最后报告
ITU-D第2研究组

第24/2号课题

ICT与气候变化

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第 24/2 号课题

ICT 与气候变化

ITU-D 研究组

作为电信发展局知识共享和能力建设议程的后盾，ITU-D 研究组支持各国实现其发展目标。通过推动为减贫和经济社会发展进行 ICT 知识的创建、共享和运用，ITU-D 研究组鼓励为成员国创作条件，利用知识更有效地实现其发展目标。

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ITU-D 研究组通过的输出成果和相关参考资料，被用于 193 个国际电联成员国的政策、战略、项目和特别举措的落实工作。这些活动还有助于巩固成员的知识共享基础。

信息交换和知识共享中枢

共同关心议题的共享是通过面对面会议、电子论坛和远程与会，在鼓励公开讨论和信息交流的气氛中实现的。

信息存储库

研究组成员根据收到的供审议的输入文件起草报告、导则、最佳做法和建议书。信息通过调查、文稿和案例研究采集，并通过内容管理和网络发布工具提供成员方便地使用。

第 2 研究组

第 2 研究组由 WTDC-10 受命研究涉及信息通信基础设施和技术发展、应急通信和适应气候变化等领域的九项课题。着重为在规划、发展、实施、运营、维护和持续提供电信服务过程中能够优化用户得到的服务价值，并能最合适、最成功地提供服务的方法和方式。该工作包括将具体工作重点放在宽带网络、移动无线电通信和农村与边远地区的电信/ICT、发展中国家对频谱管理的需要、ICT 在缓解气候变化对发展中国家的影响中的使用、用于减轻自然灾害和赈灾的电信/ICT、合规性和互操作性测试及电子应用，特别强调通过电信/ICT 手段支持的应用。该项工作还研究探讨信息通信技术的实施，同时兼顾 ITU-T 和 ITU-R 开展研究的成果以及发展中国家的优先事宜。

第 2 研究组与 ITU-R 第 1 研究组一道共同负责涉及第 9 号决议（WTDC-10，修订版）问题的研究 – 各国，特别是发展中国家对频谱管理的参与。

本报告是由来自不同主管部门和组织的众多志愿人员编写的。文中提到了某些公司或产品，但这并不意味着它们得到了国际电联的认可或推崇。文中表述的仅为作者的意见，与国际电联无关。

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ICT 与气候变化

0 引言

地球气候一直在不断变化，变暖和变冷的周期交替出现，古气候学使得我们可以判断各个时代的重大气候变化。然而，近期大规模的人为影响导致气候出现巨大变化，地球以前所未有的速度进入了变暖周期。气候变化因此成为了一项现实问题，并可能是人类历史上长期面临的最大挑战之一，因其对我们实现经济社会目标，支持可持续发展的能力造成了挑战。发展中国家由于资源有限，因而受到的气候变化负面影响很可能更为严重。

何为气候变化?

基本而言，气候变化是指气候的平均状态或变异中明显的统计性变化，并会持续一段延长期（通常为几十年或更长）。气候变化可能是由于自然内部演变历程造成的，抑或是因为大气成分或土地使用中的持久人为变化导致的。《联合国气候变化框架公约》（UNFCCC）的第 1 条将“气候变化”定义为：“除在类似时期内所观测的的自然变异之外，由于直接或间接的人类活动改变了地球大气的组成而造成的气候变化”。

何为信息通信技术?

信息通信技术（ICT）涵盖以数字形式收集、存储、检索、处理、分析以及传输信息的一系列技术。国际电联致力于和其他组织合作，与气候变化作斗争。在联合国范围内，国际电联在制定研究 ICT 和气候变化之间关系的综合办法方面发挥主导作用。一方面，ICT 是导致气候变化的诱因之一，而另一方面，国际电联的研究可表明，新的技术高效节能，并可凸显 ICT 在应对全球变暖方面的有益作用。

空间地球观测可使我们监测地球，在帮助了解气候的当前状态和可能的演变方式方面发挥至关重要的作用。这有助于监测气候的运行状况和检测全球气候变化。对大气、海洋和陆地表面的地理参数进行持续观察是监测我们这个星球气候的必备要素。数十年来收集的准确气候信息的可用性将使各阶层人民受益，并在广泛领域协助区域和国家性规划机构更好地评估气候变化的潜在影响，从而为其基础设施规划选择最适宜的方案。

ICT与气候变化间存在何种联系?

ICT 对于缓解和适应气候变化做出了宝贵贡献。ITU-D 协助各国利用 ICT 应对气候变化，推动筹措落实所需的技术、人力和财务资源，并且促进对于 ICT 的获取。近期研究表明，ICT 在减少温室气体（GHG）排放方面做出了积极贡献，为其他经济部门的节省排放量是其自身

的一至四倍。与此同时，尽管 ICT 在减少温室气体排放方面发挥着积极作用，但同时也大量使用能源。目前在一些国家内，所有信息通信技术（计算机、电视机、电话和充电器、上网盒、服务器和数据中心）的能源消耗相当于 2008[1]年全球碳排放的 2%左右或者说是世界电力消耗的 7.15 倍。如果保持当前的增长速率，这一比例在未来几年可能更高。到 2020 年，世界范围内用于 ICT 的电力消耗将达到 14.6%[2]。本报告探讨 ICT、气候变化和发展之间的联系，这些领域之间的关系由于气候变化对现有发展挑战和脆弱性的巨大影响而日益密切。

1 气候变化

上个世纪地球的气候在不断变化。各种证据趋向于表明，过去 50 年内所观测到的大部分变暖现象主要是由于人类活动引起的。事实上，人类主要通过这些活动改变大气的构成，而如今人们认为人类正进入人类世界时代。

此外，计算机模型预测已经指出，气温在二十一世纪内将继续上升。联合国政府间气候变化专门委员会（IPCC）第三次评估报告[3]揭示了这一预测，该报告由来自许多国家的数百名科学家共同完成。

IPCC 报告（2007 年）所述如下：

> “大气系统变暖无可争议，如今这一点可以从对全球平均大气和海洋温度上升、大范围冰雪消融和全球平均海平面升高”的观察中得到印证。自1850年有仪器记录以来，全球地表温度最热的十二年有十一年出现在1995-2006年。1906-2005年这100年气温线性升高了0.74摄氏度[从0.56到0.92度]，这高于1901-2000年相应的0.6摄氏度的线性升温幅度 [从0.4到0.8度]。近50年（从1956年到2005年）的线性升温趋势为每十年0.13摄氏度[从0.10到0.16度]，几乎是1956至2005年这100年温度增幅的两倍。”

包括 2012 年 IPCC 报告的主要调查结果：解释 IPCC 设想的各种情景。

据美国国家海洋和大气管理局（NOAA）公布的“**2010 年的气候状态**”报告显示，2010 年的地上空气温度达到了历史第二高。北极地区继续变暖，速度约为低纬度地区的两倍。地方和区域层面上，温度变化可影响天气的预期分布，改变降水模式，并影响到许多其它气候指标的趋势。这些指标继续显示出长期趋势的基本特征，如温室气体浓度的稳定增长和格陵兰岛冰盖的消逝。

