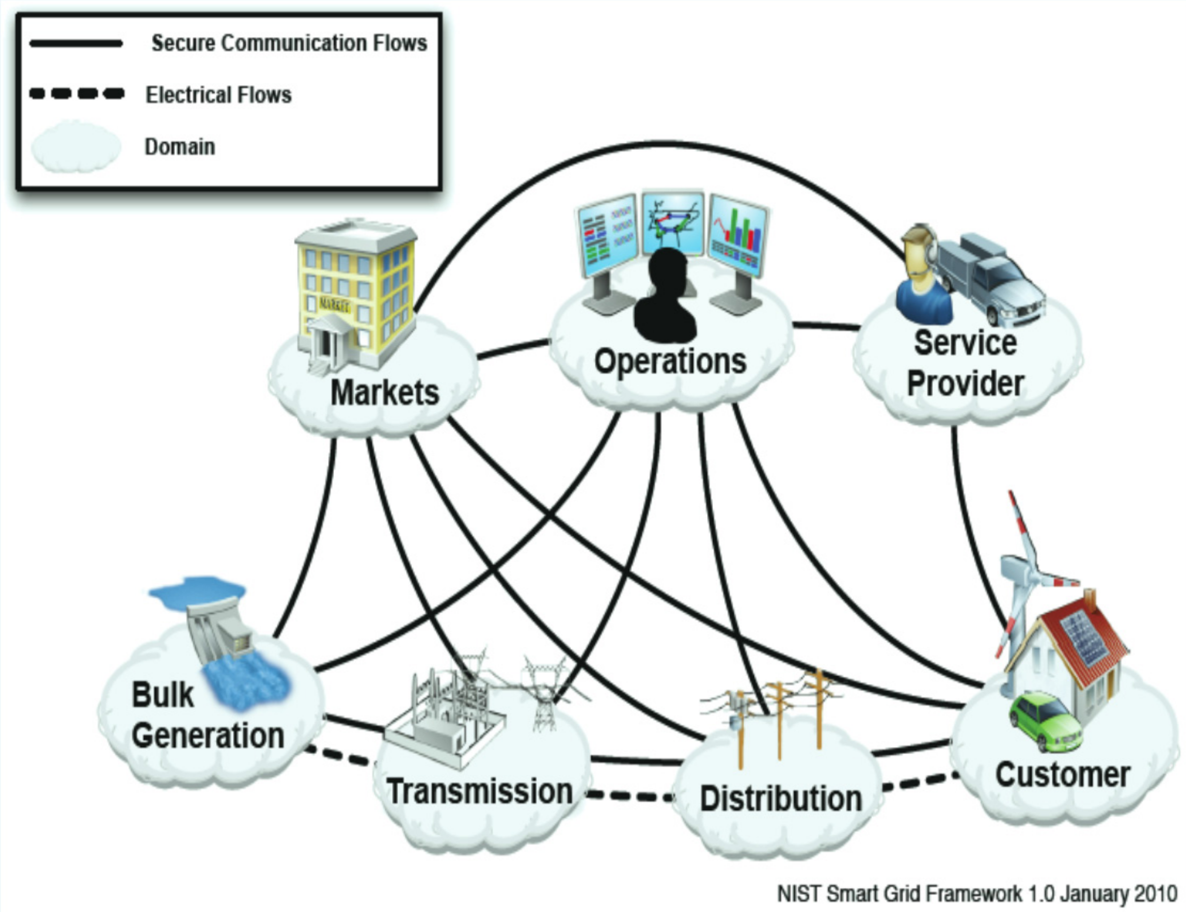
5.4 Smart grids for more efficient electricity distribution

Annex 7 fully develops the smart grid concept.
The official ITU-T terminology is as follows.

The "Smart Grid" is a two way electric power delivery network connected to an information and control network through sensors and control devices. This supports the intelligent and efficient optimization of the power network.

The conceptual, model is shown in the following figure.

Figure 7: Overview of a smart grid



Basically, a smart grid is an electrical grid that uses Information and Communications Technologies (ICTs) to gather information in an automated fashion to improve the efficiency, reliability, economics and sustainability of the production and distribution of electricity.[37] The gathered information allows decision makers to make well-informed decisions in real time. It is called "smart" because of the digital technology that allows for two-way communication between the producers and their customers, such as controls, computers, automation, and other new technologies that work with the electrical grid to respond digitally to quickly changing electric demand.[38]

The smart grid gives us an opportunity to improve the energy industry in a way that would be beneficial both to the economy and the environment. The benefits of the smart grid are numerous: more efficient transmission of electricity, quicker restoration of electricity after power disturbances, reduced operations and management costs and, consequently, lower power costs for consumers, reduced peak demand, increased integration of renewable energy sources, improved security of supply during peak demand, less lost productivity due to the increased reliability, possibility for consumers to play a part in optimizing the operation of the system, and significant reduction of the environmental impact of the whole electricity supply system.

37 Wikipedia, *Smart grid,* available at: http://en.wikipedia.org/wiki/Smart_grid#cite_note-1, December 7, 2012.

38 Smartgrid.gov, *The Smart Grid,* available at: www.smartgrid.gov/the_smart_grid#smart_grid, December 11, 2012.

A smartv grid will be able to cut energy use during times of peak demand. In addition, a way of dynamic pricing encourages to reduce power consumption voluntarily during peak period.

Smart Grids have the potential to fill the gap between the following components.

- sustainable and low-cost production of electricity by large integration of renewables;
- microgrids and islanding mode of operation for rural areas;
- improvement of efficiency by grid monitoring;
- reliable and cheaper supply of electricity by demand-response mechanisms;
- new business models to address specific needs of low-income customers and reduce administrative costs related to meter readings and billing.

ICT is the enabler of a more efficient electrical system and for the electrification of developing countries. The fundamental challenge in the Smart Grid is to ensure balance of generation and demand when integrating all those new technologies that are aimed at addressing in a sustainable manner energy independence and modernization of the aging power grid:

- Utility scale Renewable Energy Sources (RES) feeding into the transmission system
- Distributed Energy Resources (DER) feeding into the distribution system
- Plug-in (Hybrid) Electric Vehicles (PHEV)
- Demand Side Management (DSM)
- Consumer participation
- Storage to compensate for the time varying nature of some renewables
- Supporting the above technologies and applications, requires the availability of a modern, flexible, and scalable communications network that ties monitoring and control together
- The true “key” enabler for the Smart Grid is the availability of a pervasive two-way data communication network across the whole grid, from generation to load

ITU[39] published a full report which discusses the role of ICT in the smart grid with a view of energy efficiency, with the ultimate goal of hindering climate changes.

The “union” between the Communications and Power industries is still unconsummated, but it will happen as building a new ICT infrastructure is very costly

Telecom industry and service providers have a very important role in the smart grid. Cloud based hosted energy service providers will reach the home also via existing broadband access technologies. Broadband access can have a role in demand side management

Another driver for convergence is that Smart Grid does not end at the meter but it enters the home. Many aspects of the Smart Grid are directly related to the availability of a home networking and consumer participation is key in demand side management programs

This will also shape the future of the Consumer Electronics industry through new energy efficiency standards. The power grid often crosses international or jurisdictional boundaries, but applications and devices must interoperate regardless of those boundaries. The Telecom/Power/CE convergence for the Smart Grid will drive a new echo-system of products and this must happen under the auspices of International Standard Organizations.

[39] www.itu.int/ITU-T/climatechange/report-smartgrids.html

6 Conclusion

Climate change

Climate change is now an undeniable reality. Without further commitments and action to reduce greenhouse gas emissions, the world is likely to warm by more than 3°C above the preindustrial climate. Earth has never been so hot since 1850[40]. From 1850, the average temperature of the Earth has risen by 0.8 ° C compared to the average temperature established over the period 1961-1990, with 0.6 ° C over the last fifty years. In order to avoid devastating impacts on our societies, scientific recommend not to exceed a rise of more than 2°C before the end of 21st century.

Even with the current mitigation commitments and pledges fully implemented, there is roughly a 20 percent likelihood of exceeding 4°C by 2100. If they are not met, a warming of 4°C could occur as early as the 2060s. Such a warming level and associated sea-level rise of 0.5 to 1 meter, or more, by 2100 would not be the end point: a further warming to levels over 6°C, with several meters of sea-level rise, would likely occur over the following centuries.

Climate changes caused by carbon dioxide are expected to persist for many centuries even if emissions were to be halted at any point in time. Such extreme persistence is unique to carbon dioxide among major agents that warm the planet. Long-term effects are primarily controlled by carbon dioxide.

Thus, while the global community has committed itself to holding warming below 2°C to prevent "dangerous" climate change, and Small Island Developing states (SIDS) and Least Developed Countries (LDCs) have identified global warming of 1.5°C as warming above which there would be serious threats to their own development and, in some cases, survival, the sum total of current policies—in place and pledged—will very likely lead to warming far in excess of these levels. Indeed, present emission trends put the world plausibly on a path toward 4°C warming within the century.

In addition, our societies become more vulnerable due to higher intensities of extreme events because of higher damages they cause.

Satellites and Earth-based sensors have provided scientific proof of this phenomenon by measuring key geophysical parameters such as temperature and sea-level rises. Given that the main cause of this phenomenon is human activity, ICTs can provide solutions for moving towards a resource-efficient and services-based society and for reducing CO_2 emissions, particularly in those sectors where the opportunities for doing so are greatest, i.e. construction, transportation and manufacturing. The ICT sector holds great potential for mitigating climate change through the decoupling of economic growth from energy consumption, as has already been demonstrated with the introduction of the PC, the Internet and mobile telecommunications.

Role of ITU

ITU plays a significant role in climate change policy responses to Monitoring, Adaptation and Mitigation. In regards to Monitoring, mainly work is done in ITU-R sector. In regards, to Adaptation one of ITU´s key activities is the assistance provided to Member States for disaster preparedness in developing National Emergency Telecommunications Plans and implementation of Early Warning Systems. Through its dedicated programme on emergency telecommunications, ITU-D responded to floods and other natural disasters and provided emergency telecommunications equipment to several Member States for better coordination. In Mitigation, ITU has been active in promoting energy efficiency of ICTs by and developing a series of methodologies for assessing the emissions reductions that can be achieved through the use of smart technologies.

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40 La Recherche, Février 2013, réchauffement climatique 3, page 44

ICT

The ICT industry is responsible for approximately 2 per cent of global CO_2 emissions. ICT solutions have the enabling potential to reduce a significant part of the remaining 98 per cent of the total volume of CO_2 emitted by non-ICT industries.

The application of ICT solutions can help to bring about a resource-efficient and services-based society, and can deliver CO_2 emission reductions, particularly in those sectors where the opportunities for doing so are greatest, i.e. construction, transportation and manufacturing. The ICT sector holds great potential for mitigating climate change through the decoupling of economic growth from energy consumption, as has already been demonstrated with the introduction of the PC, the Internet and mobile telecommunications.

The ICT has a major challenge to address in terms of reducing its own emissions to a minimum, it being necessary to this end to adopt and implement new standards designed to boost the energy efficiency of networks and services. At the same time, it is very clear that a reduction in global GHG emissions can be achieved only by implementing measures such as the widespread application of ICTs.

ICT can certainly help slowing down climate change, green ICTs increase economies of scale and industry stakeholders are able to innovate. The obsolescence of goods and services must disappear, the lifetime of the equipments should be extended and the repair capacity of products should reduce the systematic usage of raw materials. Finally, the rebound effect associated to green ICT should not lead to over-consumption of goods and services in order to avoid excessive use of energy and raw materials.

There will continue to be a need to help countries, in particular developing countries, to respond to climate change. This report responds to the strategic goal of ITU-D, which includes the following:

- Promoting the availability of infrastructure and fostering an enabling environment for telecommunication/ICT infrastructure development and its use in a safe and secure manner. The ICTs in question here perform various functions: Earth observation, transmission of observation data to specialized centres, and information exchange to minimize physical transportation.
- Expanding the benefits of the information society to the membership in cooperation with public and private stakeholders, and promoting integration of telecommunication/ICT use into the broader economy and society as drivers of development, innovation, well-being, growth and productivity globally.
- Encouraging ICT research and development activities of relevance to the public for the monitoring and communication of GHG emission data (mobile applications and associated technologies), and facilitating the transfer of knowledge and technologies concerning the use of ICTs to foster a sustainable environment. Encouraging the financing of such research and development activities through public funds allocated to action plans for combating climate change.
- Favouring the development of a "green" economy by encouraging the recycling of electrical appliances which, for the most part, are heavy users of rare and/or toxic metals.
- The concept that increases in savings provided with energy efficient practises will be balanced with the increases in energy consumption is called rebound effect. There are some evidences showing distinct types of energy efficient technologies caused an increase in energy demand in the past. Rebound effect is quite higher in some countries and is applicable to many sectors: transportation, mobile communications for instance. It is expected that rebound effect remains high and there may be need for energy policies to take into account possible losses in energy savings due to rebound effect.

In the international negotiations on climate change, governments have agreed in Copenhagen a goal of limiting climate warming to a maximum of 2° C. This goal is attainable provided better control of emissions of greenhouse gases. It is our responsibility to limit the increase of temperature and we hope that the issues mentioned in this report can modestly contribute to this goal.

Annexes

Annex 1: Definitions — Available references on ICT and climate change

1.1 Scientific documents

Scientific journals and books

- La Recherche, Réchauffement : ce que mesurent les spécialistes, pp 62 à 66, novembre 2011
- CNRS, Le climat à découvert, CNRS éditions, 2011
- OECD, Space Technologies and Climate change, 2008

1.2 UN agencies

Convention-Cadre des Nations Unies sur les changements climatiques (CCNUCC)

- Kit d'information sur les changements climatiques, juillet 2002 ; http://unfccc.int/essential_background/background_publications_htmlpdf/climate_change_information_kit/items/305.php
- Convention-Cadre des Nations Unies sur les changements climatiques (CCNUCC), 1992 ; http://unfccc.int/essential_background/convention/background/items/2853.php

Colloque de l'UIT sur les TIC et les changements climatiques

- UIT, Colloque de l'UIT sur les TIC et les changements climatiques, Quito (Equateur), 8-10 juillet 2009 ; Rapport général sur les TIC et les changements climatiques; www.itu.int/themes/climate/

Premier séminaire UIT/OMM sur l'utilisation du spectre radio pour la météorologie: prévision du temps, eau et suivi du climat, OMM, 16-18 septembre 2009 ;

www.itu.int/ITU-R/index.asp?category=conferences&rlink=seminar-itu-wmo&lang=en

GIEC Groupe d'experts intergouvernemental sur l'évolution du climat

- www.ipcc.ch/home_languages_main_french.htm
  Rapports disponibles sur www.ipcc.ch/publications_and_data/publications_and_data.htm

1.3 Space agencies

EUMETSAT, Organisation européenne pour l'exploitation des satellites météorologiques

- http://www.eumetsat.int/Home/Main/AboutEUMETSAT/ClimateMonitoring/index.htm?l=en
- Rapport: Climate monitoring, meeting the challenge

CNES, Agence française de l'Espace

- Terre environnement climat ; www.cnes.fr/web/CNES-fr/7090-terre-environnement-et-climat.php

ESA, Agence spatiale européenne

- Le changement climatique, mythe ou réalité? ;www.esa.int/esaCP/ESAYGOZ84UC_France_0.html

NOAA, National Oceanic and Atmospheric Administration (Agence météorologique nationale américaine)

- State of the climate 2010; www.ncdc.noaa.gov/bams-state-of-the-climate/2010.php

- Indicateurs des changements climatiques ; www.ncdc.noaa.gov/indicators/

Université de Manchester (Royaume-Uni)

- Unveiling the Links between ICTs & Climate Change in Developing Countries: A Scoping Study, Angelica Valeria Ospina et Richard Heeks, 2010
- Centre for Development Informatics, Institute for Development Policy and Management, SED; www.manchester.ac.uk/cdi

1.4 Policy and strategy

- NICCD, Making Policy on ICTs and Climate Change in Developing Countries: This guide is for policy makers on ICTs and climate change identifies the ICTs, climate change and development (ICCD) policy actors and priorities at three levels: international, national and sub-national, 2012
- World Bank, Municipal ICT Capacity and its Impact on the Climate-Change Affected Urban Poor - The Case of Mozambique Report, 2012
- World Bank, African Development Bank, Africa Transformation-Ready: The Strategic Application of Information and Communication Technologies to Climate Change Adaptation in Africa, 2012
- OECD, Economic Aspects of Adaptation to Climate Change: Costs, Benefits and Policy Intruments, 2008
- Ospina, A. V. & Heeks, R., ICTs and Climate Change Adaptation: Enabling Innovative Strategies, 2011
- Roeth, H., Wokeck, L., Heeks, R., & Labelle, R. ICTs and Climate Change Mitigation in Developing Countries, 2012
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- Ospina, A. V. & Heeks, R., The Future Research Agenda for ICTs, Climate Change and Development, 2012