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

[2] 总体 ICT 脚印与绿色通信技术 – 第四届通信、控制和信号处理国际会议（ISCCSP 2010）– 会议记录，2010 年 3 月 3-5 日，塞浦路斯，利马索尔

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

美国国家海洋和大气管理局（NOAA）公布的“**2011 年的气候状态**”[4]报告显示，年度全球陆海表面温度比 20 世纪的平均表面温度 13.9°C 高出 0.51°C。2011 年是自 1976 年以来连续第 35 年年全球气温高于平均值。20 世纪只有一年，即 1998 年温度高于 2011 年。有记录的最热年份为 2010 和 2005 年，高出平均值 0.64°C。个别看，2011 年全球平均地表温度比 20 世纪的平均值 8.5°C 高出 0.8°C 而且排在有记录以来的第八位。2011 年全球平均海洋温度比 20 世纪平均温度 16.1°C 高出 0.40°C 且排在有记录以来高温第十一位。此外，拉尼娜（La Niña）造成了 2011 年世界天气和气候模式：与此前的拉尼娜年份相比，2011 年全球表面温度是此类年份中观测到最热的一年。在区域和地区层面发生了很多极端事件而拉尼娜导致了其中部分而非全部事件。至于北极冰，据称在 2011 年 9 月，海冰面积为有卫星监测数据以来第二小。在格陵兰岛，由于高出平均温度的气温和衰退的反射率，冰盖已经呈现出极速融化态势且质量损失严重。

据 **NASA**（戈达德太空研究所或 GISS）[5]，2012 年是自 1880 年以来高温排在第九位的年份，呈现出全球气温不断升高的长期持续态势。除 1988 年外，132 年间最热的九个年份均出现在 2000 年以来，其中 2010 年和 2005 年为有记录的最热年份。对全球表面温度进行持续观测的 GISS 发布了一项分析对 2012 年全球各地气温与 20 世纪中叶全球平均气温进行了对比。对比显示了地球何以经历较数十年前更热的天气。记录追溯到 1880 年，因为自那时起世界各地开始有足够的气象站提供全球气温数据。2012 年的平均温度约为 14.6°C，较 20 世纪中叶的基线值高出 0.6°C。据此项分析，自 1880 年以来，全球平均气温升高了约 0.8°C。

科学家强调，天气模式总会造成年度间平均气温的波动，但地球大气中温室气体水平的持续提高则确保了全球气温的长期升高。接下来的一年并不必然较前一年气温更高，但在目前温室气体增加的过程中，科学家预计接下来每一个十年都会较上个十年温度更高。重要的是这个十年比上个十年温度更高，而上个十年比此前一个十年温度更高。我们的地球正在变暖。变暖的主要原因在于人类正将越来越多的二氧化碳排入大气中。二氧化碳是一种锁住热量并在很大程度上控制地球气候的温室气体。它自然而然地出现而且也会因能源用化石燃料的燃烧而得到排放。受到越来越多的人为排放的影响，地球大气中的二氧化碳水平在过去几十年中一直持续升高。据美国国家海洋和大气管理局（NOAA）测算，按体积计算，1880 年，大气二氧化碳浓度（CO_2）约为百万分之 285。1960 年，这一数值达到了百万分之 315。如今，这一浓度已超过百万分之 390。这是过去 80 万年间最高水平。

美国国家海洋和大气管理局（NOAA）公布的“**2012 年的气候状态**”[6]报告显示，2012 年是自 1880 年有记录以来排在最高温的第十位。年度全球陆海表面温度比 20 世纪的平均表面温度 13.9°C 高出 0.57°C。这标志着 1976 年以来连续第 36 年年全球气温高于平均值。目前，有记录的最热年份为 2010 年，该年气温较平均气温高出 0.66°C。包括 2012 年在内，至今 21 世纪的所有 12 年（2001-2012）位居 133 年记录周期中 14 个最热年份之列。20 世纪只有一年，即 1998 年较 2012 年更热。

2012 年全球平均地表温度较 20 世纪的 8.5°C 高出 0.90°C 且位居有历史记录的高温年份第七位。拉尼娜，据定义来看是东部和中部赤道太平洋较正常水温冷的水域影响全球各地天气模式的气候现象，在 2012 年前三个月已经出现。从弱到中等强度不等的拉尼娜现象在春

[4] State of the climate in 2011，“气候状况，2011 年”（美国国家海洋和大气管理局 NOAA）

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

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

天消褪，取而代之的是该年度余下月份中的厄尔尼诺中性条件。与此前的拉尼娜年相比，2012 年全球表面温度是此类年份中所观测到最热的；2011 年是上一个有记录的最热拉尼娜年。2012 年全球平均海洋温度较 20 世纪 16.1°C 的平均温度高出 0.45°C 且排在有记录的最热年份第十位。该年也是所有拉尼娜年份中有记录的最热年份。三个最热的年度海洋表面温度出现在 2003 年、1998 年和 2010 年—均为暖位相厄尔尼诺年份。

1.1 科学因素

引起气候变化的原因多种多样，其中许多是自然成因（如太阳辐射的变化以及火山运动）。然而应重点关注的是人为的气候变化，因为它似乎正在因为温室气体排放，主要是碳排放，而加剧和加快地球变暖。联合国政府间气候变化专门委员会（IPCC）的研究表明，全球温室气体排放自 1970 年以来增长了 70%。

世界气象组织（WMO）/联合国环境规划署（UNEP）（在政府间气候变化专门委员会（IPCC）的协助下起草）的报告对于积累和传播更多有关人为气候变化的知识，以及为应对这类变化所需措施奠定基础而言有着重要意义。

导致全球变暖的各种综合科学因素如下[7]:

1 空气温度正在不断上升。自 1980 年以来，除地基气象站测量之外，新增了卫星测量，实现了整个星球的无缝覆盖。

2 海洋正在变暖。自上个世纪八十年代以来，除在世界各海域部署几百个漂流浮标外，卫星定期测量海面温度。定期生成了深至 2000 米的气温曲线图，以确定整个水体的温度和盐度。

3 冰山正在消退。山地冰川可使研究人员进行一系列的测量是一个众所周知的事实。

4 极地冰盖正在更加快速地向海洋消退。据报告，在过去的大约十年时间中，其间的格陵兰和南极每年消融了 5000 亿吨左右的冰，每年递减 360 亿吨。

5 海平面正在上升。海平面测量计显示，在上个世纪，海平面每年上升 1.6 至 1.8 毫米。自上个世纪九十年代以来，测高卫星的采用表明从 1993 年到 2010 年，海洋平均每年上升 3.3 毫米，即上升速度为 20 世纪海平面测量计所记录上升值的两倍。近期采用海平面测量计的测量确认了这种加速。

6 海冰正在消失。自 1978 年以来，卫星发现北冰洋的冰覆盖面积不断缩小，从 1980 年的 800 万平方公里降低到 2011 年的 433 万平方公里。

7 北半球的陆栖生物正在向北转移。

8 永久冻土正在升温。

气候变化是气候系统内部变异和外部因素（包括自然和人为的因素）共同造成的结果。人类世界的排放在很大程度上改变了大气中一些气体的浓度。一些这类气体预计将通过改变地球的辐射平衡对气候造成影响，影响的程度使用辐射强迫衡量。温室气体具有全球效应，通常通过吸收地球发出的红外辐射来使地球表面变暖。最主要的人为温室气体是二氧化碳

[7] 《探索》杂志：“专家们的衡量内容”，作者 Lise Barnéoud，第 457 号，2011 年 11 月 1 日

（CO_2），其浓度自 1750 年以来已增加 31%，2000 万年以来也许从未超过该水平。这一增长主要是由于燃烧化石燃料，同时也由于土地利用的变化，尤其是森林砍伐。全球大气的二氧化碳浓度已从工业化前的 280ppm（百万分之，基于碳分子的大气测量）左右增加到 2008 年的 385ppm。每年的年度增长率为 2ppm，其大大超过了过去 650 000 年中观测到的变化（180-300ppm）[8]。IPCC 将气候告警门限设为 450ppm，但也有一些科学家建议上限设为 350ppm，以避免超过此门限。其它重要的人为温室气体包括甲烷（CH_4）（自 1750 年以来增长 151%，辐射强迫是二氧化碳的 1/3）、卤烃（如氟氯化碳和其替代品）（100%的人为产生，辐射强迫是二氧化碳的 1/4）和一氧化氮（N_2O）（自 1750 年以来增长 17%，辐射强迫是二氧化碳的 1/10）。

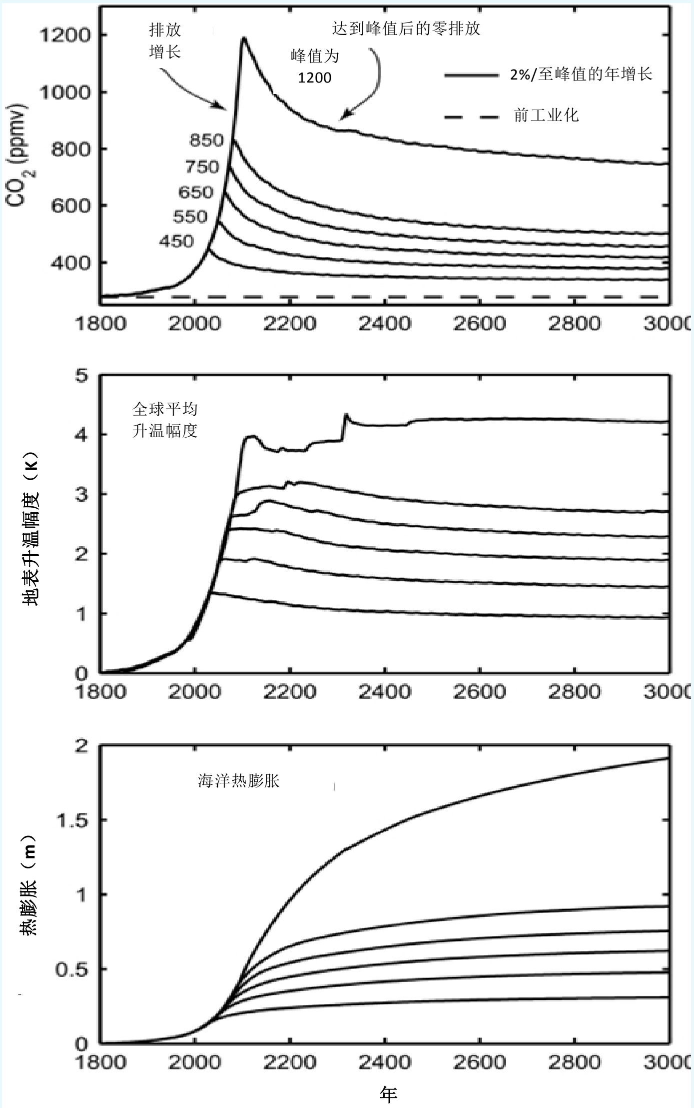
一些科学家[9]指出了不可逆转性这一潜在问题。他们认为由于二氧化碳浓度增加导致的气候变化在排放停止后的 1000 年里基本上是不可逆的。排放停止后，大气二氧化碳的去除将减少辐射强迫，但基本上被海洋热损耗的降低抵消掉了，因此至少在 1000 年里大气温度不会显著下降。应当预测到的可作为例证的不可逆转影响包括：在未来一个世纪，如果大气二氧化碳浓度从目前的约 390ppm 上升至峰值 450 到 600ppm，那么多个区域旱季降雨减少到“沙尘暴”时代的雨量并且海平面大幅度上升将是不可逆转的。海洋变暖的热膨胀效应为不可逆转的全球平均海平面上升带来了一个相对保守的下限值至少 0.4–1.0 米，如果 21 世纪 CO_2 浓度超过 600ppm，而如果峰值 CO_2 浓度超过约 1 000 ppm 则海平面上升 0.6–1.9 米。冰川和冰盖对未来海平面上升造成的额外影响尚不确定但有可能在下一个千年或更长时间达到或超过数米。

下图说明如果二氧化碳排放量以 2%的年增速分别达到 450、550、650、750、850 和 1200ppmv 的二氧化碳峰值（之后排放降为零，2100 年的二氧化碳浓度相当于 735ppm）则对表面升温和热膨胀等参数造成的影响。1980 至 2000 年间全球化石燃料二氧化碳排放率增速约为 1%/年而 2000 至 2005 年这一增速超过 3%/年（13）。使用 11 年滑动平均数得出的结果已经有所缓和。预计陆地升温幅度将超过这些全球平均值，最大幅度升温预计出现在北极圈。海平面仅因热膨胀而升高（数米）（不包括冰川、冰盖或冰原的损失）。

8 “我了解什么?气候变暖，巨大风险”第 3650 期，第 1 段，地球环境的变化

9 由于二氧化碳排放而导致的不可逆气候变化 2009 年《美国科学院院刊》，2009 年 1 月 28 日在线发布。《环境科学》

图 1: 二氧化碳浓度与全球变暖现象之间的相关性及其在**1000**年间的不可逆性



IPCC 认为，与 1980-1999 年这一期间相比，21 世纪末的温度预期将增加 1.8-4°C 。

气候变化将影响到千百万的人，特别是在水源短缺方面，更不用说是海平面上升以及其将对全球许多沿海城市带来的极端影响。

1.2 极端现象与气候变化

据 1950 年以来收集到的观测数据，有迹象表明人为影响造成了极端天气变化，包括大气中温室气体排放量的增加。

世界各地由气候变化导致的极端气候事件出现愈加频繁，对人们实现并维持发展的方式造成重大影响。

大多数人并没有感受到全球平均温度的上升，但《自然》杂志（2011 年 2 月）的两项研究指出，全球气候变暖已导致了影响数以百万计民众的极端天气事件的发生。[10]该研究认为北半球雨雪形式的降水强度增大和洪水风险增长与温室气体水平的上升有直接联系。科学家认为，二十世纪后半叶降雨强度的增加不能归因于气候内部的多变性。10 多年以来，人们已经发现一些北半球区域内极端降水事件增多，但目前科学家首次成功地明确强调其中的人为因素。