1.5 Case studies

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- Saravanan, R., e-Arik: Using ICTs to Facilitate Climate-Smart Agriculture among Tribal Farmers in North-East India. ICTs and Agricultural Adaptation to Climate Change Case Study, 2011
- Rezaul Haq, A. H., Bakuluzzaman, M., Dash, M., Uzzaman, R. & Nandi, R., An ICT-Based Community Plant Clinic for Climate-Resilient Agricultural Practices in Bangladesh. ICTs and Agricultural Adaptation to Climate Change Case Study, 2011

- Caceres Cabana, Y., Using Radio to Improve Local Responses to Climate Variability: The Case of Alpaca Farmers in the Peruvian Andes. ICTs and Agricultural Adaptation to Climate Change Case Study, 2012
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- Rajão, R., ICTBased Monitoring of Climate ChangeRelated Deforestation: The Case of INPE in the Brazilian Amazon. ICTs and Climate Change Monitoring Case Study, 2011
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1.6 National organizations

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- United Kingdom, Government ICT Strategy: Smarter, cheaper, greener, 2010
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1.7 Other related resources

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- UNCSD, The Future We Want, Rio+20 outcome document, the role of ICTs is explicitly mentioned in articles 44, 65, 114, 128 and 230 of the document, 2012
- InfoDev, ARD and World Bank, ICT and Agriculture – Research and Impact & ICT in Agriculture Sourcebook, 2010

- ITU, World Bank, IFC and InfoDev, Telecommunications Regulation Handbook (Tenth anniversary edition), 2011
- InfoDev, ICT for Development: Contributing to the Millennium Development Goals, 2003
- United States, Enironmental Protection Agency, Climate Change Impacts and Adapting to Change website
- The following link provides references to external resources compiled by the ITU-T on Climate Change and ICTs; http://www.itu.int/ITU-T/worksem/climatechange/resources.html

Annex 2: Climate change: importance of the oceans, extremes phenomena, examples of climate change in some countries

2.1 Importance of the oceans

The ocean plays an important role in climate and climate change. The ocean is under the influence of his exchanges with the atmosphere in terms of mass, energy and momentum. Its heat capacity is about a thousand times greater than that of the atmosphere and the assimilation of net heat from the ocean is several times greater than that of the atmosphere. Changes in heat transport and sea surface temperature have significant effects on many regional climates in the world. Life in the oceans depends on the biogeochemical status of the seas is affected by changes in their physical state and circulation. Pollution, greenhouse gas emissions greenhouse and commercial fishing are changing the world's oceans, vast expanses of water we thought insensitive to human activities. Scientists are trying to better understand the critical role that the oceans play in global climate. Nowadays, it is difficult to deny the following three factors:

- The amount of carbon dioxide in the atmosphere increases.
- The average temperature of the air in the lower layer of the atmosphere (the closest to the surface of the earth) and to increase the surface of the ocean.
- The mean sea level is rising faster than any time since the end of the last glacial period.

The rapid change in the chemical composition of sea water endangers ocean ecosystems that were already under pressure due to overfishing and we do not know exactly what the impact of this on future climate change.

2.1.1 The ocean: a huge "treadmill"

The five oceans of the world are not separated from each other. Groundwater flows continuously, forming a huge treadmill: the warm waters of the area are from the equator toward the poles and cold water poles deep seated range from the poles to the equator. Scientists call this phenomenon thermohaline circulation or convection because it is due to temperature (thermo) and salinity (haline) water.

The waters are divided into several layers according to their density, which rarely mix. The warm waters circulate to the surface, while the cold water flow at depth. Even in the tropics, deep waters are almost cold. There is an increasing expansion of hot water when the sea level rises with ocean warming.

In the North Atlantic, the flow of convection maintains the temperature of the atmosphere at a level higher than it would otherwise be. Under the effect of the thermohaline circulation and wind, surface waters transport heat from the equator toward the poles.

With global warming, it is possible that the glaciers of the North Pole is so rapid that a large volume of fresh water flowing into the ocean, causing a slowdown or shutdown of the thermohaline circulation. Some evidence suggests that this phenomenon occurred in this place there for thousands of years, ending the glacial period. Many researchers believe that it is unlikely that this phenomenon is repeated today.

According to most climate models, the slow movement, but nobody knows exactly how fast or how far. Slowing the circulation in the North Atlantic has an impact on the climate in Europe: average temperatures continue to rise, but less rapidly as the traffic slows.

2.1.2 A carbon sink and heat

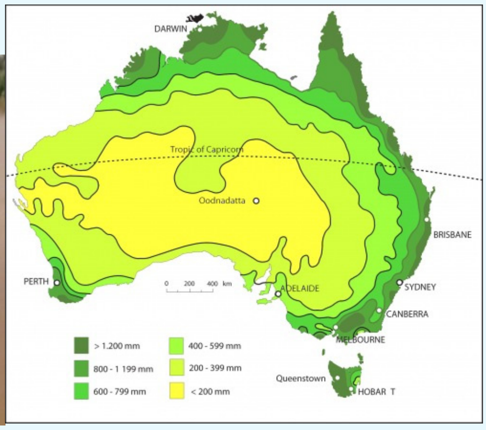
Oceans absorb from 80 to 90% of the heat from the atmosphere. Without them, the planet would warm much faster. An increase in air temperature that would normally take hundreds of years does take while dozens. The oceans absorb carbon dioxide from entering the water where it dissolves to form carbon dioxide, like bubbles in a carbonated beverage. A large-scale thermohaline circulation induced cold-water diving (so rich in CO_2, because CO_2 has a greater solubility in cold water) to the deep ocean at high latitudes, especially in the North Atlantic then rise more or less diffuse these deep waters to the surface areas of deep water formation. Variability of solubility with temperature exacerbates the "degassing" of CO_2 at low latitudes and absorption by the ocean at high latitudes. Carbon storage in the ocean is strongly associated with the ability of the deep ocean to collect and retain carbon exported. A change in the thermohaline circulation induced disruption of trade between the ocean surface and the deep ocean: on short time scales, a decrease in the circulation will reduce the intensity of the pump dynamics and thus reduce the training of CO_2 to the deep ocean, while on longer time scales, the return of carbon to the deep surface is also reduced.

According to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change (2007), ocean acidity has increased by nearly 30% over the last 200 years, and mainly due to increasing the carbon dioxide released by humans into the atmosphere.

2.2 Extreme phenomena such as floods in Australia (December 2010/January 2011)

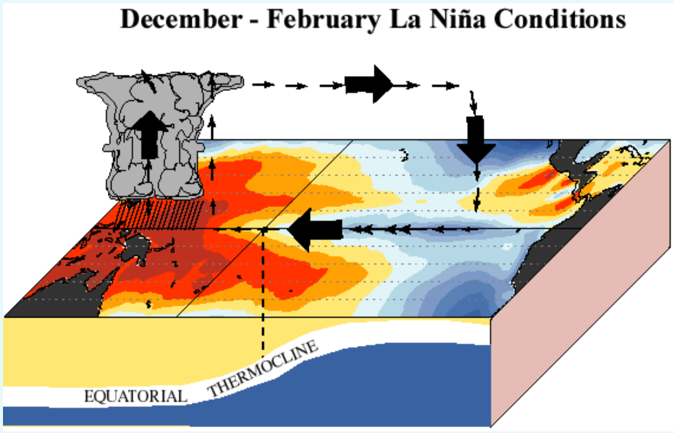
Meteorological services in Australia have announced that the floods that killed ten people between November 2010 and January 2011 were due to the La Niña weather phenomenon, which has been the source of the wettest year ever recorded in Queensland since meteorological records are established. In contrast to El Niño, La Niña is characterized by an increase in surface temperature of the sea areas in central and eastern Pacific.

According to the World Meteorological Organization, this phenomenon reappeared in July, usually accompanied by heavy rains Indonesia, Malaysia and Australia, droughts in South America, more storms in the Atlantic tropical, cold waves in North America and rainy weather in the south-eastern Africa.



In its original sense, El Niño is a warm water current that flows periodically along the coast of Ecuador and Peru, disrupting the local fishery. This ocean is associated with a fluctuation regime intertropical surface pressure and circulation in the Indian Ocean and the Pacific, called the Southern Oscillation. Collectively, this coupled atmosphere-ocean phenomenon is known as the El Niño Southern Oscillation, or ENSO.

Under normal circumstances, the tropical Pacific warm in the West Pacific and cold in the East. When El Niño occurs, the prevailing trade winds diminish and the equatorial countercurrent strengthens, accordingly, the warm surface waters in the area of Indonesia moves eastward to cover the cold waters of the Peru current. This has a significant impact on the wind, the temperature of the sea surface and precipitation patterns in the tropical Pacific. It has climatic effects throughout the Pacific region and in many parts of the world. However, this phenomenon El Ni no lui_meme contains its own end, as snaps a wave that relaxes the system to the "normal" state. The opposite of an El Niño event is called La Niña.



2.3 Examples of climate changes in some countries

Impacts of climate change in Ghana

– Evidence of climate change abound in Ghana. **Temperature has increased** by 0.6 - 0.8 °C since 1960.

– According to projections of the Environmental Protection Agency (EPA), by 2080 the **rainfall will reduce** by 20% to 40% while the temperature will rise by 4.5 C.

– All these conditions will not be suitable for the **growing of cocoa** anywhere in the country.

– The **rainfall pattern is** affecting maize production. By 2020 it is projected that there will be a 7% decline in production.

Annex 3: Questionnaire about ICT and climate change - Proposal for an ITU-D Recommendation

This annex contains an analysis of the questionnaire, and following the answers and the findings contained in the Report and the other annexes, an ITU-D recommendation is proposed on the overall issue on ICT and climate change.

1. Does your government (or company) have any policy regarding climate change?

☐ Yes ☐ No

If yes, what is your policy regarding ICT for combating climate change?

If no, do you intend to have future plans for implementing a policy regarding ICT?

2. Does your government (or company) have current actions in terms of adaptation to climate change? Note: Adaptation involves taking action to cope with the effects of climate change on a local or country level. ICT can greatly support this action. Examples include remote sensing to gather climate data, dissemination of information such as forecast sea level rise and taking action to minimize the impact such as building on higher ground. ICT infrastructure is already used to warn of natural disasters such as earthquakes and tidal waves. Additional or new ICT infrastructure and services may be needed to help deal with problems such as water and food shortage etc. arising from extreme climate conditions.

☐ Yes ☐ No

If yes, please specify these actions.

a) Have you implemented measures to extend the lifespan of ICT equipment?

☐ Yes ☐ No

b) Have you implemented recycling of ICT equipment in your country?

☐ Yes ☐ No

c) Do you have a policy in the management of electronic waste?

☐ Yes ☐ No

If no, do you intend to propose adaptation measures to climate change in the future?

3. Have you estimated the global ICT footprint in your country, in terms of greenhouse gas (GHG) emissions? Note: ICT global footprint: The ICT industry has for a long time been focused on delivering productivity enhancements in and through its products and solutions. Energy efficiency has only recently become a critical issue: in some countries, energy consumption of ICT is now more than 13%. It is estimated that the ICT industry accounts for approximately 2% of global CO_2 emissions.

☐ Yes ☐ No

If yes, what measures are you taking to reduce your GHG ICT footprint?

If no, what are your plans for the future?

4. Are you aware of "green" ICT initiative which would provide better design and energy consumption?

☐ Yes ☐ No

If yes, are they: (please explain)

a) regional initiatives, please explain the details, and indicate the level of implementation of these initiatives in your country.

b) global initiatives, please explain the details, and indicate the level of implementation of these initiatives in your country.

If no, what specific aspects of green ICT would you like to learn more about?

5.	Are you aware of the so-called rebound effect that would offset the beneficial aspects of green ICT or any ICT consuming less energy? Note: Rebound effect: The rebound effect (or take–back effect) is well-known in economy and in energy saving. It generally refers to the introduction of new technologies, or other measures taken to reduce resource use: these responses tend to offset the beneficial effects of the new technology or other measures taken. While the literature on the rebound effect generally focuses on the effect of technological improvements on energy consumption, the theory can also be applied to the use of any natural resource. ☐ Yes ☐ No If yes, please indicate if your are planning future actions in this area If no, would you consider this phenomenon in the future?
6.	What severe weather conditions are typical in your rural/remote regions?
7.	Is your administration using any Systems and Applications of ICT to adapt to climate change? ☐ Yes ☐ No If yes, please specify in which area and the type of system and application used: ☐ Water supply (see ITU-T tech watch report on smart water and ICT) ☐ Food supply (see ITU-T tech watch report on this) ☐ Health ☐ Maintenance of infrastructure ☐ Electricity ☐ Gas ☐ Road ☐ Rail ☐ Airport ☐ Others
8.	What ICT services would enable communities to better adapt to climate change? (One example could be automated text messages to communities about water shortage and emergency water supply, etc.)
9.	What specific technologies or standards for ICT equipment are used by your administration to gather data to monitor climate change? Please select. ☐ Satellite systems ☐ Airborne systems ☐ Terrestrial systems (fixed and mobile) ☐ Subsea systems ☐ Others If others, please specify:
10.	What technologies and/or standards could enhance the gathering of data/information about climate change for your administration?
11.	What information communication technologies and standards are used by your administration to disseminate information about climate change to those who need it (e.g. in broadcast, Satellite systems)? Examples include the following:

☐ Terrestrial systems (public fixed) ☐ Terrestrial systems (public cellular) ☐ Terrestrial systems (private networks/private mobile radio) ☐ Interactive voice ☐ Others If others, please specify:
12. What technologies and/or standards could enhance the dissemination of information about climate change to those who need it?
13. Access to information is important for communities needing to adapt to climate change. What are the challenges to deploying Telecommunication infrastructure in rural/remote areas in your region? Please indicate those that affect you most from the following examples: ☐ Access to electricity ☐ Expense of power backup ☐ Terrain ☐ Accessibility and transportation ☐ Lack of skills manpower ☐ Installation and maintenance of networks ☐ Operating costs high ☐ Average revenue per user low ☐ Population sparse and scattered ☐ Others (e.g. vandalism and/or theft) Please explain any key challenges:
14. What primary and backup energy sources are available in your rural/remote areas? Examples include the following: ☐ Solar ☐ Wind ☐ Diesel ☐ Others If others, please specify:
15. What types of telecom/mobile systems are needed to allow enhanced access to information concerning climate change or extreme weather events in rural/ remote regions?
16. What are the educational opportunities in rural/remote regions to train individuals in the use of ICTs for adaptation to climate change?
17. Some systems are specifically developed for developing countries most of them have some features that are not essential enough to justify their cost and / or lack the required specification to meet the existing conditions in developing countries. What are the specifications and features that are essential in rural / remote regions in your country?

Question 1: Policy about climate change

Most countries (70%) reported having a policy on climate change. However, 30% of countries said they don't have such a policy.

Japan has a policy goal requiring that the level of CO_2 emissions should be reduced by more than 10% by 2020 through full-fledged utilization of ICT.

It has been noted that the importance of working with member companies to help reduce energy consumption and facilitate adoption of energy saving methods and equipment.

<u>Question 2: On-going actions about adaptation to climate change</u>

It is recognized that ICTs can be an effective control measure against global warming. **80% of authorities said they have on-going actions for adaptation**.

The use of ICT vis-à-vis climate change takes place in the three categories below.

1. ICT applications for adaptation to climate change.
2. ICT applications to mitigate the effects of climate change: preferential use of electronic media, e-mail, phone calls, Internet, video conferencing instead of traveling expenses, limiting printing on paper.
3. Development of a sustainable ICT sector (green economy): recycling of ICT (equipment and accessories, equipment with low power consumption).

63% of the replies favored a longer lifespan of ICT. 70% of the replies promote a recycling of the ICT. 63 % of the replies are in favor of a management of electronic waste.

Note that some countries have started a "National Strategy for Sustainable Development 2010-2013." It does not specifically address climate change, but all aspects of sustainable development. This includes for example: objectives of energy saving and emission reduction, measures for industrial restructuring and disposal of obsolete industrial capacity.

Regarding the management of electronic waste, several European directives establish a general framework.

Directive 2002/96/EC called "WEEE" aims to promote recycling of electronic and electrical equipment (EEA). It requires manufacturers and importers of electronic and electrical equipment to support the costs of collection and treatment of waste electrical and electronic equipment (WEEE).

Directive 2002/95/EC known as the "RoHS" (Removal of Hazardous Substances) complements the WEEE Directive. It states that, since 1 July 2006, the electrical and electronic equipment covered by the EU directive, whether imported or manufactured in the EU, must be placed on the market without six hazardous substances:

– Lead (used for welding ...);
– Mercury (used for batteries ...);
– Cadmium (used for batteries, integrated circuits ...);
– Hexavalent chromium (used to plug contacts ...);
– PBBs (used for microprocessors ...);

<u>Question 3: computation of the ICT footprint</u>

The study footprint of ICT is a key topic in conjunction with the rebound effect. According to the survey, only **30% of the countries have evaluated the corresponding GHG footprint due to ICT.** The various actions are involved in various jurisdictions.