2007 年 IPCC 报告指出：

> "过去 50 年里，一些极端事件发生的频率和/或强度已经出现变化：
>
> – 很可能在大多数陆地区域冷昼、冷夜和霜冻的发生率已减小，而热昼和热夜的发生率已经提高。
>
> – 有可能在大多数陆地区域热浪的发生率已经提高。
>
> – 有可能大多数区域极端降水事件（或豪雨产生降水量占总降水量的比重）已经提高。
>
> – 有可能自 1975 年以来世界范围内广大区域的极端海平面上升事件发生率已经有所提高。
>
> 有观测证据表明，大概自 1970 年以来，强热带气旋活动有所增加，并且有迹象表明在对数据质量关注度更高的其它一些区域强热带气旋活动有所增加。数十年的变异性以及 1970 年实现常规卫星观测之前热带气旋记录的质量使对热带气旋活动长期趋势的探测工作复杂化。"

此外，2012 年发布的一份有关极端事件的 IPCC 报告[11] 指出：

> "有证据表明，由于人为影响，包括大气温室气体浓度升高而改变了某些极端事件"

总之[12]，21 世纪气候模型趋于显示，随着全球变化幅度每提高°C，观测到的热带气旋数量就减少 0-10%。每升高 1°C，平均强度预计提高 1-4%，每升高 1°C，破坏力（风速的立方）提高 3-12%。

基于预期的水蒸气全球增幅的测算显示，在以一个热带气旋为中心的 100 公里范围内每上升 1°C 降雨量有可能增加 7%。尽管预计大部分热带海洋会变暖，但已经给出了一个强有力的理由，即大洋之间的相对变暖程度影响着哪些地方的飓风增多亦或减少。由于分别受相对温暖和凉爽的热带水域驱动的上升和下沉空气所具有的循环模式，海洋表面温度较高的区域趋于产生更多的气旋而升温幅度较低区域则不会产生这么多气旋。尽管在过去数十年里，热带大西洋较其它热带大洋升温更快，但各种模型并未指向一致，即这种趋势将在未来延续。

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

[11] IPCC，2012：应对极端事件和灾害引发的风险从而促进气候变化适应。

[12] 不断升温的世界：温度带来的影响。基于国家研究理事会报告，"气候稳定化目标：排放、浓度及数十年到千年的影响"（2011 年）

正如前文已经做出的解释，我们知道当大气上升一摄氏度时，空气湿度增加约 7%[13]。这一科学事实有可能解释在北美、中亚和东南亚地区观测到的极端条件下降水的增加。这是一项无可争议的事实：随着气温增高，水循环进一步推动了全球降水量的抬升[14]。总体温度更高趋于提高大气中的水蒸气含量和蒸发水平，这解释了这些更高的降水量 – 有时降水取代了降雪。

有可能出现的另一种未预测到的极端事件[15]与群山，特别是喜马拉山脉上的冰川消融有关。当由于水压或发生地震而导致这样一座天然水坝遭侵蚀"溃坝"，成吨的冰石坠落，有可能引发海啸。上个世纪在喜马拉雅山脉至少发生了 50 起此类海啸而且这一现象会随着气温升高而愈发严重。在喜马拉雅山脉某些地区因冰川融化而形成的许多湖泊被认为存在危险，因而可能对生活在这些地区的人们构成严重威胁。

1.3 气候变化的来源

自 18 世纪早期以来，由于人类世界二氧化碳排放进入大气层（使用化石燃料）以及森林砍伐，人类（人类世界）的活动影响到了碳循环。

地球的气候受诸多因素影响，如大气中的温室气体和气溶胶的数量、来自太阳的能源量或地球表面的属性。这些因素的变化通过人为或自然作用，对地球产生升温或降温作用，这是因为它们改变了保留或反射回太空的太阳能的量。

自 1750 年以来，温室气体（如二氧化碳（CO_2）、甲烷（CH_4）和氧化亚氮（N_2O））的大气浓度显著增加，现已远远超过工业化前的水平。

二氧化碳是最重要的人为温室气体。目前二氧化碳在大气中的浓度（2005 年为 379ppm）远远超过了过去 650 000 多年的自然分布范围（180 到 300ppm），并且自 1960 年开始连续直接测量以来以前所未有的速度增长。增长的主要原因是化石燃料的使用，土地使用变化也在较少程度上有所影响。在近一百万年的时间内，地球大气的二氧化碳浓度从未如此之高。例如，使用化石燃料产生的二氧化碳排放量从 20 世纪 90 年代的每年 6.4Gt 增长到 2000-2005 年间的每年 7.2Gt。甲烷和氧化氮的大气浓度自前工业化时代以来亦大幅增加，主要归因于人类的活动（如农业和化石燃料的使用）。[16]

二氧化碳对气温的影响已经得到检验[17]。人类对全球变暖做出的"贡献"主要集中在温室气体和气溶胶颗粒浓度的提高，这改变了地球的能量预算。就温室气体二氧化碳这一特例而言，累积排放也是衡量人类对气候系统影响的一项重要指标或测量方式。最佳预测是，1 000 千兆吨的人类碳排放导致全球平均气温上升约 1.75°C。截至目前（2010 年）的累积碳排放约为 500 千兆吨，而全球排放率仍将提高。依据目前的理解，预计在未来超过 1000 年

[13] 《探索》，2013 年 2 月期，气候变暖 1，第 38 页

[14] 空间技术和气候变化，经济合作与发展组织（OECD）2008 年，见第 1 章，第 22 页

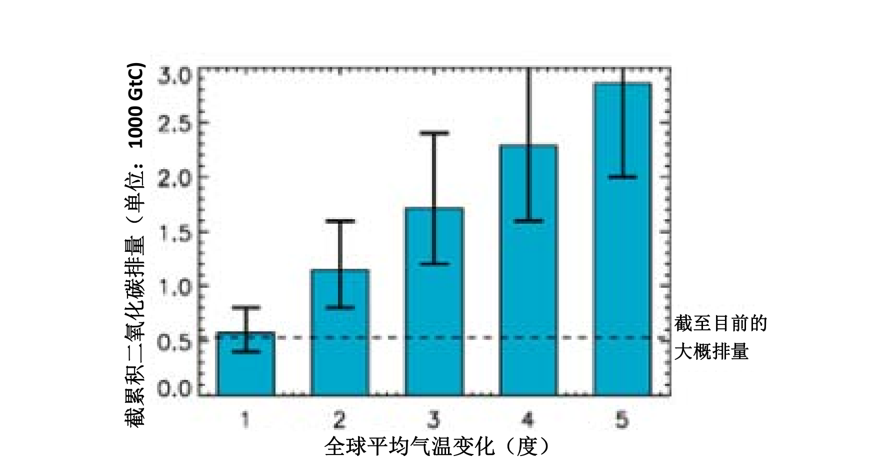
[15] http://www.7sur7.be/7s7/fr/2665/Rechauffement-Climatique/article/detail/1654151/2013/06/20/L-Himalaya-menace-par-les-tsunamis.dhtml

[16] http://co2now.org/

[17] 不断升温的世界：温度带来的影响。基于国家研究理事会报告，"气候稳定化目标：排放、浓度及数十年到千年的影响"（2011 年）

时间里，这一变暖趋势将是不可逆转的。总的或累积的二氧化碳排放量越高且随之造成的大气浓度越高，那么下一个千年变暖程度越高。排放量越高将导致未来数千年变暖程度越高，这使得地球系统的关键却缓慢组件有更多的时间作为气候变化的放大器发挥作用。例如，未来几个世纪里深海变暖将释放储存在深海沉积物中的更多的碳，而如果在未来数千年来全球变暖仍维持在 3.5°-5.0°C 范围内，使全球海平面升高 4-7.5 米，那么格陵兰岛冰盖将缩小，直至消失。