1. Decrease in energy consumption "data centers", by promoting best practices;
2. Encouraging the production and use of electronic components that consume less energy;
3. Promotion of green procurement on the Internet (be careful not to penalize e-commerce);

4. Massive development of smart grids ("smart grids") and intelligent transport systems (see relevant paragraphs) and support R & D in these areas to prepare for future technology generations;
5. Defining indicators to assess the energy and environmental performance of digital industries;
6. Training so that the responsible people for these actions have the required skills.

Alcatel-Lucent has publicly committed to reduce our absolute carbon footprint by 50% by 2020 (2008 baseline). The carbon reduction targets set in 2007 were achieved a year ahead of schedule. Have expanded the collection of their Scope 3 emissions, increased their assessment of key and preferred suppliers, further reduced energy usage in labs and cooling systems in data centers as well initiatives at the local levels.

Concerning France, a detailed study conducted in 2009 found that consumption of global ICT sector in 2008 represents 7.3% of French electrical consumption, or 35.3 TWh / year. Despite growing ICT use, consumption could be reduced to 34.3 TWh / year by 2012 and 33.9 TWh / year in 2020.

This is generally about 5% of the production of CO ^{2} in France estimated at 554 Mt

Japan has the intention to achieve CO_2 emissions target for FY 2020: the domestic emissions will be reduced by more than 10% of the FY 2008 total (120,000 t-CO_2) through progressive reduction totaling more than 689,000 tons.

In Thailand, Government policy specifies target in reduction of energy consumption per productivity as 25% within 20 years, by means of promotion and eco-design for products and buildings, using clean energy to reduce GHG emissions and mitigate global warming phenomena, and continuing to raise environmentally consciousness in consumers.

Adaptation requires carrying out activities to cope with the effects of climate change at local or national. ICTs can be an important support for these activities, for example, the use of remote sensing to gather climate data, information dissemination, such as forecasts of rising sea levels, and application of measures to minimize the effects, such as building more in height above sea level is already using the ICT infrastructure to raise the alarm when a natural disaster like an earthquake or a tidal wave, occurs. It may be necessary infrastructure and ICT services additional or a new genre to help cope with problems such as lack of food or water due to extreme weather conditions.

Question 4: Green ICT initiative

63% replies said they are aware of the green ICT initiative, 37 % said no.

The Directive 2009/125/EC of the European Parliament and of the Council of 21 October 2009, establishes a framework for the setting of eco design requirements for energy-related products.

It is obvious that rare metal should be recycling: t is not only for a single country but also for the whole world.

In some countries, the Environmental Code states that Orders in Council of State may require the manufacturers and users to control energy consumption and pollutant emissions of their property, at their own diligence and costs.

The European Union (EU) has a number of projects under the Horizon 2020 initiative that touch upon better design and energy consumption. These include: the EU Environmental Technology Verification pre-program, the Environmental Technologies Action Plan, the Waste Electrical and Electronic Equipment (WEEE) Directive, the EU Code of Conduct for Data Centers, the ICT for Energy Efficiency Forum.

Question 5: Are you aware of the so-called rebound effect that would offset the beneficial aspects of green ICT or any ICT consuming less energy?

45% of the answers said they are aware of the so-called rebound effect. 55% said they are not aware.

Alcatel-Lucent is planning future actions to perform studies on the enabling effects of certain telecommunications network service applications within its portfolio. These enabling effects include the social, economic and environmental beneficial aspects as well as the rebound effects of the new (telecom networks services (TNS) application. In performing these studies, Alcatel-Lucent will use the GeSI methodology approach to assessing these net enabling effects.

Microsoft is involved in the methodologies assessment on rebound coordinated by the Global e-Sustainability Initiative (GeSI).

The rebound effect is well known in economics and energy saving and such a concept can be very attractive in the field of climate change. Its inclusion may be beneficial because the basic idea is very similar. It usually refers to the introduction of new technologies (in our case green ICT), or other measures to reduce resource use (in this case electricity): these responses tend to offset the effects benefits of new technology or other measures. France has not yet examined the effect of technological improvements on energy consumption, but believes that this theory should be used to accurately assess a policy or project decisions.

Question 6: What severe weather conditions are typical in your rural/remote regions?

In Bangladesh, there are cyclones and floods, excessive rainfall and humidity.

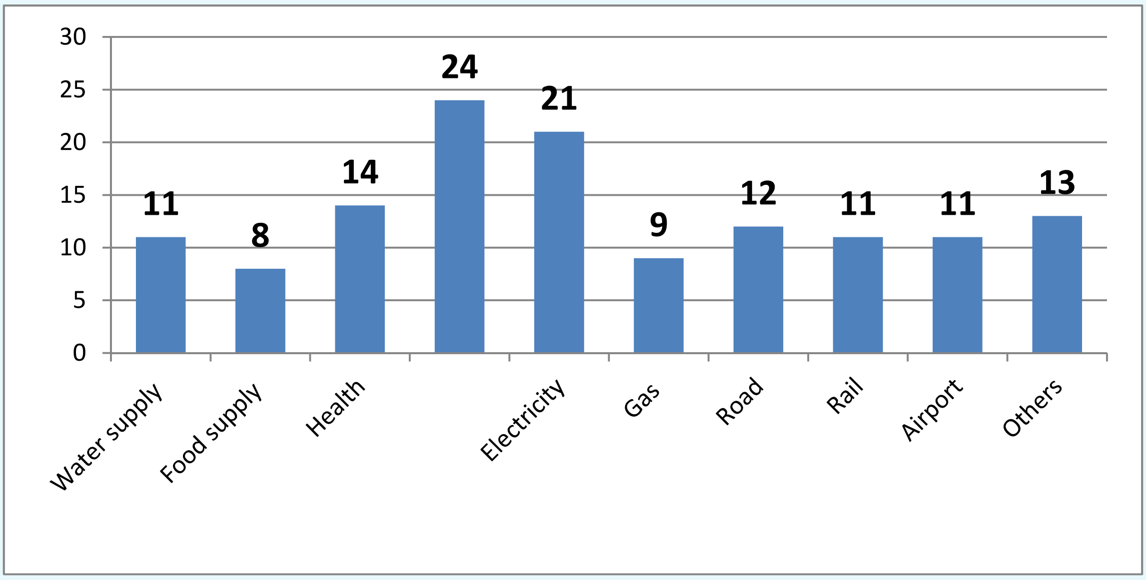
In Qatar: Desert climate with occasional sand storm, occasional flooding in urban area.

In Nepal: Changes in rainfall patterns, increase in atmospheric temperature, landslides, forest fires, cyclonic winds, drought, melting glaciers, regions with high snowfall, regions where there is no snowfall more than a week. Direct/Indirect impact on water resources, agriculture, forestry, biodiversity, etc.

Question 7: Is your administration using any systems and applications of ICT to adapt to climate change?

About 60% of the answers said they are using ICT to adapt to climate change, 40 % said they don't use ICT for that purpose.

The following figure shows the number of answers regarding the types of systems and applications.



Question 8: What ICT services would enable communities to better adapt to climate change?

Better energy efficiency is probably one of the key issues. Within this context, smart homes can be one solution. However, the solutions must be kept as simple as possible in order not to create additional. The most common communication platforms indicated are: fixed, Internet, mobile.

Ecuador: Emergency community telecommunication systems. Automation of mobile systems. Automatic calls to fixed services.

Greece: Smart grids and broadband services over power line (BPL). On-line climate change monitoring.

Qatar: Mobile Short Messaging Service (SMS) notification of sand storm, flooding. Severe weather warning through smart phones.

Question 9: What specific technologies or standards for ICT equipment are used by your administration to gather data to monitor climate change?

Concerning climate monitoring, Earth observation satellites are an essential tool, taking into account the repeatability of measurements and their high quality and accuracy.

A variety of means and technologies to gather key geophysical parameters representative of the phenomenon of climate change is currently used.

– Satellite systems are very effective because they provide a repeating series of accurate and reliable measurements of the number of geophysical parameters such as ocean salinity, soil moisture, temperature at all levels of the atmosphere, sea surface temperature, average height of sea level, ... For example, the French space agency (CNES) in collaboration with NASA, NOAA, EUMETSAT, ESA, ISRO, JAXA (...) is involved in the following programs: Jason, SMOS, MEGHA-TROPIQUE, AltiKa (....). All these satellite systems, which provide many key indicators for climate change, are fully operational and the data retrieved are constantly reviewed and analyzed by experts from space and meteorological agencies.

– The airborne systems are mainly used to test prototypes of future payloads to be flown on future satellites to validate future operational systems. Indeed, we must always bear in mind that the analysis of climate change requires a continuous series of reliable measurements, repetitive and compatible.

– Terrestrial systems (fixed and mobile) are also used as they complement the satellites cannot provide all categories of measures. Moreover, they are also essential to calibrate the data collected through satellites.

– The submarine systems are very useful because, for example, satellites can provide salinity of the ocean surface and it is not possible to obtain salinity below the surface. Satellite networks cannot provide all ocean parameters: this is why submarine systems are complementary to satellite systems.

– Experts use physical models continuously updated by terrestrial and satellite measurements: this process is called assimilation where data from ground sensors are enriched with satellite data. In addition, the comparison to a model is needed to validate the magnitude of the recovered data. Indeed, some data may be inaccurate due to poor measurement or disturbance, and under these conditions the corresponding wrong measurement are eliminated by the model from the set of measurements.

Question 10: What technologies and/or standards could enhance the gathering of data/information about climate change for your administration?

France said that it is working in collaboration with experts from space agencies and meteorological (including the World Meteorological Organization) to improve knowledge of climate change. Satellites and terrestrial measuring devices are the main sources of information.

Establishing systematic observation systems, monitoring networks and institutional information systems on sea level rising would an adequate support for decision making. The identification of vulnerable areas, the building of databases, the development and implementation of measures for resource protection, and the follow up and enforcement of planning regulations, would be the main objectives of administrations.

For example, the Egyptian Environmental Affairs Agency (EEAA) monitors an air quality monitoring network with a number of monitoring stations for CO_2, CH4, and Volatile Organic Compounds. The establishment of a network of tide gauges monitoring the Mediterranean, the Red Sea, and Lake Nasser is one of the main objectives. Egypt is supporting the establishment of a Regional Center for Research and Studies of Climate Change. This Center would be responsible for data collection, monitoring and assessing climate changes and likely impacts within Egypt and in the other Nile Basin countries, developing and maintaining a database in this regard, as well as networking with other research institutes.

Some countries need a basic satellite and terrestrial monitoring service supported by a basic telecommunications network (e.g. mobile/broadband).

- Some would like new equipment types, especially wireless sensor networks.
- Pioneering technologies on monitoring and halting deforestation should be widely disseminated and copied.

Question 11: What ICTs and standards are used by your administration to disseminate information about climate change to those who need it (e.g. in broadcast, satellite systems)?

The next IPCC report will be published very soon and this report is an important source of public information, scientists and policy makers. In addition to this comprehensive report, there are reliable sources of information available online, such as:

- www.aviso.oceanobs.com
- www.mercator-ocean.fr
- www.esa.int/SPECIALS/Space_for_our_climate/index.html

Question 12: What technologies and/or standards could enhance the dissemination of information about climate change to those who need it?

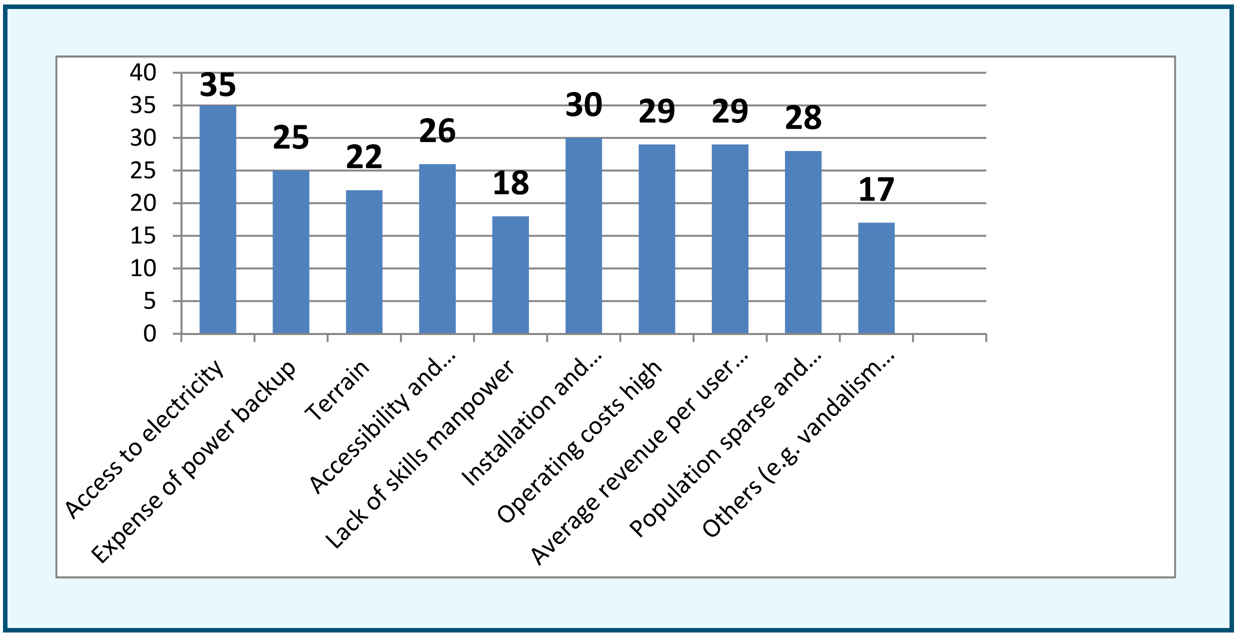
It seems that there is a need of a single/international standards to transmit climate change information.

ICT provides a tremendous support to data collection, storage, dissemination and weather and climate modeling, which is fundamental to improve knowledge about climate change. An efficient climate service delivery mechanism is fundamental to reach users.

- Brazil is participating in the development and implementation of the WMO GFCS (Global Framework for Climate Services) which addresses very well the user requirements.
- Information dissemination could be improved using dedicated standards based on research documentaries, on real statistics, on the impact of climate change and carbon footprint, and the repercussion thereof on social, economic and other parameters.
- Currently, there is a large variety of means to disseminate information. The frequently Cited Solutions for Dissemination are as follows:
  - Private networks, private mobile radio and community radio
  - Interactive voice systems
  - Broadcasting; TV channels, radio… internet.
  - Satellite and terrestrial systems (2G, UMTS, HSPA/HSPA+, LTE, etc).
  - Fixed Communication Systems
  - Traditional channels indispensable to raise awareness about ICT’s potential in dissemination: leaflets, brochures, newspapers, public gatherings, workshops…

Question 13: What are the challenges to deploying telecommunication infrastructure in rural/remote areas in your region?

This figure shows the key challenges mainly cited.



Here are some key challenges mentioned by the administrations.

Ecuador: High operating costs for the introduction and deployment of telecommunication centers in rural areas of Ecuador.

Qatar: No wire-line communications can be deployed to remote desert areas. These areas can only be covered by wireless networks

Burkina-Faso: Access to electricity: the relatively underdeveloped electric power grid does not cover most rural areas. Expense of power backup: Solar energy equipment and generators are expensive. Low average income: in general the population's purchasing power is low

Lesotho: Rural areas experience the scarcity/absence of public facilities such as reliable electricity supply, access roads and regular transport. Scarcity of technical personnel. Difficult topographical conditions - construction of wire telecom networks become costly. Severe climatic conditions make critical demands on the telecom equipment. The initial capital cost of electricity and the purchase ICT devices is high. Lack of ICT usage skills

Question 14: What primary and backup energy sources are available in your rural/remote areas?

- Diesel : 39%
- Wind: 18%
- Solar : 29%
- Others: 14%

Question 15: What types of telecom/mobile systems are needed to allow enhanced access to information concerning climate change or extreme weather events in rural/remote regions?

- Radio and regular mobile systems.
- Full coverage of UMTS/satellite networks
- Wireless technology such as GSM/3G, trunk radio systems or Wimax.
- Access to broadband networks are the foundation for enhancing access to information concerning climate change
- Long distance wireless links are very useful, given the distances in many remote regions

Question 16: What are the educational opportunities in rural/remote regions to train individuals in the use of ICTs for adaptation to climate change?

- These opportunities are very underdeveloped. Broadcasting plays a major role in raising the population's awareness of climate change.
- This could be done through the training given in the Computer Training Centers. The trainers should be trained first to be able to educate individuals about the use of ICTs for adaptation to climate change.
- Can be done through village schools (Television, Mobile Communications)

Question 17: Some systems are specifically developed for developing countries. What are the specifications and features that are essential in rural/remote regions in your country?

- Low power consumption, ease of deployment in rural areas with low and scattered populations (cost factor).
- Low energy consumption, running on solar power; robust and extremely watertight.
- Special system for desertification and high temperature areas
- High reliability of equipment requires less energy expense for maintenance and replacements. Simplicity drives costs down.
- Robust to withstand very hot weather conditions and serious power surges. Ability to withstand high lightening voltages, especially during rainy seasons. Wireless based systems and use of low frequency bands to cover the vast mountainous rural areas. Simple and user friendly.