图 2: 累积排放量与全球平均气温的增量



上图说明了近期开展的研究表明，累积二氧化碳排放是将排放量与对气候影响关联起来的一种有用度量标准。误差线反映了由于观测受限和模型结果范围所限而造成的碳循环的不确定性以及二氧化碳排放的气候响应。累积二氧化碳排放以碳的兆吨计（万亿立方吨或1000 千兆吨）

1.4 联合国气候变化大会

1.4.1 联合国气候变化框架公约（UNFCCC）

联合国气候变化框架公约（UNFCCC）[18] 于 1992 年 5 月 9 日在纽约通过，同年 6 月于里约热内卢开放供签署。该公约于 1994 年 3 月生效，截至 2011 年 9 月共 194 个缔约方批准（194 个国家和 1 个区域经济一体化组织）[19]。缔约国首先要承诺采取一系列措施（各国清查、变化应对项目、采用并推广适当的技术、准备应对不利后果等）。

这些措施被用来设定附件 I 各国加入《京都议定书》以及这些国家做出 GHG 减排承诺所要达到的 1990 基准线。

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

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

该公约及缔约方大会可能通过的相关法律文本的终极目标是根据公约相关条款实现大气温室气体浓度稳定化，将温室气体浓度稳定在某一水平以免对气候系统造成危险的人为干扰（第 4 条）。

秘书处（气候变化秘书处），其职责已在公约第 8 条做出了规定，秘书处自 1996 年起从此前的驻地瑞士日内瓦迁至德国的波恩[20]。IPCC 作为为秘书处提供科学支持的实体发挥了关键作用。

公约的第 2 条特别规定：

> "本公约以及缔约方会议可能通过的任何相关法律文书的最终目标是：根据本公约的各项有关规定，将大气中温室气体的浓度稳定在防止气候系统受到危险的人为干扰的水平上。这一水平应当在足以使生态系统能够自然地适应气候变化、确保粮食生产免受威胁并使经济发展能够可持续地进行的时间范围内实现"

自 2007 年以来，《联合国气候变化框架公约》缔约方一直在努力建立一个旨在改进国际合作和适应行动的适应框架，以减少脆弱性并建设各国，特别是发展中国家，尤其是特别易受气候变化不利影响冲击国家的适应能力。各方认识到合作的有效性和适应措施取决于相关各方的承诺，缔约方请具备资格的多边、国际、区域和各国组织、公共和私营部门、民间团体和其他相关各方做出承诺并支持有利于一致协调地进行适应的行动。

1.4.2 国际电联参与框架公约的进程

在《联合国气候变化框架公约》以外，国际电联就"信息通信技术与气候变化"主题组织的七场专题研讨会（最近的一次于 2012 年 5 月在蒙特利尔举行）已凸显了 ICT 可在降低温室气体总体排放方面发挥的重要作用。本报告反映了这些专题研讨会的许多结论和文稿。

国际电联也积极参与了框架公约的进程，包括在 2010 年 11 月 29 日至 12 月 10 日在墨西哥坎昆召开的第 16 次缔约方大会（COP-16）以及 2011 年 12 月在德班举行的缔约方大会。国际电联在这次大会期间组织了几次非正式会议，吸引了众多与会者。

联合国气候变化大会（墨西哥坎昆）最终通过了被广泛认为是一揽子平衡、折衷方案的"坎昆协议"。"坎昆协议"的主要内容包括：

- 发达国家的目标在多边进程下得到正式认可，这些国家将制定低碳发展计划和战略，评估达成目标（包括通过市场机制）和每年汇报库存的最佳方式。
- 发展中国家降低排放的行动在多边进程下得到正式认可。将设立注册处，用于记录发展中国家的缓解行动，并将此类行动与发达国家的财务和技术支持相匹配。发展中国家将每两年公布一次进度报告。
- 缔约方，根据《京都议定书》召开的会议同意继续进行磋商，以完成他们的工作并确保条约的第一和第二承诺期之间没有差距。这将在下届在德班召开的缔约方会议继续讨论。

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

- 《京都议定书》的清洁发展机制得到了加强，推动更多主要投资和技术进入发展中国家的有效环保和可持续的减排项目。
- 缔约方发起了一系列倡议和机制，保护易受气候变化的国家，并部署发展中国家计划和构建可持续未来所需的资金和技术。
- 截至 2012 年，发达国家将提供总计 300 亿美元的快速启动资金，用于支持发展中国家的气候行动；并承诺将在 2020 年之前筹措 1000 亿美元的长期基金，均包含在会议决议中。
- 在应对气候变化的融资措施方面，建立了大会缔约方授权的设计大会“绿色气候基金”的一项机制，此项机制的运作由相同数目的发达国家和发展中国家代表组成的董事会负责。
- 制定了一个新的“坎昆适应框架”，目的在于通过增加资金和技术支持（包括一个明确的损失和损害继续工作流程）确保发展中国家更好地规划和实施适应项目。
- 政府同意利用技术和资金支持增强行动，以遏制发展中国家的森林砍伐和森林退化造成的排放。
- 缔约方已建立了一个由技术执行委员会与气候技术中心和网络组成的技术机制，以加大技术合作，支持适应和缓解方面的行动。

第十六次缔约方会议（COP-16）和作为《京都议定书》缔约方会议的《公约》缔约方会议（CMP）第六次会议（CMP-6）通过的决议可查询网址：www.unfccc.int。

国际电联继续积极支持联合国气候变化框架公约（UNFCCC）缔约方大会（COP）的有关磋商并推动 ICT 作为该决议不可分割的组成部分。特别是，国际电联参加了 2012 年联合国气候变化大会（COP18-CMP8），此次会议于 2012 年 12 月在卡塔尔多哈举行。在会议期间，国际电联与 ictQatar、Ericsson 和宽带委员会组织了非正式会议“宽带桥梁：连通 ICT 与气候变化— —致力于一个低碳的未来”，汇聚了研究低碳技术问题的相关利益攸关方。国际电联将继续排除官方代表团参加未来的 COP 会议并推动更有效地使用 ICTs 以应对气候变化相关的挑战。

1.4.3 各界大会的成果

1.4.3.1 《京都议定书》

《京都议定书》系 1995 至 1997 年间经谈判所达成并于 2005 年生效，但前提条件是各国必须主要通过各国采取的措施实现其目标。在京都谈判达成的目标是到 2012 年，温室气体排放要比 1990 年达到的水平降低 5.2%。1990 主要基准年的选择依然在京都，因为它确实含在最初的框架公约中。该条约于 2005 年 2 月 16 日生效。38 个工业化国家分摊了减排配额而且如果 2008 年至 2012 年间这些配额分配能够受到重视，那么应当实现工业化国家总体 5.2%的温室气体减排量。

但是，《京都议定书》也为他们提供了通过采用三种市场机制来实现其目标的额外方法。京都机制是：

- 排放贸易 — 亦称作“碳市场”。各国获得一定数量根据经过批准的排放上限计算出的碳数量。其原则是各国向各企业划分特定数量的温室气体排放权，该权利以“吨二氧化碳当量”表示。此类权利可进行交易。

- 联合落实。某个缔约国在另一个缔约国进行投资的企业可获得由此产生的配额（或避免排放），并在排放市场将其转售。
- 清洁发展机制（CDM）。该机制与前一个类似，但适用于富裕的缔约国的企业与贫穷国家的企业之间。

这些机制协助刺激绿色投资并帮助缔约国按照低成本高效益的方式实现其排放目标。

《京都议定书》的一个创新特征在于可在计算工业化国家排放平衡时，可扣除由于增加森林而以碳的形式存储的二氧化碳部分（称为“碳汇”）。应注意到有关碳汇有效性的讨论仍在进行中。

根据议定书，必须监控各国的排放并严格记录所有的交易。登记系统登记并记录缔约方根据议定书进行的交易。位于德国波恩的 UNFCCC 秘书处维护国际交易记录，以确保交易符合议定书确定的原则。

缔约方通过提交议定书所要求的年度排放清查和定期国别报告履行其问责义务。

存在一个系统，以确保缔约方履行其承诺且如其在该过程中遇到困难，可协助其步入正轨。

关于适应问题，如公约所定，《京都议定书》也寻求通过促进开发和落实可增强抵御气候变化弹性的技术这一方式，协助各国适应气候变化的不利影响。

1.4.3.2 《哥本哈根议定书》

哥本哈根大会是 UNFCCC 第 15 次缔约方大会（COP-15）。本次会议于 2009 年 12 月 7-18 日在（丹麦）哥本哈根举行。根据 2007 年 COP-13 确定的路线图，这是 192 个批准公约的国家重新谈判达成一项取代《京都议定书》（该议定书于 1997 年 COP-3 上启动，其第一阶段于 2012 年终止）的国际气候协议的场合。COP-15 也是《京都议定书》第 5 次缔约方会议（MOP-5），即 2005 年开始生效的《京都议定书》的第五次年会。

COP-15，即批准《联合国气候变化框架公约》国家的代表的第 15 次年度峰会，制定了“第一份真正全球性协议”，旨在到 2050 年将温室气体排放量减半，降低到 1990 年水平，以便 2100 年时，相对于前工业化时代，气温上升平均不超过 2°C。

该协议并不具备法律约束力，因其并未延续将于 2013 年中止失效的《京都议定书》。它也未规定截止期限或量化的目标，但为了将相对于工业化前时代的温度上升稳定在两度，工业化国家应当在 2020 年之前将其温室气体排放削减 40%。在起草该文件时，各种谈判达成的目标总计形成的数量还不超过 20%。在 2010 年 1 月底之前，各国已就其 2015-2020 年的温室气体减排目标做出了承诺。尽管如此，一些发展中国家同意落实抑制措施，以便在国家层面应对森岭砍伐并就这些工作发布双年度进展报告，而富裕国家则同意每年（从 2020 到 2100 年）向发展中国家提供 1000 亿美元。

1.4.3.3 坎昆协议

缔约方第 16 次会议（COP-16）的目标是实现“一揽子平衡方案”。《坎昆协议》认识到平均气温上升必须保持在 2 度以下。但是，公约缔约方同意重新审议 2 度这一目标，以便在 2015 年之前，根据 2014 年将要发布的 IPCC 报告，增加承诺水平，实现 1.5°C 的目标。缔约方同意在大会的最终决定中采用“历史性责任”这一表述，但该表述仅出现在与发达国家减排有关的部分中。

适应气候变化的后果也是发展中国家，特别是不再为《坎昆协议》所提及的易受气候变化影响的发展中国家的主要关注之一。在以前的会议中，特别强调了非洲国家以及小岛屿发展中国家（SIDS）的脆弱性；但是，由于发展中国家之间就“脆弱性”的定义存在很大的分歧，有关适应问题的案文干脆就没有提及非洲和小岛屿发展中国家。

《坎昆协议》的案文包括了设立“适应委员会”的决定，以“推动按照协调一致的方式落实改进行动”并开始设立新的机构。

还研究了气候变化造成的损失和破坏问题，也就是落实重大气候事件造成的损害的全球保险系统。但是，尽管在 2010 年遇到了严峻的气候事件，但各方未能就该问题达成协议，仅决定就此设立一个工作计划。

发展中国家的核心要求之一即是设立一个针对这些国家适应和减排的全球基金。他们也呼吁在基金的管理委员会中体现发展中国家和发达国家的平等代表性。《坎昆协议》规定设立绿色气候基金。

关于《京都议定书》的第二承诺期（这也是坎昆 COP-16 的重点之一）在坎昆未就此达成任何协议。

关于碳汇的保护问题，气候谈判以两种不同的机制为重点，即 LULUCF 和 REDD。

LULUCF（土地利用、土地利用变化及森林）是一种将发达国家中通过森林“呼吸”（以及潮湿地区其他汇集）吸收二氧化碳考虑在内的机制。随后，在附件 I 国家（工业化国家）减排中考虑吸收水平。

因此，这种机制衡量森林捕捉二氧化碳的自然行为。但是，它是一种可被用来掩藏一个国家排放的极其复杂的工具。根据某些非政府组织的预测，不完善的 LULUCF 规则使得每年“掩藏”约 400Mt 的二氧化碳成为可能（相当于西班牙每年的排放量）。

坎昆谈判并未使代表们就此达成协议。有关规范 LULUCF 的规则的五种不同选项仍在谈判过程中，将在今年继续讨论。

另一种机制称为 REDD+（减少因砍伐和森林退化造成的排放）。REDD+仅涉及发展中国家，特别是那些森林（应理解为湿润森林）覆盖密度大的国家。

REDD 机制是谈判中取得最大成果的问题之一。挪威等一些国家已开始向巴西和印度尼西亚（正在明确寻求快速落实 REDD 机制的国家）提供数十亿美元。应注意到，REDD 本质上是一种旨在避免森林砍伐的森林管理机制。

关于保护碳汇的问题，各方起草了一份冗长且明确的清单，包含在 COP 的决定中。该清单特别考虑了原住民的权益。

关于市场问题，似乎未达成协议。但 COP 决定指出，发达国家在 REDD 框架内提供的支持必须“充足且可预测”。

各方同意设立技术执行委员会，其主要任务是分析并制定技术需求的概览。各方还同意成立“气候技术中心与网络”，协助各国开发并部署现有的技术并确定区域和国家层面的技术需求。

1.4.3.4 德班协议

各国于 2011 年 12 月在（南非）德班召集会议，以便在气候变化方面向国际社会做出响应，同时认识到有必要立即共同设定温室气体的减排目标，以便将全球平均上升温度保持在 2 度以下。

各国政府在德班决定尽快，但不迟于 2015 年通过一项有关气候变化的全球法律协议。将立即在新设立的“特设工作组”的框架下开始此方面的工作。因此，他们决定联合国气候进程必须高要求，重点因素之一即是公布下一份 IPCC 报告。应注意到，下一次 UNFCCC 气候变化大会将于 2012 年 11 月 26 日至 12 月 7 日在卡塔尔举行。