Annex 4: ICT footprint

4.1 Overview

According to the report "Impacts of Information and Communication Technologies on Energy Efficiency" produced by BIO Intelligence Service (specializing in research and consultancy services in the field of information relating to environmental and health products) for the European Commission in 2008, information technology and communication (or ICT) accounted for 2% of the emissions of greenhouse gas emissions in Europe in 2005.

According to the conclusions of the report, by 2020, this share could reach nearly 4% as a likely scenario ("business as usual" - no modification of current behaviors and habits), against nearly 3% in economy scenario (effective solutions). However, ICT is now an integral part of our professional and personal lives. Given that these new practices are called to grow, their impact on the environment is becoming a major concern.

4.2 e-mail

On average, 247 billion e-mails were sent each day in the world in 2009, taking into account the spam, and this figure is expected to climb to 507 billion by 2013. In France, every employee in a company of 100 people, receives an average of 58 emails a day and send 33, whose average size is 1 MB. The sending of these emails has an effect on the gas emissions greenhouse. If we consider that each employee works 220 days a year, these emails are 13.6 t CO_2 equivalent.

10% reduction in sending emails systematically including his manager and one of his colleagues in a company of 100 people saves about 1 ton of CO_2 equivalent over the year (approximately one round-trip Paris / New York).

The case of a French company that an employee sends an email of 1 MB to several people (10 and 100) was studied. The results showed that to increase the number of recipients multiplied by four the impact on climate change.

To obtain more accurate data, the scenarios evaluated the difference in the incidence depending on whether you send an email from 1 MB to 1, 2 or 3 recipients. Each sending an email to an additional recipient produces about 6 g of CO_2 equivalent, which represents nearly 44 kg of CO_2 equivalent per employee per year.

4.3 Research on the Internet

The Internet is like: it browses endless page to page and from link to link. A French user performs on average 2.66 Internet searches per day, 949 searches per year, according to Médiamétrie.

Surfing the Internet is therefore polluting the environment in the sense that servers consume electricity and generate heat. According to ADEME, seeking information via a search engine is the final 9.9 kg CO_2 equivalent per year per user. How to reduce this impact? Use specific keywords in searches, enter the address directly into the navigation bar if known, record the sites that are often used in his "favorites": all actions that can earn 5 kg equivalent CO_2 per year per person.

4.4 USB key

This use far less studied for both the impact of the production of a USB drive and play files it can store. Total transmit a 10 MB document to a person by USB 512MB emits 11 grams of CO_2 equivalent. In the case of a file sent to 1000 people at a conference, for example, emissions rise and equivalent to those generated by a journey of 80 km by car.

How to explain this impact? Production of the USB requires a lot of energy, water and rare metals. This is the position most polluting lifecycle. Then the energy consumption of the computer that is used the key. According to ADEME, if the time to read the document does not exceed 2 to 3 minutes per page, screen reading is the one that has the least impact on climate change. In addition, the document is printed in black and white, double-sided and two pages per sheet becomes preferable to reduce emissions.

Annex 5: Green ICT

5.1 Moving beyond the established diesel generator paradigm

Installing wireless base stations in regions of the world previously cut off from a modern electricity grid is not an entirely new concept. However, it has become increasingly obvious that diesel generator powered stations are becoming a much less viable option for network operators looking to expand into new markets.

First, from an environmental standpoint, diesel gensets are noisy, dirty and exhaust harmful hydrocarbons into the atmosphere during their operation. Second, diesel gensets are ultimately too expensive — their operation and maintenance typically accounts for 35 percent of the total cost of ownership (TCO) of a base transceiver station (BTS). With fuel costs on the rise, that percentage will continue to climb and remain dependent on international fluctuations of the fuel market.

In addition, diesel-powered BTS sites are notoriously unreliable. These generators can suffer a variety of types of failures and are responsible for typically more than 60 percent of the outages that result in a loss of telecom service. When a breakdown or failure does occur, it takes considerable time and money to get a technician to the site to effect repairs — if the replacement parts are even locally available. Simply getting the diesel fuel to a remote site can also be a challenge — one such network in Kenya needs 100 trucks operating on a full-time basis just to transport sufficient fuel to keep its stations operational.

The inherent instability of diesel fuel itself must also be taken into consideration. The fuel has a limited shelf life and can quickly degrade and build up contaminants, a process that is accelerated in warmer, tropical climates. Theft and vandalism of generators and fuel can also pose significant problems at remote locations and in struggling economies. Stations in these regions often require the implementation of costly security measures.

Finally, old BTS sites powered with diesel generators often rely on indoor telecom cabinet technology, housed in heavy shelters and cooled by electricity-guzzling air conditioning systems. State-of-the-art BTS sites, in comparison, use outdoor cabinets that make it possible to avoid the use of shelters and air conditioning, providing very important power consumption and cost savings for the network operator.

5.2 Energy migration steps (cooling)

The preliminary step in optimizing the energy of telecom sites is to minimize energy usage. Beyond reducing power consumption from the telecom equipment and the telecom network, which is largely addressed by the Telecom Industry (e.g. GreenTouch consortium, Light Radio initiatives, etc.), power consumption for site cooling needs to be considered.

In traditional base station shelters, cooling is provided by an air conditioner. The air conditioner employs a refrigerant and fans to cool and pump the air around the inside of the base station. When the air conditioner is active it recycles air continuously, e.g. hot air exiting the telecommunications equipment enters the air conditioner and mechanical cooling is performed on the hot air. In an attempt to alleviate this energy burden “Free Cooling” (also known as fresh air cooling) was introduced into air conditioner design. There are two different free cooling options available; 1) a compact system that combines the air conditioner and free cooling hardware. Some of the key issues with this design are high cost and poor reliability and 2) another type of free cool solution combines a split air conditioner and separate free cool system. This system has the advantage that it is less expensive; however, the performance in general is poor in the high ambient temperature range.

In more advanced cooling solutions, smart sensing and smart control algorithms are implemented in order to achieve efficient low cost “free air” cooling solution that maximizes the temperature range over which ambient air can be used to cool the equipment thereby reducing the time that the air conditioner is active leading to energy savings and improved reliability of the air conditioner.

5.3 Energy migration steps (alternative energies)

After optimizing the energy consumption, efforts must go towards on-site energy generation and storage. A usual primary migration step, often called "hybrid genset battery (HGB)" consists of replacing one diesel generator by a deep cycle battery bank that is providing the energy to the load when the genset is switched off periodically. This solution has been described in many papers, some of which are referenced below. It reduces the runtime of the diesel generator typically by 50-60 % but the fuel consumption reduction is lower because the genset needs to recharge the batteries at the same time that it is powering the load when it is running.

A typical next migration step, called "single alternative energy (SAE)", consists of taking advantage of localized alternative energy production to further reduce the diesel generator runtime and consumption. Solar panels are usually chosen in this case because the genset can be synchronized with its daily production cycles. This migration can be done with limited modifications of the energy controller and the surface of solar panels can be matched to the shadow-free areas available on the site and the financial targets defined by the operator. Depending on the size of solar panels installed on site, it reduces the runtime of the diesel generator typically by 70-80 %.

The ultimate migration step consists of deploying "multiple alternative energies (MAE)", typically leveraging on solar and wind complementary productions on the site but also leveraging benefits of fuel cells. In this configuration, one pre-existing diesel generator may remain or may be replaced by a fuel cell to address the few worst case climatic conditions without over dimensioning the batteries and solar panels. This is also a way to match the site footprint and budgetary constraints. With the MAE configuration, the diesel generator runtime savings are typically higher than 90 %, depending on the site dimensioning constraints. Wind production is provided by small wind turbines in the range of 2 to 6 kW. Where the mechanical and regulatory constraints can be addressed, it is preferred to install the wind turbine on top of the existing telecom mast for better efficiency.

If the multiple alternative energies (MAE) configuration is the ultimate solution in terms of reducing the carbon footprint and keeping the network operator's operating expenditures (OPEX) out of diesel fuel availability issues and price fluctuations, it is still requiring a significant level of Capital expenditures (CAPEX). Therefore the migration strategy implemented by network operators needs to be defined site per site, resulting in a mix of the three configurations described above (HGB, SAE and MAE), depending on climatic, telecommunications, infrastructure and financial parameters, and what typical multi-year migration process should be envisaged on the sites.

5.4 Network-wide energy management tools

The migration process described above can be implemented in very different ways by each network operator, depending on its existing footprint, its investment strategy, planned traffic increase etc. To assess and analyse their current situation in order to plan their migration process, network operators need real-time and consolidated data from each site, including grid power availability (hours per day, where the grid connection exists), fuel consumption, cooling consumption, temperature etc. as well as energy relevant alarms and faults. Getting and managing these data requires a dedicated central network management tool. This type of software has commonalities with traditional telecom Operation and Maintenance Center (OMC) but with a special focus on Energy topics. It has therefore all the potential to be managed directly by the Network Operating Center (NOC) of the telecom operator, and be interfaced with larger OSS configurations. These tools are going to be largely deployed in the coming 5 years. They will enable operators to real-time and centrally assess, analyze, plan, challenge, optimize all their energy related operating costs, operation processes and transformation programs.

5.5 ICT and climate change stakeholders

In a joint press release (08.03.2011), the World Resources Institute (WRI), the World Business Council for Sustainable Development (WBCSD), the Global e-Sustainability Initiative (GeSI), and the Carbon Trust announced that they will work with ICT companies and their customers to develop common approaches and methodologies to calculate the carbon footprints of ICT products and services thanks to industry guidance due to be published at the end of 2011. The guidance will also involve NGOs, government experts and academics. GeSI is playing a leading role in bringing ICT companies on board and in promoting the initiative to the ICT industry. Already a number of major global ICT companies have committed their support.

It is expected that the new guidance will encourage companies to measure, report, and reduce the carbon footprint of their ICT products and services, thus contributing to global emission reductions.

This guidance will be published as an ICT Sector Supplement to the Greenhouse Gas (GHG) Protocol Product Accounting and Reporting Standard - part of the Greenhouse Gas Protocol Initiative, which is the most widely used global accounting and reporting standard for corporate GHG emissions.

5.6 References:

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Annex 6: ICT case studies

6.1 Case study 1: Field trials of mobile base stations using tribrid electric control technology

Summary: Mobile base stations account for approximately 60% of all of KDDI’s electric power consumption, and reducing power consumption in base stations is a key issue for reducing carbon dioxide (CO_2) emission in terms of the Green of ICT. KDDI has now started the pilot project using the tribrid electric power control technology in base stations to achieve a next-generation power saving. This technology is expected to achieve power savings and carbon dioxide reductions of 20 to 30 percent compared to the same base stations without the technology.

6.1.1 Introduction

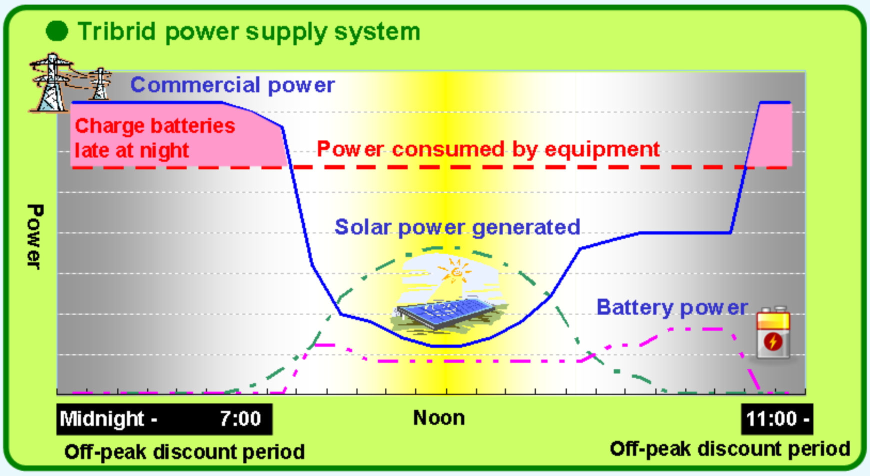
Crucial concern should be provided to reduce electric power consumption by systems and facilities used for the provision of telecommunications services and to cut carbon dioxide emissions as a general telecommunications carrier. Mobile base stations ("base stations") account for approximately 60% of all of KDDI's electric power consumption, and reducing power consumption in base stations is a key issue in cutting power use. KDDI has worked to reduce power consumption through various measures such as downsizing base stations and introducing cooler-free base station equipment. KDDI has now started using the tribrid electric power control technology in base stations to achieve a next-generation power saving. This technology is expected to achieve power savings and carbon dioxide reductions of 20 to 30 percent compared to the same base stations without the new technology.

6.1.2 Tribrid electric power control technology

The tribrid electric power control technology achieves the maximum efficiency in different time periods by controlling the following three power sources to be provided to base stations: (1) power generated from solar panels, (2) power from batteries that are charged from commercial power at night, and (3) power from commercial sources. In a good weather condition, solar panels provide sufficient power to the wireless equipment and any excess power is stored in the batteries. After the sun sets, the wireless equipment is powered by the batteries, and the batteries are also charged from commercial power late at night when the electric bill is inexpensive.

A key feature of this technology is the fact that power from the solar panels is supplied to a DC power unit connected between the rectifier, batteries, and the base station wireless equipment. Direct current generated by solar panels is generally converted to alternating current before being supplied to household appliances, lighting equipment, and so on. Although a lot of ICT equipment such as servers and also many household appliances directly operate on direct current, the direct current is converted from the commercial alternating current internally at the equipment. Taking a laptop computer as an example, the alternating current from an outlet is converted to direct current by an AC adaptor, and then the direct current is supplied to the computer. In using the solar power, the power is converted twice, i.e. from direct current to alternating current and then back to direct current, resulting in substantial power losses. The tribrid control technology directly links DC components to the direct current source to reduce conversion losses, resulting in efficient use of the green power generated by solar panels. The power generation by solar panels is also expected to increase in the future. With the tribrid system, excess power from solar panels can be charged in batteries without flowing into the network.

Figure 6.1 - Tribrid electric power supply system



6.1.3 Operation principle

To achieve the tribrid power control, solar panels, a power control unit and an output voltage control unit with a rectifier are added to a conventional base station. The equipment can be installed in base stations that are already in operation.

Discount schemes by power companies are available for feeding base stations during off-peak times, and even when the same amount of power as a daytime is used, electricity late at night costs lower and results in lower emissions of carbon dioxide (a greenhouse gas). Note that the discount scheme depends on the price policy of the power company. In natural disasters, power outage can be occurred. To prevent base stations against such events, conventional base stations are equipped with rechargeable lead batteries (secondary batteries) as a backup. With the tribrid power control technology, batteries are charged late at night from commercial power, and excess power generated by the solar panels is also used for the wireless equipment. To accommodate this usage pattern, batteries have to be equipped with good charge/discharge characteristics. The use of smaller and lighter lithium-ion batteries is being explored.

The following is an explanation of the operating principles of the output voltage control function. When voltage at the rectifier is reduced, the relative voltage of the batteries increases, resulting in the supply of power from the batteries to the wireless equipment and a decrease in the use of power from the commercial power supply. When power from the solar panels increases, the output voltage of the power control unit increases to a level higher than the battery voltage, and the percentage of supply to the wireless equipment from the solar panels increases. As the batteries discharge, the voltage declines and power from the solar panels is also used to charge the batteries. As power from the solar panels decreases, the percentage of power supplied by the batteries increases. As the battery voltage continues to decline, the supply of commercial power from the rectifier increases. Generally, solar panels generate a lot of power during daytime in a good weather condition, and solar panels in the Kanto area of Japan generate power at their rated capacity for an average of three hours per day. Thus, 1.5 kWh solar batteries can be expected to generate 4.5 kWh of power each day.

Figure 6.2 – Configuration diagram

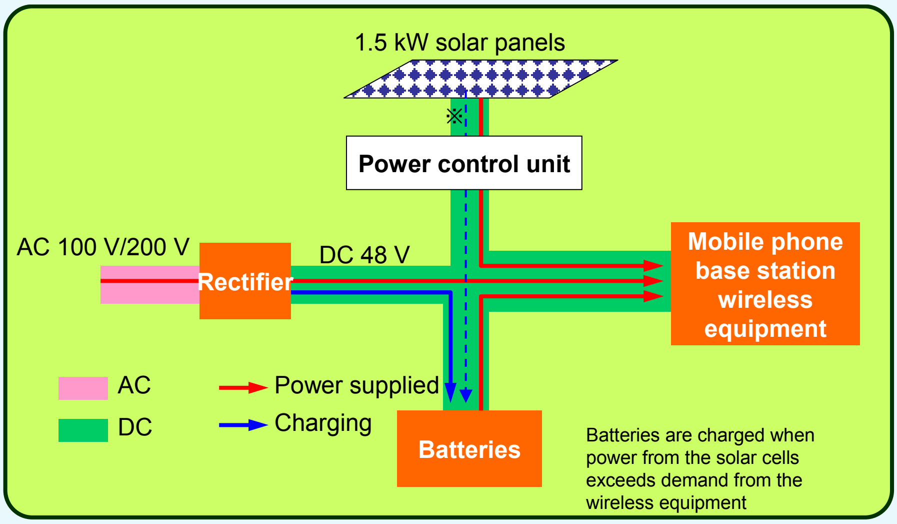


Figure 6.3 shows the screen shot of the tribrid power control monitor. It shows the power supply from solar panels to the wireless equipment and the excess power charged in batteries. Only a very small amount of commercial power is being used.