德班的 COP-17 做出了以下重要的决定：

绿色气候基金。设立了一个常设委员会以便监督 UNFCCC 框架内的气候融资问题。该委员会将包括 20 名委员，代表发展中国家和发达国家的人数相等。已经就以长期融资为重点的工作计划达成了一致。

适应。由 16 人组成的适应委员会将向缔约方大会报告其为改进全球适应措施的协调而开展的工作。必须加强最贫穷国家，尤其是最易受到影响国家的适应能力。各国制定的适应规划将使得发展中国家可以评估并降低其易受气候变化影响的脆弱性。最易受到影响的国家将获得更好的保护，以避免与气候变化有关的极端气象事件所带来的损害和破坏。

技术。技术机制将在 2012 年完全投入使用。其执行机构将是气候技术中心与网络。

支持发展中国家的行动。各国政府同意设立登记处，记录发展中国家的缓解行动。

其他重要决定。设立了与气候变化行动和政策意料之外结果有关的论坛并制定了工作计划。根据《京都议定书》的清洁发展机制，各国政府采取了措施，实现碳捕获和存储项目。各国政府同意制定一项新的市场机制，协助发达国家按照《公约》实现其部分目标或承诺。将在 2012 年具体推动该项工作。

1.4.3.5 多哈协议

2012 年在卡塔尔多哈举行的 UNFCCC 气候磋商（COP 18）[21]确定了《京都议定书》第二承诺期的规则。做出了有关透明度、经费、适应性和森林经济（REDD+）的一系列决定。此外，通过了旨在就一项到 2015 年具有法律约束力的新国际气候协议进行磋商的工作计划。将全球平均气温升幅控制在两摄氏度以下这个目标仍是一项严峻挑战[22]。

在德班 COP 17 上，欧盟同意履行《京都议定书》的第二承诺期，但没有时间确定所有规则。在多哈，第二承诺期规则最终获得同意，使其能够进入另一个八年周期（2013 至 2020 年）。尽管加入这一第二承诺期的国家（包括欧盟、澳大利亚、瑞士和挪威）仅“贡献”了 15%的全球排放，这是重要一步，因为它维持着根据 UNFCCC 制定的唯一具有法律约束力的手段。

[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

在新的法律安排下，这些国家将能够从 2013 年 1 月 1 日开始无空当地履行其新的承诺。KP2 同样突显了一种"雄心触发式"要求，它要求 KP2 缔约方到 2014 年（而非 2015 年）再次访问并增加它们的承诺，达到 IPCC 第四份评估报告提出的 25%至 40%减排要求。确实，IPCC 估算，到 2020 年，工业化国家需要减少 25%至 40%的温室气体排放量从而不超过气温平均 2°的提升。该问题将在 2014 年高级别部长级圆桌会议上予以讨论。此外，发展中国家被赋予一定增幅的"收益分享"，这是使用碳市场机制产生的一定比例收益帮助发展中国家满足气候变化适应成本的一种手段。

COP 18 还就两项重要的适应问题做出了决定：国家适应计划和适应委员会。

COP 18 推出了一套新的适应计划措施，通过了一套技术指南以帮助缔约方开发国家适应规划（NAPs）。NAPs 被视为帮助建立适应能力并回应气候变化的长期、灵活且迭代的计划过程。这是根据《国家行动适应计划》（NAPAs）从过去采取的适应计划方式中分离出的一种方式，此种方式短期、高度基于项目且限于为最不发达国家（LDC）缔约方付诸实施。COP 呼吁全球环境基金（GEF）借助现有最不发达国家的资金（LDCF）满足为 LDC 准备 NAP 所需的全部成本。它还要求双边和多边资助方和 GEF 气候变化特别基金帮助非 LDC 发展中国家缔约方开发其 NAP。

COP 18 还通过了适应委员会的一项三年工作计划，该计划代表了为增进公约框架内许多适应磋商派之间的一致性而付出的一项新的重要努力。该委员会还提出了支持 UNFCCC 和公约外部组织的适应活动间协同增效的目标，并且将为缔约方提供技术支持和指南。委员会与 COP 合力举办的一场年度论坛将是改善全球交易与适应学习状况的一项重要载体。

2 气候变化监测

对"地球系统"进行观测是所有科学气候研究的根本且无可争议的基石。如今，依靠极地和对地静止轨道运行卫星的网络并使用地基传感器的全球观测网络，来进行全球气候观测。

2.1 背景

2.1.1 国际电联无线电通信部门

地球观测卫星的使用提供了用于支持科学分析的系统性、同质测量数据。ITU-R 负责为气候监测和灾害预测、检测及救灾行动（包括与世界气象组织（WMO）在遥感应用领域建立合作协议）确定必要的无线电频谱。

ITU-R 通过有关用于环境监测、公众保护和救灾的无线电通信使用的第 646 号（WRC-03）、647 号（WRC-07）、673 号（WRC-07）决议，在环境变化监测中发挥重要作用。无线电通信部门负责空间系统和地球站的具体协调和记录程序，用于气候数据收集和环境监测。

ITU-R 第 7 研究组（特别是 7C 工作组）负责处理称作传感器（有源或无源）的无线电设备，这是用于在全球范围内监测地球及大气地理物质参数的主要工具。包括气候监测数据在内的环境信息目前是通过传感器的测量结果获得的，遥感器对所接收的无线电波的特点进行分析。空间遥感器是唯一可长期、反复、可靠地在全球范围内提供环境数据的工具。

2007 年世界无线电通信大会（WRC-07）通过了一系列有关遥感研究的决议，遥感研究在气候变化科学中占据极其重要的位置。有关"地球观测无线电通信应用的重要性"的第

673 号决议（WRC-12，修订版）源于 WRC-12 议项 8.1 并呼吁 ITU-R 研究可能采取的方法，以提高对地球观测无线电通信应用所发挥的重要作用和其在全球范围内的重要性的认识，以及各主管机构对这些应用使用和收益的认识和理解。这些研究结果汇集成一份 ITU-R RS 报告（见 ITU-R RS.2178 报告：用于地球观测和相关应用的无线电频谱使用的重要作用和其在全球范围内的重要性）。

大多数用于世界气象组织（WMO）全球观测系统（GOS）和全球气候观测系统（GCOS）的数据均由在地球探测卫星、气象辅助业务和气象卫星业务方面工作的无线电通信系统和无线电应用提供。多份 ITU-R 建议书均对这些系统有所描述。特别需要指出的是，7C 工作组已制定了一份关于遥感在气候变化及其影响研究中的使用的建议书（见新的 ITU-R RS.1883 建议书：遥感系统在气候变化及其影响研究中的使用）。ITU-R 第 7 研究组（科学业务）与世界气象组织（WMO）合作制定 WMO 和国际电联无线电频谱用于气象：天气、水和气候监测与预测手册，提供有关开发和正确使用用于环境观测、气候控制、天气预测和自然及人为灾害预测、检测和缓解的无线电通信系统和无线电技术的信息。

在 ITU-R 报告《用于地球观测和相关应用的无线电频谱使用的重要作用和其在全球范围内的重要性》中强调指出，有关气候、气候变化、天气、降水、污染或自然灾害的信息对于全球社会来说是一个至关重要的日常问题。地球观测活动为我们提供这一信息，这是日常天气预报、气候变化研究、环境保护、经济发展（运输、能源、农业、建筑）以及生命和财产安全所必需的信息。此外，值得注意的是，地球表面和大气的空间遥感（无源和有源）在气象研究和操作中发挥必不可缺且日益重要的作用，尤其是在缓解天气和气候相关灾害以及了解、监测、预测气候变化及影响方面。