Figure 6.3 – Screen shot of tribrid power control system

6.1.4 Conclusion

To assess the availability and scale ability of the technology, the tribrid power control equipment was installed in commercial base stations and field trials commenced in December 2009. The trials are being conducted at 10 locations nationwide to determine optimal solar panel installation methods and power supply configurations, taking into consideration environmental conditions such as geography and climate.

Figure 6.4 – Equipment installed for tribrid technology field trials

6.5 Future outlook

KDDI intends to expand the technology into efficient use of natural energy including solar power, looking beyond base stations towards applications for energy-saving systems at communications offices, data centers and even private homes.

6.2 Case study 2: ICT and climate change adaptation and mitigation: the case of Ghana

6.2.1 Background

Information and Communication Technologies (ICTs) are playing an increasing role in our society. From the local to the global level, ICTs have enabled the development of new skills, competitiveness and growth, particularly in developing nations. The capacity of ICT to mitigate the harmful effects of climate change imposes a responsibility of policymakers, and indeed all stakeholders of the Information Society, to promote the technology as an effective way of mitigating the current changes.

ITU published a report[41] that recognizes the productive and the transformative potential of ICTtools, it can help Ghana, as well as other developing countries, to better adapt to the challenges posed by climate change. It is currently estimated that the ICT sector contributes approximately 2 to 2.5 per cent of global greenhouse gas emissions, and this is likely to increase as ICTs become more widely available. Due to the potential for the ICT industry to dramatically decrease the GHG emissions in nearly every other sector, as well as providing access to information, the challenge addressed in this report is how to make ICTs available to the whole population in Ghana without having an adverse impact on climate by adding to carbon dioxide emissions. If emissions are not stopped in the ICT and other industry sectors, Ghana will become a significant emitter of carbon dioxide along with the developed countries. By focusing on the lowest power ICT solutions, as described in this report (which focuses specifically on developing countries)

41 Information and communication technologies (ICTs) and climate change adaptation and mitigation: The case of Ghana

the evolution path for Ghana will be on a much lower emissions trajectory, saving energy cost and minimizing emissions. Climate change adaptation can take the form of anticipatory or reactive, spontaneous or planned actions that are undertaken by actors in response to climatic events3. As climate change science predicts an increase of 2°C in the average temperature of the planet above the pre-industrial level, efforts aimed at designing and implementing strategies to moderate, cope with and take advantage of the impact

The case of Ghana, a West African nation that has reported temperature increase of 1°C over the past 30 years, as well as the impacts of erratic rainfall, floods and more extreme weather events19, serves to illustrate the severity with which climatic challenges are affecting developing nations, as well as the actions taken and the resources needed to address them. Ghana's case will also help to demonstrate the potential of ICTs towards the fulfilment of adaptation goals, setting the context to draw lessons learned and suggested steps in subsequent sections of the report.

6.2.2 Climate change in Ghana

Ghana is located in one of the world's most complex climate change regions. At the intersection of three hydro-climatic zones, and subject to the impact of El Niño Southern Oscillation (ENSO), the Inter-Tropical Convergence Zone (ITCZ) and West Africa monsoon, the country is highly vulnerable to climate change, variability and uncertainty. The increase in the frequency and intensity of rainfall, floods and landslides, along with the occurrence of extended periods of drought, intense temperatures and heat, have been linked to changing climatic patterns. Such extreme and unpredictable events have devastating consequences for Ghana's socioeconomic development and food security, particularly for millions of people whose livelihoods depend on agriculture and livestock. Ghana is located in one of the world's most complex climate change regions. At the intersection of three hydro-climatic zones, and subject to the impact of El Niño Southern Oscillation (ENSO), the Inter-Tropical Convergence Zone (ITCZ) and West Africa monsoon, the country is highly vulnerable to climate change, variability and uncertainty.

The increase in the frequency and intensity of rainfall, floods and landslides, along with the occurrence of extended periods of drought, intense temperatures and heat, have been linked to changing climatic patterns. Such extreme and unpredictable events have devastating consequences for Ghana's socioeconomic development and food security, particularly for millions of people whose livelihoods depend on agriculture and livestock.

The intensification of extreme weather events such as excessive rainfall has led to the overflow of Ghana's major water bodies. For example, for the first time in twenty years, the level of the Akosombo Dam Reservoir, which provides electricity to Ghana and its neighbouring West African countries including Benin and Togo, rose to 274.8 ft, close to the maximum of 278 ft in 2010. Consequently, regions which have communities close to the Volta River or lying along the path of the river towards the south of the Hydro-Electric Power Generator were flooded. It is estimated that in 2010, over 377,652 people were internally displaced due to the floods, one of the most severe catastrophes that Ghana has ever had to face. The consequences were even more severe considering that some areas which were affected by the Akosombospillage had already been hit by flood waters from the Bagre and Kompeanga dams in neighbouring Burkina Faso. According to the Volta River Authority (VRA), there are significant possibilities that the floods will reoccur if erratic rainfall patterns continue.

As in the case of other developing countries, the impacts of climate change and variability in Ghana contribute to intensify the pre-existing challenges of poverty and rural marginalization, rapid urbanization and growth of informal settlements, land depletion and fragile ecosystems, among others.

While the future projected changes in the climate are still uncertain, studies41 suggest a temperature increase between 1.0 to 3.0°C by the 2060s, and 1.5 to 5.2°C by the 2090s, as well as severe changes in seasonality, among others.

6.2.3 Priorities in Ghana for the climate change adaptation strategy

The main priorities of Ghana's National Climate Change Adaptation Strategy are as follows.

1. Increasing resilience to climate change impacts: identifying and enhancing early warning systems
2. Alternative livelihoods: minimizing impacts of climate change for the poor and vulnerable
3. Enhance national capacity to adapt to climate change through improved land use management
4. Adapting to climate change through enhanced research and awareness creation
5. Development and implementation of environmental sanitation strategies to adapt to climate change
6. Managing water resources as climate change adaptation to enhance productivity and livelihoods
7. Minimizing climate change impacts on socio-economic development through agricultural diversification
8. Minimizing climate change impacts human health through improved access to healthcare
9. Demand- and supply-side measures for adapting the national energy system to impacts of climate change
10. Adaptation to climate change: sustaining livelihoods through enhanced fisheries resource Management

At the national level, Ghana has demonstrated high level of political awareness about the potential of ICTs in the climate change field, which has translated into concrete actions to mobilize key stakeholders, and move forward the agenda on using ICTs to monitor climate change, mitigate and adapt to its effects. In 2011 the Ministry of Communications (MOC) of Ghana hosted the Sixth Symposium on ICTs, the Environment and Climate Change. This was the sixth symposium on climate change following successful events held between 2008 and 2010 in Kyoto, London, Quito, Seoul and Cairo. The event gathered leading specialists in the field, from top policy-makers to engineers, designers, planners, government officials, regulators and standards experts, among others.

The symposium in Ghana focused on the issue of ICTs, the environment and climate change in Africa and the needs of developing countries. Topics discussed included adaptation to climate change, e-waste, disaster planning, costeffective ICT technologies, methodologies for the environmental impact assessment of ICTs, as well as challenges and opportunities in the transition to a green and resource efficient economy. The symposium concluded with a Call to Action addressing climate change as an input to the United Nations Climate Change Conference (COP17) held in Durban, and the 2012 United Nations Conference on Sustainable Development (UNCSD 2012 or Rio+20) held in Rio de Janeiro.

At the sectoral and community levels, evidence of ICT's use as part of adaptation actions is starting to emerge. Yet, further efforts are needed in order to systematise, document and analyse these experiences, particularly in regards to the role of ICTs in specific areas of vulnerability (e.g. agriculture, water management, infrastructure) that are intensified by the impacts of climate change. It is important to highlight some specific areas for ICT's potential at both the sectoral and the community levels in the context of Ghana. One of them is Ghana's cocoa sector. This sector accounts for approximately 32 per cent of Ghanaian exports, and is a key component of rural livelihoods. Much of the cocoa is grown by farmers with small farms, for whom the crop represents from 70 to 100 per cent of their annual household income. Highly sensitive to temperature and rainfall variations, cocoa is very vulnerable to the effects of climate change and variability that are affecting the country. Producers face multiple development challenges and resource constraints, and therefore, their capacity to prepare, respond and recover adequately to the effects of climatic events is limited. ICTs can play an important role in enabling more effective adaptation in the cocoa sector. ICTs such as mobile phones and radio, broadly adopted by low-income communities, can be used as part of a sector-wide strategy to disseminate appropriate technical information on efficient farming practices, drought and flood management, to build capacity on the use of resistant seed varieties, or raise awareness on local climatic conditions and future trends, among others, thus enhancing the adaptive capacity of Ghana's cocoa farmers. At the same time, cocoa farming communities can use ICT tools to strengthen networking and information sharing on new and traditional adaptive practices, as well as to access climatic and productive information in more appropriate/user friendly formats (e.g., audio and video applications).

6.2.4 Actions decided in Ghana

The main priorities of Ghana's National Climate Change Adaptation Strategy are as follows.

The growing demand for ICTs for new multimedia services, and the resulting expansion of digital traffic, is leading the telecommunications industry towards the convergence and optimization of traditional networks. The goal is the coming together of existing networks (fixed, mobile, Internet, broadcast, etc.) into a unitary network architecture which has been termed Next Generation Networks (NGNs). This emerging technology is a packet-based network able to make use of multiple broadband technologies, providing telecommunication services to users, with independence of service-related functions from transport technologies. NGNs are more energy efficient than the current generation of public fixed networks, and the principles should be adopted.

Introduction of NGNs could provide at least a 40 per cent reduction in energy use due to:

- A significant decrease in the number of switching centres required.
- More tolerant temperature range for NGN equipment.
- Use of more advanced technologies such as passive optical networks (PONs).

International standards are fundamental to delivering benefits in terms of energy efficiency because their use will result in:

- Lower energy usage of all ICT equipment that meets the standard, particularly where the standard is referenced in procurement directives.
- Lower equipment costs through commoditization of equipment, leading to greater deployment of the most energy-efficient equipment available.
- Lower costs will also lead to greater deployment of equipment in support of mitigation and adaptation.
- Common measurement and assessment methods so that the performance of different ICT-based solutions can more readily be compared and evaluated.

6.2.5 Conclusions

This report has shown the close linkages that exist between ICTs and climate change adaptation and mitigation are gaining momentum in the policy, the research and the practice agendas, from the international to the local levels. Within vulnerable environments affected by more frequent and intense climatic events, the increasing diffusion of Information and Communication Technologies (ICTs) is enabling new ways to withstand, recover and adapt to climatic impacts, as well as to improve energy efficiency and mitigate GHG emissions in a variety of sectors.

It is now an evidence for developing countries to adopt innovative ICT-enabled strategies to tackle climate change adaptation and mitigation, while ensuring a long-term, coordinated approach to the integration of ICT tools into broader climate change strategies.

Several key areas of action to be considered in the design of ICTs and climate change adaptation and mitigation strategies, including the development of policy content, and the establishment of adequate structures and processes, have been identified. The document builds upon the experiences and progress being achieved by Ghana, an African country that has being a pioneer in the integration of ICTs and climate change strategies. While there are still challenges to overcome, Ghana's experience provides valuable principles and suggested actions that have been reflected throughout this document. It is expected that the suggestions provided in the report will help to guide the actions of other developing countries in this field, as well as to raise the awareness of policy and decision-makers, and ultimately encourage the design of new policies strategies and standards that foster ICT’s adaptation and mitigation potential.

As the experience of Ghana demonstrates, ICT and climate change policies should be designed based on a holistic perspective, and as a collaborative, long-term process of continuous learning and interaction among a varied set of stakeholders and levels. Leadership, articulation of efforts, active participation in international climate change processes, partnerships with key stakeholders and local engagement in the design of technology solutions, are among the key components of effective ICT and climate change strategies.

ICTs will continue to play an increasing role in climate change networking and decision-making, information and knowledge sharing, capacity building, livelihoods strengthening, and low-carbon/resource-efficient economies.

Annex 7: ICT, electricity and SMART grids

7.1 Background

In 2000, the US National Academy of Engineering identified the single most important engineering achievement of the 20th century: electrification.[42] Electric power is present almost everywhere; it makes our lives safer and more convenient. One very important component of electrification, the one that delivers electricity from the place where it is generated to the place where it is used, is the electrical grid. This short paper aims to give a brief overview of the most important issues related to the traditional grid, and possible solutions and benefits that the smart grid offers.

The electrical grid is a network of wires, substations, transformers and other devices that carry electricity from the power plant to consumers. Although electrical grids have improved, they are still analogue and centralized, with limited control over power flows and one-way communication. These main features of the traditional grid make it unreliable and inefficient, prone to failures and blackouts and with no or limited consumer choice.

Reliability is one of the most important issues that have to be addressed, because increasing demand for electricity often overloads the existing grid's capacity. For example, out of five massive blackouts that occurred in the US in the last 40 years, three of them happened in the last decade.[43] The demand growth is the leading cause of major blackouts in developing countries.[44] This can be clearly seen on the example of one of the most serious power blackouts in history, which took place in India in July 2012, affecting between 600-700 million people. The blackout started in Agra, and was caused by an overload: the transmission lines were apparently carrying twice the permitted load.[45] A blackout affects almost every aspect of economy, such as banking, communications, traffic and security, causing a significant economic loss. Managing blackouts during winter is particularly difficult because many homes would be left without basic necessities to perform daily duties.

Another important question is the one on efficiency. Current power plants have limited capabilities to change their electricity supply mechanism, which makes them highly inefficient due to the fact that their full capacities are only used for very short periods of time.[46] However, a small increase in efficiency could lead not only to large economical savings for countries, but would also mean a significant reduction in greenhouse gas (GHG) emissions. The reduction in GHG emissions can be reached not only by improved efficiency, but also by the increased use of renewable energy sources for power generation. Although it is very difficult to integrate sources such as solar or wind power into the existing electrical grid, there is a way to address this and many other issues that the traditional electrical grid faces: the smart grid is a viable response to the challenges of electric power supply.

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7.2 Smart solutions for a smart world

The Smart Grid system as a communication system should respond to some applications or systems requirements as the following, for example:

- Reliability as to support the required real time monitoring and management of communication between the energy supplier and the final user. As such, the quality of service offered by the network should be very high in order to assumed low latency and high reliability;

Security and confidentiality of privacy related data should be ensured.

The above list is not exhaustive in a context of generic definition of smart grid systems. Such requirements or any standardization needs should be defined by the users of the Smart Grid system/networks.

The ICT issue is twofold.

- Electricity is essential for ICT.
- ICT Energy footprint is continuously increasing.

All such various ICT infrastructures could be suitable to ensure the service which should be delivered by Smart Grid systems/network. The advantage of a mixed infrastructure allow a better suitability of the network according to:

- the topology of the area (urban, semi-urban, rural, mountain…),
- the individual energy market situation in each country (one main energy supplier or multiple energy suppliers),
- the existing network infrastructures which reduce the investment;
- the cost of deployment of a new communication network or facilities.

GHG emissions are expected to grow much faster than in the last two centuries and GHG emissions are largely ascribable to production of electricity. Large fluctuations in electricity demand during seasons and daily hours are noted and require overprovisioning power plants and the electrical grid.

Oil and coal fired power plants are the most widespread solution for bulk generation. They are responsible for GHG emissions for electricity production.

- New paradigms like Smart grids are able to reach high efficiency and are expected to cut down GHG emissions.
- Many implementations of Smart Energy Grids issues are likely to occur.
- Intelligence is required to:
  – retrieve, share, process, store and transmit information;
  – make grid management automatic, reliable, resilient, safe and secure.

Cutting off the carbon footprint will only be possible by enabling smart applications, in order to avoid wasting part of the previous gains in green ICT for example (rebound effect).

It is to be noted that there is a large disparity among different countries in terms of production of electricity and grid infrastructures. Most developing countries have power grids with limited coverage and low efficiency. In many developing countries just a very small part of the population has access to the electrical grid.

The coexistence of multiple technologies like wireline (offers higher performance, but with higher deployment costs especially in remote areas), wireless (provides cost-effective solutions, yet with worse performance and some limitations to reach underground installations). In addition, for wireless, interferences are likely to occur for unlicensed technologies.

The survivability of the telecommunication network to blackouts for example is one challenge. It is absolutely needed to enable automatic and prompt recovery from failures of the electrical grid, and to guarantee backup energy resources. However, these considerations are limited by technical, economic and environmental factors.

Within this context, ICT can be helpful to make progress in the issue of a more efficient control and distribution of electricity.

Standardizing: ICT can provide information in the form of standards on energy consumption and emissions, across the sectors.

Monitoring: ICT can incorporate monitoring information into the design and control of energy use.

Accounting: ICT can provide the capabilities and platforms to improve accountability of energy and carbon.

Rethinking: ICT can offer innovations that capture energy efficiency opportunities across buildings/homes, transport, power, manufacturing and other infrastructures, and provide alternatives to current ways of operating, learning, living, working and travelling.

Transforming: ICT can apply smart and integrated approaches to energy management of systems and processes, including benefits from both automation and behavioural change and develop alternatives to high carbon activities, across all sectors of the economy.

What is a smart grid? A smart grid is an electricity network that can integrate the actions of all the users connected to it, in order to efficiently deliver sustainable, economic and secure electricity supplies.

Smart Grids could be described as an upgraded energy network to which two-way digital communication between supplier and consumer, intelligent metering and monitoring systems have been added. Intelligent metering is usually an inherent part of Smart Grids, which can manage direct interaction and communication among consumers, households or companies, other grid users and energy suppliers. It could also enable consumers to directly control and manage their individual consumption patterns, providing incentives for efficient energy use if combined with time-dependent tariffs for electricity consumption. Improved and more targeted management of the grid translates into a grid that is more secure and cheaper to operate.

The European Commission launched a public consultation within the context of Radio Spectrum Policy Program (RSPP). RSPP states that the Commission, in cooperation with the Member States, shall consider making spectrum available for wireless technologies with a potential for improving energy saving, including smart energy grids and smart metering systems. Apart from the ICT aspects of energy efficiency, it is also possible that EU wide harmonization of the spectrum usage conditions for these purposes could bring benefits to European consumers. The main policy objective of the initiative is to consider how a harmonized approach on the use of spectrum at EU level could contribute to ensuring reliability of the utility networks, cost effective use of renewable electricity sources and enhancing the efficiency of electricity and other energy grids.

The draft RSPP text states *inter alia* that the Commission, in cooperation with the Member States, shall conduct studies on saving energy in the use of spectrum in order to contribute to a low-carbon policy, as well as consider making spectrum available for wireless technologies with a potential for improving energy saving and efficiency of other distribution networks, including smart energy grids and smart metering systems.

Over the long term, the Commission’s Communication on a 'Roadmap for moving to a competitive low carbon economy in 2050' identifies Smart Grids as a key enabler for a future low-carbon electricity system, facilitating demand-side efficiency, increasing the shares of renewables and distributed generation, and enabling electrification of transport.

The public consultation aims at collecting further information and views, including appropriate justifications for requirements on any specific spectrum needs for mission-critical purposes, from all the relevant sectors and stakeholders. The outcome will be used as input for an impact assessment, based on which the Commission will then decide on the next steps in this field.

The summary of this consultation is contained within reference 3.

Smart grids are expected to offer great benefits to all the actors of the upgraded electricity system. Grid operators can manage the network more efficiently, retailers will be able to improve customer service. For consumers smart electricity grids mean a shift from a passive receiver of electricity into an interactive participant in the supply chain. The Commission will closely monitor that Member States ensure consumers' access to their consumption and billing information: being able to follow their actual electricity consumption in real time gives consumers strong incentives to save energy and money. The trends show that through smart meters European households could save 10 % of their consumption.

The smart grid differs from the traditional electrical grid in many ways. It is digital, decentralized, semi or fully automated, enables real time pricing and a two-way communication. It is possible to make a comparison between the smart grid and a smart phone. Basically, smart phone is a cell phone with a computer. Likewise, the smart grid means computerizing the electrical grid. It includes adding two-way digital communication technology to devices associated with the grid. Some of the key features of the smart grid are: reliability, flexibility, efficiency, sustainability and automation technology that lets the utility adjust and control each individual device or millions of devices from a central location.[47]

The reliability of the smart grid is improved compared to the traditional grid in the sense that the technologies used have better fault detection and enable self-healing of the network without the intervention of technicians. This means that the supply of the electricity is more reliable, because the smart grid adds resiliency to electric power systems. The use of ICTs to transform traditional electricity power stations, build them better resilient to withstand natural and man-made disasters. In the case of natural disasters and in order to minimize the risk, the smart grid should be able to guarantee at least sufficient performance when facing extreme meteorological events, such as floods, hurricanes, droughts, as well as earthquakes, tsunamis, tornadoes, solar magnetic storms, etc. As for man-made disasters, the smart grid should be able to mitigate and minimize the impact by providing relevant information of its status. It will also help to ensure that electricity recovery resumes quickly and strategically during and after an emergency, for example, by routing electricity to emergency services first.[48] Finally, if power outages occur, the smart grid would be able to detect and isolate them before they become large-scale blackouts. Important components in improving the reliability are the Phasor Measurement Units (PMU) and the Distribution Management System (DMS). The function of PMU is to estimate the phasor equivalent for power system voltage and current signals many times per second at a given location, thus giving a clear picture of the power system, easing congestion and bottlenecks and mitigating (or even preventing) blackouts. DMS is a combination of software and hardware that monitors and controls the entire distribution network, thus improving its efficiency and reliability resulting in reduced outages.

The smart grid improves efficiency by load adjustment and peak leveling. The peak demand is a time when there is the greatest need for electricity during a particular period. Since the electricity must be consumed the moment it is generated, the traditional response to this load varying would be to put in use spare generators before a large generator can start working.

A smart grid can warn all individual customers to reduce the load demand on critical times or increase demand at times of high production and low demand. The inclusion of customers is called the demand response program, and it is being used by electric system planners and operators for balancing supply and

[47] Energy.gov, Smart grid

[48] Smartgrid.gov, The Smart Grid

demand.[49] One of the methods used to include customers was to increase the prices of electricity during high demand periods, and to decrease them during low demand periods. This method motivated the consumers to decrease electricity usage during periods of high demand and vice versa. This approach is, of course, well known, but with the smart grid, there would be no need to wait until the end of the month to know how much electricity has been used, because the smart grid will allow every consumer to have a clear picture of consumption at any time. Smart meters will output the amount of energy used, when it was used, and the cost; and this output will allow consumers to save money by using less power when electricity is most expensive.[50] The tool that is used in this process is one of the core elements of the smart grid, called the Advanced Metering Infrastructure (AMI). AMI is a system that measures, collects and analyzes energy usage, but at the same time it provides consumers with the ability to use electricity more efficiently. The difference from traditional meter reading lies in the fact that it enables two-way communication between the meter and the central system. AMI can influence consumption because consumers can use the information provided by the system to change their behavior to take advantage of lower prices.[51]

The last, but not the least important feature of the smart grid is sustainability. In the context of smart grid, sustainability would be achieved not only through the efficiency improvement, but also through the smart grid's ability to include renewable energy sources such as solar power and wind power. Unlike the existing network infrastructure, which is not built to allow for many different feed-in points, the smart grid technology permits distributed generation of power, for instance from solar panels, wind turbines, pumped hydroelectric power, and other sources.

In the European Commission's communication to the European Parliament, called *Energy Roadmap 2050,* the development of a smarter distribution grid that could include renewable energy sources is seen as one of the main tools in achieving a secure, competitive and decarbonized energy system in next decades.[52]

7.3 Benefits

In order to address energy efficiency and increase consumer awareness about the link between the electricity and the environment, the existing energy infrastructure has to be upgraded or replaced. Apart from increased awareness, it provides concrete ways to address environmental issues, for example by allowing the integration of distributed renewable energy sources such as solar panels.[53] Solar panels are also very interesting from the consumer point of view, because the owners of solar panels will be able to sell the portion of the power they generate back to the local utilities. By doing so, they will not just lower their energy costs, but could also earn a profit. And since solar panels produce electricity during daytime, they will also help to meet peak demand.[54] A good practical example of how renewable sources can be

[49] Energy.gov, Demand response, available at: http://energy.gov/oe/technology-development/smart-grid/demand-response, December 10, 2012

[50] Smartgrid.gov, The Smart Grid

[51] Wikipedia, Advanced Metering Infrastructure, available at: http://en.wikipedia.org/wiki/Advanced_Metering_Infrastructure#Advanced_metering_infrastructure, 7 December 2012

[52] Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions, Energy Roadmap 2050, Brussels, 15.12.2011, COM(2011) 885 final, available at: http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=COM:2011:0885:FIN:EN:PDF, 20 December 2012

[53] R. Lyster, Smart Grids: Opportunities for Climate Change Mitigation and Adaptation, (June 21, 2010). Sydney Law School Research Paper No. 10/57, 5, available at: http://ssrn.com/abstract=1628405, 16 November 2012

[54] Emerson Network Power, What Smart Grid Means to You, available at: www.cisco.com/web/partners/downloads/765/other/WhatSmartGridMeansToYou.pdf, 20 December 2012

included in power supply are Ghana, which is already providing 50 per cent of its electricity this way,[55] and Spain, where renewable technologies provide more than 40 per cent of the daily demand on certain days.[56] The smart grid will also enable an unseen level of consumer participation, by allowing them to monitor real-time information and price signals and create settings to automatically use power when prices are lowest.[57]

A promising opportunity lies also in coordinating smart grid deployment with internet infrastructure deployment, namely high-speed broadband, which can be very cost-efficient. With better broadband communications, utilities will be able to respond far better to peak demand and outages. This approach could offer families not only electricity savings due to the Automated Metering Infrastructure, but also affordable broadband access.[58]

Finally, broadband could be beneficial in the field of environmental protection as well, by transferring data from automated pollution detection mechanisms, based on biosensors. Biosensors, organized in flexible, integrated networks, can provide a sensitive and robust method of pollution monitoring.[59] Such a network would consist of a large number of biosensors with the ability to communicate with each other, and sending collected data to the base station.[60] The biosensors can be self-powered, and thus independent from the electrical grid. This real-time detection infrastructure is already used to measure ecological health of waterways in Australia.[61]

The goal is to make the transformation from a centralized, producer-controlled electrical grid to one that is decentralized and consumer-interactive, which will link power generation from distributed sources together with traditional power plants.[62] The transfer from the traditional to the smart grid cannot happen overnight; the idea is that during a decade or so, new technologies should be deployed step by step. But the implementation of the smart grid will probably revolutionize every aspect of our lives in the same way that Internet did.

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Annex 8: Resolution ITU-R 60 (2012) - Reduction of energy consumption for environmental protection and mitigating climate change by use of ICT/radiocommunication technologies and systems

The ITU Radiocommunication Assembly,

considering

a) that the issue of climate change is rapidly emerging as a global concern and requires global collaboration;

b) that climate change is one of the major factors causing emergency situations and natural disasters afflicting humankind;

c) that the United Nations Intergovernmental Panel on Climate Change (IPCC) estimated that global greenhouse gas (GHG) emissions have risen by more than 70 per cent since 1970, having an effect on global warming, changing weather patterns, rising sea-levels, desertification, shrinking ice cover and other long-term effects;

d) that information and communication technologies (ICTs), which include radiocommunication technology, contribute approximately 2-2.5 per cent of GHG emissions, which may grow as ICTs become more widely available;

e) that ICT/radiocommunication systems can make a substantial contribution to mitigating and adapting to the effects of climate change;

f) that wireless technologies and systems are effective tools for monitoring the environment and predicting natural disasters and climate change;

g) that ITU, at the United Nations Conference on Climate Change in Bali, Indonesia, on 3 14 December 2007, highlighted the role of ICTs as both a contributor to climate change, and an important element in tackling the challenge;

h) that ITU R Reports and Recommendations that address potential energy-saving mechanisms applicable to different radiocommunication services can contribute to the development of systems and applications that operate in these services,

further considering

a) that the ITU Plenipotentiary Conference (Guadalajara, 2010) approved Resolution 182, on the role of telecommunications/information and communication technologies in regard to climate change and the protection of the environment, which instructs ITU to continue applying ICTs to address the causes and effects of climate change and strengthen collaboration with other organizations working in the field, and encourages the Union to raise public and policy-maker awareness of the critical role of ICTs in addressing climate change;

b) that the ITU T work programme developed on the basis of WTSA Resolution 73, does not contain specific studies focusing on energy consumption related to radio transmission technology or planning characteristics of radio networks;

c) ITU D Report Q.22/2, on utilization of ICT for disaster management, resources, and active and passive space-based sensing systems as they apply to disaster and emergency relief situations;

d) that ITU D Question 24/2 examines the links between ICTs, climate change and development, as these fields become increasingly interlocked due to the magnifying effect of climate change on existing development challenges and vulnerabilities;

e) that ITU D Question 24/2 also addresses the role of Earth observation in climate change, as this radio technique is essential for monitoring the state of the Earth in terms of climate and its evolution,

taking into account

a) Resolutions 673 (WRC 07), on radiocommunications use for Earth observation applications, and 644 (Rev.WRC 07), on radiocommunication resources for early warning, disaster mitigation and relief operations, adopted by the World Radiocommunication Conference (WRC 07);

b) Resolution ITU R 53, on the use of radiocommunications in disaster response and relief, and Resolution ITU R 55, on ITU studies of disaster prediction, detection, mitigation and relief, adopted by the Radiocommunication Assembly (RA 07);

c) Resolution 66 (Hyderabad, 2010), on information and communication technology and climate change, adopted by the World Telecommunication Development Conference (WTDC 10);

d) Resolution 73 (Johannesburg, 2008), on information and communication technologies and climate change, adopted by the World Telecommunication Standardization Assembly (WTSA 08),

noting

a) the leadership of ITU R, in collaboration with the ITU membership, in identifying the necessary radio-frequency spectrum for climate monitoring and disaster prediction, detection and relief, including the establishment of cooperative arrangements with the World Meteorological Organization (WMO) in the field of remote-sensing applications;

b) Recommendation ITU R RS.1859 "Use of remote sensing systems for data collection to be used in the event of natural disasters and similar emergencies", and Recommendation ITU R RS.1883 "Use of remote sensing systems in the study of climate change and the effects thereof";

c) Report ITU R RS.2178 "The essential role and global importance of radio spectrum use for Earth observations and for related applications";

d) Volume 4 – Intelligent Transport System – of the ITU R Handbook on Land Mobile (including Wireless Access), which describes the use of radio technologies for minimizing transportation distances and cost, with a positive effect on the environment, and the use of cars as an environment monitoring tool to measure air temperature, humidity and precipitation, with data sent through wireless links for weather forecasting and climate control;

e) that ITU R provides an opportunity to share technical information about evolution of new methods and technologies to reduce energy consumption within a radio system or by the use of a radio system,

resolves

1 that ITU R Study Groups should develop Recommendations, Reports or Handbooks on:

- best practices in place to reduce energy consumption within ICT systems, equipment or applications operating in a radiocommunication service;
- possible development and use of radio systems or applications which can support reduction of energy consumption in non-radiocommunication sectors;
- effective systems for monitoring the environment and monitoring and predicting climate change, and ensuring reliable operation of such systems;

2 that ITU R Study Groups, when developing new ITU R Recommendations, Handbooks, or Reports or reviewing existing Recommendations or Reports, take into account, as appropriate, energy consumption as well as best practices to conserve energy;

3 to maintain close cooperation and to regularly liaise with ITU T, ITU D and the General Secretariat, and to take into account the results of the work carried out in these Sectors and avoid duplication,

instructs the Director of the Radiocommunication Bureau

1 to take the necessary measures, in conformity with Resolution ITU R 9, to further strengthen collaboration among ITU R, ISO, IEC and other bodies as appropriate, with a view to cooperating in identifying and fostering implementation of all appropriate measures to reduce power consumption in radiocommunication devices and to utilize radiocommunications/ICTs in monitoring and mitigation of the effects of climate change, inter alia, in order to contribute to a global reduction of energy consumption;

2 to report annually to the Radiocommunication Advisory Group and to the next Radiocommunication Assembly on the results of studies in the application of this Resolution,

invites Member States, Sector Members and Associates

1 to contribute actively to ITU R's work in the field of radiocommunications and climate change, taking due account of relevant ITU initiatives;

2 to continue to support ITU R's work in the field of remote sensing (active and passive) for monitoring of the environment.

invites standardization, scientific and industrial organizations

to contribute actively to the work of the Study Groups related to their activities specified in resolves 1 and 2.

Annex 9: Rebound effect

The rebound effect is defined as increases in demand that offset some of the positive impact of ICT implementation: rebound effects act as counter-acting agents to enabling effects. This increase in demand reduces the energy conservation effect of the improved technology on total resource use

The ICT Enablement Methodology proposed by GeSI goes further than a typical product or service, which considers life cycle stages and processes of a single system. In addition to the direct life cycle emissions of an ICT system, the methodology considers the emissions saved or generated by various enabling and rebound effects resulting from changes to the BAU system the BAU (or business-as-usual, system refers to the components in the existing manual, mechanical or physical processes that are impacted by the implementation of the ICT solution). Enabling effects are those that reduce emissions in non-ICT sectors; rebound effects are those that increase emissions, thus offsetting the emission reductions. Rebound effects are typically changes within the BAU system, though may also result from increased use of the ICT system above its intended use to mitigate non-ICT sector emissions.

9.1 Intended use and limitations of the ICT enablement methodology

Comparative assessments across studies can only be made using this methodology if care has been taken to set similar system boundaries and other parameters. In the absence of formal assessment standards, established knowledge and/or existing data may help to define the set of potential enabling and rebound effects. This includes considering the entire set of potential enabling and rebound effects resulting from implementation of the ICT system.

The primary, direct ICT emissions are the emissions generated over the life cycle of the implemented ICT system.

Primary rebound: Immediate increase in BAU or ICT system emissions occurring as result of ICT system implementation, often driven by behavioural changes in demand for carbon-intensive goods or activities. They can take one of three forms:

- Increased energy consumption
- Increased travel or shipment
- Increased materials

Primary rebound effects occur immediately after and as a direct result of implementation of the ICT system.

Secondary rebound: Non-immediate increase in BAU or ICT system emissions occurring as result of ICT system implementation, often driven by behavioural changes in demand for carbon-intensive goods or activities. These can take one of four forms:

- Increased use of goods/vehicles
- Increased production of goods/vehicles
- Increased use of infrastructure
- Increased development of infrastructure

Secondary rebound effects are those occurring later in time, often as a result of the cumulative impacts of larger-scale adoption.

Certain secondary enabling and rebound effects can be excluded from rigorous assessment based on the goal and scope of the study. However, the primary enabling effects and direct ICT emissions should always be considered relevant.

As with secondary enabling effects, the scale of adoption often drives the decision on whether to include or exclude individual rebound effects. Figure 7 provides illustrative rebound impacts.

The primary rebound is mainly derived from the following factors.

- Home energy monitoring: increased energy use during non-peak periods instead of use during peak periods.
- Telecommuting: increased home energy use (e.g., heating and lighting on at home).
- Online media: increased computer use to browse and sample music.

Secondary rebound is mainly derived from the following factors.

- Home energy monitoring: increased consumption of goods using savings from lower energy bill.
- Telecommuting: increased urban sprawl (and associated inefficiencies) from employees' ability to live further from office.
- Online media: increased computer and server manufacturing

Here are some examples of ICT effects.

- The emission reduction from air travel: secondary enabling effect.
- Emissions generated by use of telepresence to replace air travel: direct ICT emissions.
- Emissions generated by use of telepresence for additional non-necessary meetings using telepresence: primary rebound effect.

In sectors such as telephony or automobile, improving eco-efficiency was more than offset by increasing the production, resulting in lower energy costs and increase in consumption.

In general, to avoid overstating the positive impacts of ICT implementation, greater levels of proof are needed for the exclusion of any rebound effect than for the exclusion of secondary enabling effects. Unfortunately, the uncertainty of rebound effects, especially secondary rebound effects, makes them difficult to quantify. However, performing sensitivity analysis during assessment and presenting a range of potential net enabling effects can mitigate this uncertainty. This conservative approach to assessment will enhance the credibility of the reported net enabling effect.

From a general point of view, governments emphasize the gap between the consumer intentions and actions. This shift ("value action gap") is due to social and psychological issues of consumption, but also to consumption patterns "closed" (phenomena of "lock-in"), due to economic or institutional constraints, unequal access to devices encouragement, cultural norms and routines. On the other hand, public policies for sustainable consumption have so far focused on the dissemination of "Green products", on improving energy efficiency through innovation technology, or the lifting of the obstacle budget during the act of purchase. in the most cases, this strategy has led to overconsumption ("rebound effect") and and played down the initial environmental goals.

The rebound effect explains why support for technological innovation is not enough to reduce the environnemental pressure. Improving the energy efficiency of goods and services generate fiscal savings, these in turn lead on the economy the rebound effects of which can be analyzed in the two effects (primary and secondary) as explained before.

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Annex 10: ICT and climate change relevant standardization activities

10.1 ETSI

The European Telecommunications Standards Institute (ETSI) recognized climate change was a global concern and required efforts from all industry sectors, including the ICTs. ETSI is strengthening its efforts by improving the tools for electronic work, introducing a check list that energy saving is considered for all new work items, and initiating a number of new work items in the ICT and environment area. ETSI has published a few deliverables and has a few on-going work items as follows:

Here are published deliverables:

- **TR 102 530**, *"Reduction of energy consumption in telecommunications equipment and related infrastructure"*: This document reports some techniques and some aspects to take in account during the evaluation of the possible reduction of energy consumption at equipment level and at installation level. The first version of this document refers principally at broadband equipment.
- **TR 102 531** (2007-04), *"Better determination of equipment power and energy consumption for improved sizing"*: This document gives guidance on a more appropriate determination of equipment energy consumption with the goal to be able to realize a good design of power station and related power distribution network. A correct design help to have a better energy efficiency of power station with impact on the energy saving and with a not oversized dimensioning of power network permits to reduce the use of material (copper) and as consequence a minor impact on the environmental and a cost reduction.
- **TS 102 532** (2009-06), *"Environmental Engineering (EE) – The use of alternative energy sources in telecommunication installations"*: The use of alternative energy sources in the telecommunication installation/application such as solar, wind, and fuel cell is considered.
- **TS 102 533** (2008-06), *"Measurement Methods and limits for Energy Consumption in Broadband Telecommunication Networks Equipment"*: This document establishes an energy consumption measurement method for broadband telecommunication network equipment; give contributions to fix target energy consumption value for wired broadband equipment including ADSL and VDSL.
- **TS 102 706** (2009-08), *"Environmental Engineering (EE) – Energy efficiency of wireless access network equipment"*: This work will establish wireless access network energy efficiency metrics, which define efficiency parameters and measurement methods for wireless access network equipment. In the first phase GSM/EDGE, WCDMA/HSPA and WiMAX are addressed. Other systems, such as LTE, will be added when a stable system data is available.
- **EN 300 132-3** (2003-8), *"Power supply interface at the input to telecommunications equipment; Part 3: Operated by rectified current source, alternating current source or direct current source up to 400 V"*: This document standardizes a new power interface able to supply both telecom and ICT equipment. This solution permits to build only a power network, with backup, to supply energies at all type of equipment present in a data center without using UPS or AC/DC converters at 48 V so the global energetic efficiency of the entire system is greater than other solutions contributing and the energy saving.
- **TR 105 175**, *"Access, Terminals, Transmission and Multiplexing (ATTM); Broadband Deployment - Energy Efficiency and Key Performance Indicators"*
  - Part 2: Network sites
    - Sub-part 1 (TR 105 174-2-1): Operator sites (2009-10)
  - Part 4 (TR 105 174-4): Access networks (2009-10)
  - Part 5: Customer network infrastructures
    - Sub-part 1 (TR 105 174-5-1): Homes (single-tenant) (2009-10)

        - Sub-part 2 (TR 105 174-5-2): Office premises (single-tenant) (2009-10)

- **TS 105 175,** "Access, Terminals, Transmission and Multiplexing (ATTM); Broadband Deployment - Energy Efficiency and Key Performance Indicators"
    - Part 1 (TS 105 174-1): Overview, common and generic aspects (2009-10)
        - Sub-part 1 (TR 105 174-1-1): Generalities, common view of the set of documents (2006-06)
    - Part 2: Network sites
        - Sub-part 2 (TS 105 174-2-2): Data centers (2009-10)
    - Part 3 (TS 105 174-3): Core, regional metropolitan networks (WG approval is planned on 2010-09)
    - Part 4: Customer network infrastructures
        - Sub-part 3 (TS 105 174-5-3): Industrial premises (single-tenant) (WG approval is planned on 2010-09)
        - Sub-part 4 (TS 105 174-5-4): Data centers (customer) (2009-10)

Here are on-going work items:

- DTR/EE-00006, *"Environmental Engineering (EE) – Environmental consideration for equipment installed in outdoor location"*: It is planned to write a technical report on the applicability of ETSI environmental classes to equipment installed in outdoor cabinet. Also acoustics noise emission will be considered.
- DTR/ATTM-06002, *"Power Optimization for xDSL transceivers"*: Possibilities to optimize the power consumption of the xDSL transceiver are investigated. These investigations may include power modes that are beyond the currently existing modes. The potential influence of power optimization schemes on the stability and performance of each line of the network due to power optimization, e.g. non-stationary noise, will be an important part of this work.

ETSI also has more work items as follows:

- DES/EE-00014, "Life Cycle Assessment (LCA) of ICT equipment, ICT network and ICT service: General definition and common requirement"
- DES/EE-00015, "Measurement method and limits for energy consumption in broadband telecommunications equipment"
- DES/EE-00018, "Measurement methods and limits for Energy consumption of End-user Broadband equipment (CPE)"

10.2 ATIS

The Alliance for Telecommunications Industry Solutions (ATIS) Network Interface, Power and Protection (NIPP) committee intends to produce a document or suite of documents for use by ICT service providers to assess the true energy needs of equipment at time of purchase such as:

- Energy use as a function of traffic
- Energy use as a function of environmental conditions
- Cooling requirements
- Suitability of a product for use with renewable energy sources
- Improvements in environmental footprint through Life Cycle Assessments
- Standby and off-mode definitions
- Standby and off-mode losses

It provides the methodology to be used by vendors and third party test laboratories in the formation of a Telecommunications Energy Efficiency Ratio (TEER). In general, each TEER will follow the formula below:

$$TEER = \frac{Parameter}{Power}$$

Where:

Parameter = Defined in the supplemental standard based on the equipment function. Examples could be, but are not limited to: data rate, throughput, processes per second, etc.

Power = Power in Watts (dependent on the equipment measurement).

The TEER standards consist of five parts:

- ATIS-0600015.2009 (Energy Efficiency for Telecommunications Equipment: Methodology for Measurement and Reporting – General Requirements)
- ATIS-0600015.01.2009 (Energy Efficiency for Telecommunications Equipment: Methodology for Measurement and Reporting – Server Requirements)
- ATIS-0600015.02.2009 (Energy Efficiency for Telecommunications Equipment: Methodology for Measurement and Reporting – Transport Requirements)
- ATIS-0600015.03.2009 (Energy Efficiency for Telecommunications Equipment: Methodology for Measurement and Reporting – Router and Ethernet Switch Products)
- ATIS-0600015.04.2010 (Energy Efficiency for Telecommunications Equipment: Methodology for Measurement and Reporting – DC Power Plant – Rectifier Requirements)

The general requirements document serves as the ATIS base standard for determining telecommunications energy efficiency. It provides a uniform methodology to measure equipment power and defines energy efficiency ratings for telecommunication equipment. In this document, equipment have been classified based on the application and the location in the network with classifications such as core, transport and access. The latter two documents (server requirements, and transport system or network configuration requirements) are part of an ongoing series to define the telecommunications energy efficiency of various telecommunications components.

10.3 Ecma International

The Ecma International is working on Green of ICT issues in the following projects:

- ECMA-328, *"Determination of chemical emission rates from electronic equipment"*: this standard specifies methods to determine chemical emission rates of analyst from ICT and CE equipment during intended operation in an Emission Test Chamber (ETC). The methods comprise preparation, sampling (or monitoring) in a controlled ETC, storage and analysis, calculation and reporting of emission rates. This standard includes specific methods for equipment using consumables, such as printers, and equipment not using consumables, such as monitors and PC's.
- ECMA-341, *"Environmental Design Considerations for ICT & CE Products"*: This standard applies to all audio/video, information and communication technology equipment referred to products, specifying requirements and recommendations for the design of environmentally sound products regarding life cycle thinking aspects, material efficiency, energy efficiency, consumables and batteries, chemical and noise emissions, extension of product lifetime, end of life, hazardous substances/preparations, and product packaging. This standard covers only criteria directly related to the environmental performance of the product. Criteria such as safety, ergonomics and electromagnetic compatibility (EMC) are outside the scope of this standard. ECMA-341 was adopted as IEC 62075 in 2008.

- ECMA-370, *"The Eco Declaration"*: this standard specifies environmental attributes and measurement methods for ICT and CE products according to known regulations, standards, guidelines and currently accepted practices. The standard is also applicable to products used as subassemblies, components, accessories and/or optional parts. The standard addresses company programs and product related attributes, not the manufacturing processes and logistic aspects. Although the declarations as defined in Annex A and B are optimized for application in the European Union, this Standard is intended for global use.
- ECMA-383, *"Measuring Energy Consumption, Performance and Capabilities of ICT and CE Products"*: This standard intends to apply to desktop computers and notebook computers, defining how to evaluate and report energy consumption, performance and capabilities being the vital factors for the energy efficient performance of testing targets, i.e. those computers. Additionally it provides a standardized results reporting format. The standard requires the user to measure and record a set of energy, power, time, and capability results (using a Benchmark), not a single metric of energy efficiency. ECMA-383 is planned to be published as IEC 62623 in 2011.
- ECMA-xxx, *"Network proxying of ICT devices to reduce energy consumption"*: This on-going work develops standards and technical reports for network proxying; a proxy is an entity that maintains network presence for a sleeping higher-power ICT device. It will specify:
  – the protocols that network proxies must handle to maintain connectivity while hosts are asleep;
  – the proxy behavior including ignoring packets, generating packets and waking up host systems; and
  – the information exchanged between hosts and proxies.

10.4 GHG Protocol Initiative

WRI/WBCSD has developed the following standards under the GHG Protocol Initiative as follows (two standards were published and the other three documents are still at the draft stage:

- Corporate accounting and reporting standard
- The GHG Protocol for project accounting
- Draft stage, Product accounting and reporting standard
- Corporate value chain (Scope 3) accounting and reporting standard – Supplement to the GHG Protocol corporate accounting and reporting standard
- GHG Protocol Product Life Cycle Standard
- Draft stage, ICT Sector Guidance to support GHG Protocol Product Standard

10.5 Activities in Non-Standard Bodies

OECD

The Organization for Economic Co-operation and Development (OECD) has studied the Green ICT so far with recognition of ICT as an efficient solution to improve environmental performance and address climate change across the economy. It is going to hold a conference on "Smart ICTs and Green Growth" on 29 September 2010 which will discuss environmental opportunities, existing barriers and some potential risks to the wider roll-out of smart infrastructures. Focus areas include: smart technologies, smart life-styles and electric mobility. The OECD has held many other conferences such as "Green ICT" side-event at the UN Climate Change talks, Barcelona, 2-6 November 2009; a virtual meeting with video conferencing technology on the sidelines of COP15 in Copenhagen on the topic, "The role of ICTs for climate change.

Lead role or supporting act?" and an OECD conference, "ICTs, the environment and climate change", Helsingr, Denmark, 27-28 May 2009.

Various study results of the OECD have been released as OECD reports as follows:

- *Smart Sensor Networks: Technologies and Applications for Green Growth:* Published in December 2009, this report gives an overview of sensor technology and fields of application of sensors and sensor networks. It discusses in detail selected fields of application that have high potential to reduce greenhouse gas emissions and reviews studies quantifying the environmental impact. The review of the studies assessing the impact of sensor technology in reducing greenhouse gas emissions reveals that the technology has a high potential to contribute to a reduction of emissions across various fields of application. Whereas studies clearly estimate an overall strong positive effect in smart grids, smart buildings, smart industrial applications as well as precision agriculture and farming, results for the field of smart transportation are mixed due to rebound effects. In particular intelligent transport systems render transport more efficient, faster and cheaper. As a consequence, demand for transportation and thus the consumption of resources both increase which can lead to an overall negative effect.
- *Towards Green ICT Strategies: Assessing Policies and Programs on ICT and the Environment:* Governments and business associations have introduced a range of programs and initiatives on ICT and the environment to address environmental challenges, particularly global warming and energy use. Some government programs also contribute to national targets set in the Kyoto. Business associations have mainly developed initiatives to reduce energy costs and to demonstrate corporate social responsibility. Published in June 2009, this report analyses 92 government programs and business initiatives across 22 OECD countries plus the European Commission. Fifty of these have been introduced by governments and the remaining 42 have been developed by business associations, mostly international. Over two-thirds of these focus on improving performance in the ICT industry. Only one third focus on using ICT across the economy and society in areas where there is major potential to dramatically improve performance, for example in "smart" urban, transport and power distribution systems, despite the fact that this is where ICT have the greatest potential to improve environmental performance.

The OECD has three on-going works as follows:

- Developing a framework for analysis of ICT and environmental challenges. The aim is to comprehensively model environmental effects of ICT production, use and their application across industry sectors.
- Analyzing existing indicators and statistics on the relationship between ICT and the environment with the aim of improving availability and comparability of official statistics.
- Identifying priority areas for policy action including life cycle analysis of ICT products and impact assessments of smart ICT applications. This work covers the potential of sensor-based technologies and broadband networks to monitor and address climate change and facilitate energy efficiency across all sectors of the economy.

WWF

The World Wide Fund For Nature (WWF[63]) considers ICT as a tool that constitutes a new infrastructure, changing the way our societies function, while ICT applications will give us totally new opportunities to both preserve the best elements of our society, and develop new and better solutions to our existing

[63] When it was found in 1961, WWF stood for the World Wildlife Fund. But the legal name became the World Wide Fund for Nature during the 1980s by expanding its work to conserve the environment as a whole, except in North America where the old name was retained.

problems. As a whole, ICT is best viewed as a catalyst that can speed up current negative trends, or alternatively contribute to a shift towards sustainable development. The WWF devoted a lot of efforts to study on the Green ICT and published the following reports:

- *Sustainability at the speed of light:* the WWF invited experts to describe the future role of ICT for sustainable development and summarize the most important challenges for the future. This report was published in July 2002 and the result of invited contributions. The report was an attempt to bridge the gap between ICT experts and policy makers in politics and business, as well as other stakeholders in society.
- *Saving the Climate at the speed of light:* this report describes a potential to allow the ICT sector to provide leadership for structural changes in infrastructure, lifestyles and business practice to achieve dramatic reductions of CO_2. It describes the opportunity of ICT services to reduce CO_2 emissions such as videoconference, audio-conference, virtual answering machine, online phone billing, web-taxation, flexi-work, and so on. Then it suggests two-phase roadmap for actions [23]:
  - The first phase is a concrete (numerical) target for 2010 of 50 million tons CO_2 annually. This target is based on the implementation of several strategic ICT applications, e.g. virtual meetings, e-dematerialization and flexi-work. This also includes some additional tasks like policy revision (e.g. energy, tax, transport, innovation, etc.) and supplementary, parallel actions.
  - The second phase is a target for 2020. This target should be set before 2010 and should include more services and system solutions, where a number of services are combined, as well as a more ambitious target for CO_2 reduction. Possible focus areas for the second phase are sustainable consumption, production, city planning and community development.
- *Outline for the first global IT strategy for CO_2 reductions:* this report is a shorter report than just the below one and presents ten strategic ICT solutions that help accelerate the first billion tons of CO_2 reductions and begin the transformation towards a low-carbon society. It describes low vs. high-carbon feedback scenarios for the ten ICT solutions.
- *The potential global CO_2 reductions from ICT use*: this report addresses ten ICT solutions that can help accelerate the reduction of CO_2 emissions. It identifies one billion tons of strategic CO_2 reductions based on a bottom up approach with concrete solutions. These reductions are equivalent to more than one quarter of EU's total CO_2 emissions. The ten solutions areas are smart city planning, smart buildings, smart appliances, dematerialization services, smart industry, I-optimization, smart grid, integrated renewable solutions, smart work, and intelligent transport.

The WWF made the following achievements also:

- Communication Solutions for Low Carbon Cities: Helping cities to reduce CO_2 with existing low carbon ICT solutions
- A five-step-plan for a low carbon urban development: Understanding and implementing low carbon ICT/telecom solutions that help economic development while reducing carbon emissions
- From Workplace to Anyplace: assessing the global opportunities to reduce greenhouse gas emissions with virtual meetings and telecommuting
- From fossil to future with innovative ICT solutions: increased CO_2 emissions from ICT needed to save the climate
- From coal power plants to smart buildings at the speed of light: How urbanization in emerging economies could save the climate

SMART 2020

The SMART 2020 is a report by the Climate Group on behalf of the GeSI. This study was initiated by feeling a responsibility to estimate the GHG emissions from the ICT industries and to develop opportunities for ICT to contribute to a more efficient economy. The "SMART 2020 – Enabling the low carbon economy in the information age" presents the case for a future-oriented ICT industry to respond quickly to the challenge of global warming.

This report has quantified the direct emissions from ICT products and services based on expected growth in the ICT sector. It also looked at where ICT could enable significant reductions of emissions in other sectors of the economy and has quantified these in terms of CO_2e emission savings and cost savings. In total, ICT could deliver approximately 7.8 $GtCO_2e$ of emissions savings in 2020. This represents 15% of emissions in 2020 based on the BAU estimation. It represents a significant proportion of the reductions below 1990 levels that scientists and economists recommend by 2020 to avoid dangerous climate change. It is an opportunity that cannot be overlooked.

The report identified some of the biggest and most accessible opportunities for ICT to achieve these savings as follows:

- Smart motor systems: A review of manufacturing in China has identified that without optimization, 10% of China's emissions (2% of global emissions) in 2020 will come from China's motor systems alone and to improve industrial efficiency even by 10% would deliver up to 200 Mt CO_2e savings. Applied globally, optimized motors and industrial automation would reduce 0.97 $GtCO_2e$ in 2020.
- Smart logistics: Through a host of efficiencies in transport and storage, smart logistics in Europe could deliver fuel, electricity and heating savings of 225 $MtCO_2e$. The global emissions savings from smart logistics in 2020 would reach 1.52 $GtCO_2e$, with energy savings.
- Smart buildings: A closer look at buildings in North America indicates that better building design, management and automation could save 15% of North America's buildings emissions. Globally, smart buildings technologies would enable 1.68 $GtCO_2e$ of emissions savings.
- Smart grids: Reducing T&D losses in India's power sector by 30% is possible through better monitoring and management of electricity grids, first with smart meters and then by integrating more advanced ICT into the so-called energy internet. Smart grid technologies were the largest opportunity found in the study and could globally reduce 2.03 $GtCO_2e$.

10.6 References:

- Korea (Republic of), Document 2/INF/29, "ICT&CC relevant standardization activities of ISO, IEC and ISO/IEC JTC 1," contributed by Mr Yong-Woon Kim, 2011
- APT, ASTAP19/REPT1, "Introduction to Green ICT Activities", 2011

Annex 11: World Summit on the Information Society (WSIS) and the environment

Analysis of projects submitted to the WSIS Stocktaking Platform

The WSIS secretariat launched in October 2004 the WSIS Stocktaking Platform, a registry for stakeholders to submit projects, both planned and implemented, that relate to the 11 WSIS Action Lines. The goal of the platform is to provide an opportunity for governments, international organizations, businesses, civil society and other entities to network, create partnerships, increase visibility and share ideas, thereby adding value to the projects at the global level.

During the period from 2004 up to September 2012, a total of **95 projects** were submitted to the WSIS Stocktaking Platform related to MDG7 and/or WSIS Action Line C7 by a variety of organizations including governments, international organizations, civil society and the business sector. These projects reflect the diverse ways in which organizations are addressing environmental protection and sustainability through ICTs.

Action Line C7 can be broken down to three categories: (1) Environment and Natural Resources; (2) Greening the ICT Sector and (3) Natural Disasters. Nearly two-thirds of the projects submitted fall under the first category. These projects demonstrate the use or promotion of ICTs as instruments for environmental protection and the sustainable use of natural resources. 28% of the projects analyzed fall within the second category. These projects deal with minimizing the environmental footprint of the ICT sector. 12% of the projects are related to the third category. These projects relate to the use of ICTs for emergency and natural disaster preparation, risk evaluation and recovery.

Projects were also categorized and analyzed by activity type to provide further data on how organizations are implementing their projects. In this regard 35% of the projects relate to a centralized location for collecting, managing and analyzing environmental data. A quarter of the projects make use of geographical information systems (GIS) and other ICTs to collect and/or monitor real images and data to promote decision making based on accurate scientific information.

ITU-D Study Group 2 document 2/179, provides all the details of the projects as retained by WSIS for the following 3 categories.

A. Environment and natural resources

These projects demonstrate the use or promotion of ICTs as instruments for environmental protection and the sustainable use of natural resources. Two-thirds, or 66% of projects submitted fall under this category. These projects promote the use of ICTs for collecting, managing and disseminating information related to ecosystems, natural resources, land use, climate and weather and sustainable development.

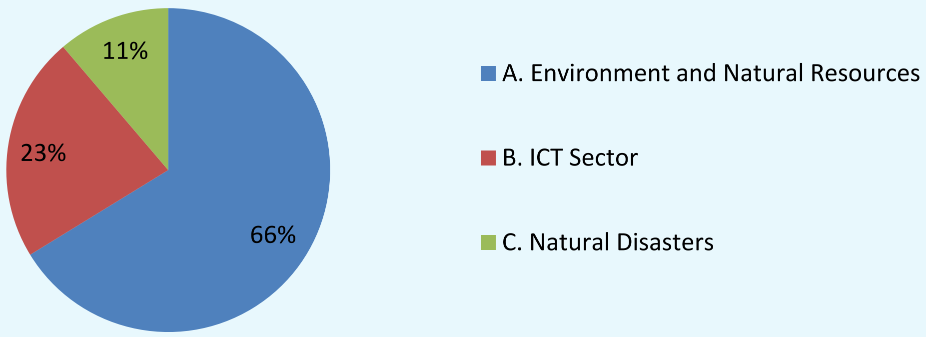
B. Greening the ICT sector

These projects under this category deal with the minimizing the environmental footprint of the ICT sector (*or greening the ICT sector*), such as projects and programs for the environmentally safe disposal and recycling of ICT equipment after its end of life. 23% of the projects analyzed fall within this category, including demonstrate initiatives, national plans and Events and Conferences that prepare for the expansion of the ICT sector or the minimization of the environmental impacts associated with the ICT sector, such as e-waste;

C. Natural disasters

These projects establish monitoring systems, using ICTs, to forecast and monitor the impact of natural disasters and man-made disasters, particularly in developing countries, LDCs and small economies. 12% of the projects analyzed fall in this category, showcasing the use of ICTs for emergency and natural disaster preparation, risk evaluation and recovery.

Figure 1: Projects by sub-category within WSIS Action Line C7 e-environment



Of the projects submitted to WSIS Stocktaking Platform, trends regarding activity type of e-environment projects were identified. Projects were categorized and analyzed by activity type to provide further data on how organizations are implementing projects related to the WSIS Action Line C7, e-environment. Figure 2 provides a summary of the projects by activity type.

1 Mapping/ Modeling/ Monitoring: the use of geographical information systems (GIS) and other ICTs to collect and/or monitor real images and data to promote decision making based on accurate scientific information;

2 Information System/ Database: establishment of a centralized location for collecting, managing and analyzing environmental data to provide a clear overview of important information, avoid duplication and disseminate information;

3 Initiative: Activities, planned or implemented, by organizations to achieve on the ground results for mitigating environment impact through ICTs or of the ICT sector;

4 Web Information Portal: Creation of a document or set of documents published shared online to promote education, disseminate and increase accessibility of information topics related to e-environment and disseminate relevant information;

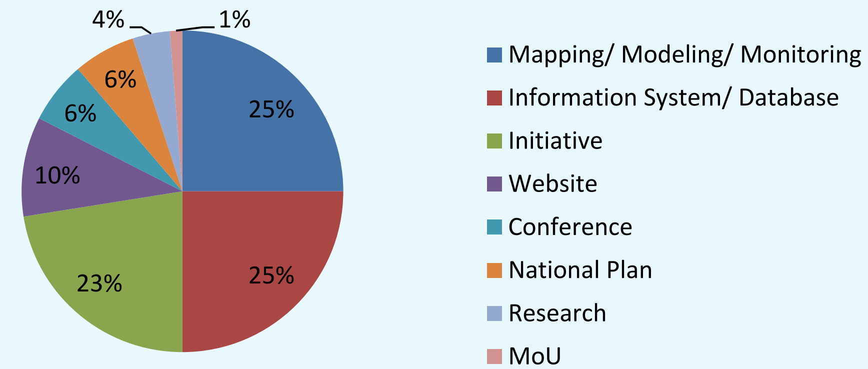
5 Events and Conferences: Organization of a public event (workshop, Events and Conferences or similar) for consultation, exchange of information, or discussion related to objectives pursuant action line C-7, e-environment;

6 National Plan: DDefining, developing and outlining a course of actions for managing ecosystems and resources, expanding the ICT sector or mitigating impacts, or preparing for natural disasters;

7 Research: a detailed study of a subject, especially in order to discover information or reach an understanding.

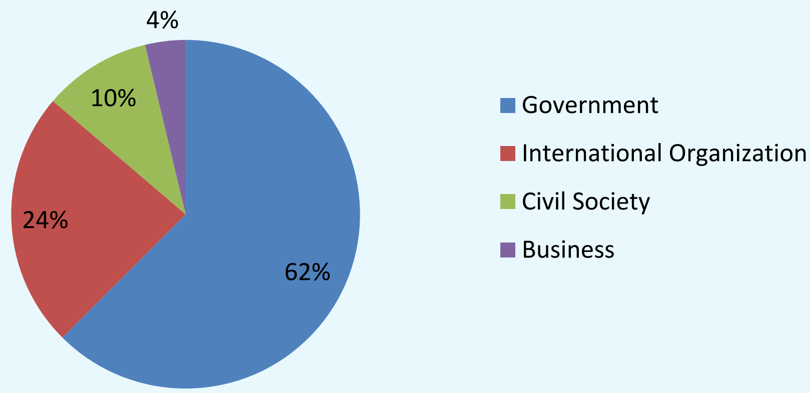
8 Memorandum of Understand (MoU): Signature of agreements to promote cooperation between entities.

Figure 2: e-Environment projects by activity type



A variety of organizations contributed to the stocktaking process, including government, international organizations, civil society and businesses. Figure 4 shows the percentage submission by organizations type. Nearly two-thirds of projects (62%) were submitted by governments.

Figure 3: Project submissions by organization type



Annex 12: List of relevant ITU Reports and Recommendations

A12.1 ITU climate change reports

ITU and Climate Change, 2008: www.itu.int/pub/S-GEN-CLIM-2008-11/

ITU ICT and Climate change resources: www.itu.int/en/action/climate/Pages/default.aspx

A12.2 ITU-T climate change documents

Recommendations:

K series: Protection against interference

L series: Construction, installation and protection of cables and other elements of outside plant

L.1000: Universal power adapter and charger solution for mobile terminals and other hand-held ICT devices (approved)

L.1001: External universal power adapter solutions for stationary information and communication technology devices (approved)

L.1100: Procedure for recycling rare metals in information and communication technology goods (approved)

L.1200: Direct current power feeding interface up to 400 V at the input to telecommunication and ICT equipment (approved)

L.1300: Best practices for green data centres (approved)

L.1310: Energy efficiency metrics and measurement methods for telecommunication equipment (approved)

L.1400: Overview and general principles of methodologies for assessing the environmental impact of information and communication technologies (approved)

L.1410: Methodology for the assessment of the environmental impact of information and communication technology goods, networks and services (approved)

L.1420: Methodology for energy consumption and greenhouse gas emissions impact assessment of information and communication technologies in organizations (approved)

L.1430: Methodology for assessment of the environmental impact of information and communication technology greenhouse gas and energy projects (approved)

L.recBat: Recycling of discarded batteries (under Study)

L.UPA portable: Universal Power Adapter for portable ICT equipment (under study)

L.Infrastructure and adaptation: Recommendations to support adaptation to climate change and the ICT infrastructure to the impacts of climate change (under Study)

L.Green Batteries: Green battery solution for mobile phones and other ICT devices (under study)

L.Eco_rating: Development of a Recommendation for eco-specifications and rating criteria for mobile phones eco-rating programs (under study)

L.AssDC: Data center infrastructure energy efficiency assessment methodology concerning environmental and working conditions (under study)

L.broad_impact: Environmental impact assessment of broadcasting services (under study)

Handbooks:

CCITT Directives concerning the protection of telecommunication lines against harmful effects from electrical power and electrified railway, and its volumes.

Mitigation Handbook

Technical Papers:

Environmental sustainability in outside plant and ICT equipment – facilities

Life-cycle management of ICT equipment

Setting up a low cost sustainable telecommunications infrastructure for rural communications for developing nations.

Life-cycle management of ICT equipment (under study)

Supplements:

L Suppl.1 ITU-T L.1310 – Supplement on energy efficiency for telecommunication equipment

Assessment case studies using L.1410 (under study)

Supplement to L.ICT projects for RNS projects (under study)

Reports

The case of Korea: the quantification of GHG reduction effects achieved by ICTs

Toolkit on Environmental Sustainability for the ICT Sector

Sustainable ICT in Corporate Organizations

Using submarine cables for climate monitoring and disaster warning: Engineering Feasibility Study

Climate Change Adaptation, Mitigation and Information & Communications Technologies (ICTs): the Case of Ghana

Boosting Energy Efficiency through Smart Grids

A12.3 ITU-R climate change documents

ITU Radiocommunications and Climate Change, ITU-R presentation, June 2007

Report RS. 2178: The essential role and global importance of radio spectrum use for Earth observations and for related applications

Recommendation ITU-R RS.1883: Use of remote sensing systems in the study of climate change and the effects thereof

Resolution ITU-R 60 (2012): Reduction of energy consumption for environmental protection and mitigating climate change by use of ICT/radiocommunication technologies and systems. (See annex 8 for full text).

ITU Handbook on Use of Radio spectrum for meteorology: weather, water and climate monitoring and prediction
Resolution 673 (Rev.WRC-12): The importance of Earth observation radiocommunication applications

Report: Radio-based technologies in support of understanding, assessing and mitigating the effects of climate change, 2012

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