近期（2012 年），ITU-R 发布了一份名为《支持了解、评估和缓解气候变化影响的无线电技术》报告（仅有英文版）。该报告特别强调了卫星观测的重要性。如以下段落所述，由于其测量的可重复性和均一性，这是了解气候演变不可或缺的一种方法。该报告也建立了与 WRC-12 所做出各项决定的关联。除修订第 673 号决议外，也可忆及，2012 年的 2 无线电通信全会（RA-12）通过了一项名为《利用 ICT/无线电通信技术和系统降低能耗以保护环境并减缓气候变化》的决议，在该决议中，请各 ITU-R 研究组制定有关降低 ICT 系统内部能耗的现行实践的建议书、报告或手册，其间也提及需要监控环境以及监控和预测气候变化的高效系统。该决议的全文复制于附件 8 中。

2.1.2 国际电联电信标准化部门

2012 年迪拜举行的世界电信标准化全会对国际电联电信标准化部门有关信息通信技术、环境和气候的第 73 号决议进行了修订并予以通过，该决议提出以下几点：

– 决定促进 ICT 用作评估并减少温室气体排放，优化能源和水消耗，最小化电子垃圾并改善其管理的跨领域工具；

– 支持有关（特别是有关）绿色数据中心、智能建筑、绿色 ICT 采购、云计算、能效、智能运输、智能物流、智能电网、水管理、气候变化适应与防灾准备以及温室气体减排的研究；

– 鼓励内部和外部协作以推进环境全球议程。

国际电联电信标准化部门制定了一个新的有关电子垃圾的第 79 号决议，在 2012 年迪拜世界电信标准化全会上获得通过，该决议敦促国际电联电信标准化部门：

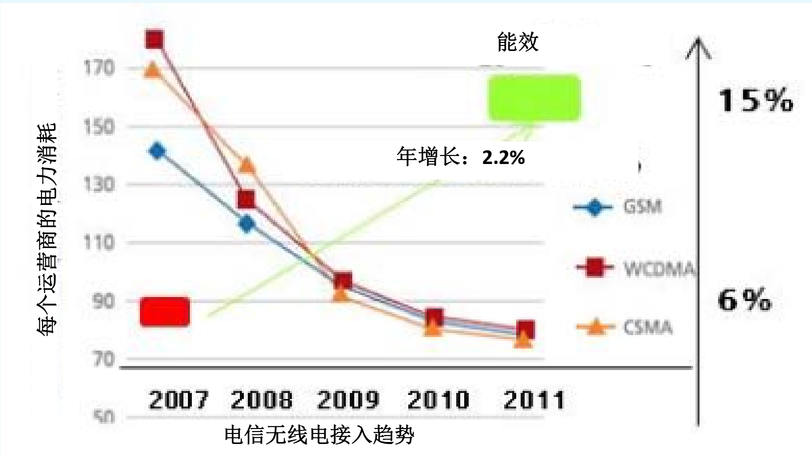
– 致力于缓解电子垃圾对环境和健康的负面影响；

– 致力于开展并加强有关处理和控制 ICT 设备电子垃圾的国际电联活动以及处理该问题的方式：

- 为政策制定者通过最佳做法、建议书、方法和其它出版物及指南；
- 协助发展中国家，这些国家是受电子垃圾侵害最深却应付责任最小的国家；
- 与所有相关利益攸关方写作。

在电信设备的能效指标和测量方面，国际电联电信标准化部门制定了 ITU-T L.1310 号建议书：该建议书包含评估电信设备能效所需的能效指标、相关测试程序、方法和测量文件。它包括有线和无线宽带接入；光传输技术；路由器；交换机；移动核心网络设备以及用于家庭和小企业的工作设备。通过对比信息通信技术性能（有效功）与其能耗，来用这些指标评估信息通信技术设备的能效。

图 3：未来放射粒子系统的电力消耗



在方法方面，国际电联电信标准化部门制定了一套评估信息通信技术碳足迹的通用方法。没有此类方法，将无法提供有意义的对比，而且它有助于确立生产或使用绿色产品的商业案例。

一项有关信息通信技术设备电力供应的节能意识调查报告了对一系列商业可用外部电源（超过 300 个已查实设备和 200 多个用电测量的设备）进行广泛分析的结果以协助在国际电联电信标准化部门第 5 研究组（SG5）范围内开展标准化活动（ITU-T L.1001 建议书）。已评估了机械、电气和环境特征；也已经建立了相关性并形成了统计数据。

国际电联电信标准化部门还制定了一份有关通过智能电网提高能效的报告：该报告着眼于能效，终极目标是减缓气候变化而讨论了信息通信技术在智能电网中的作用。最后，国际电联电信标准化部门也正在制定有关设备使用寿命的手册。

2.2 遥感：用于监测气候变化的手段

2.2.1 卫星有源和无源遥感

卫星系统非常有效，因其提供了海洋盐度、土壤湿度、大气各层温度、海洋温度、平均海平面等各种地球物理学参数一系列可重复的精确且可靠的测量。例如，空间和气象机构（CNES、NASA、NOAA、EUMETSAT、ESA、ISRO、JAXA 等）在卫星地球观测项目（Jason、SMOS、Megha-tropique 等）中协同合作。所有这些卫星系统提供了各种对于研究气候变化而言非常重要的指标，且处于完全工作状态，它们提供的数据不断被空间和气象机构的专家用于研究和分析。

卫星测高旨在观测平均海平面的演变，监测地球表面的总冰量。通过储存、比较所有测高任务得出的数据，科学家可以跟踪、解释并预计与全球变暖相关的一系列影响。平均海平面是指针对所有海洋海平面高度所取的平均值，作为参考值使用。然而，目前已观测到了区域性差异，建议参考[23] 进一步的细节和解释（参见 §2.2.2）。

2.2.2 一个实例：监测海平面上升

海平面在一定时间和空间范围内发生变化。海洋的总体积可随着海洋质量（包括从陆地进入海洋的水）的变化或者海水因变暖/冷却而扩张/收缩而变化。

此外，海洋并不像“浴缸”一样 – 即，海平面不随着海水增加或流失而均匀变化。即使全球总体平均海平面正在上升，也仍有大片海域的海平面下降。显然，必须有上升趋势高于平均值的海域，以平衡上升趋势低于平均值的海域。

目前全球海平面上升速度为 3 毫米/年，而热膨胀速度仅为一半左右。这一速度已从 20 世纪后半叶的大约 0.5 毫米/年增加到了过去 12 至 14 年间的大约 1.6 毫米/年。这一速度预计至少在下一个世纪将继续保持这一水平，也可能由于温室气体引起的大气和海洋变暖变得更高。海洋表面温度增加 0.1°C，则海平面上升 1 厘米。因此，目前比 1900 年的温度高 0.6°C，即海平面上升了 6 厘米。

由于可用于估算长期上升速度的海洋温度数据过去分散（尤其是在过去），因此很难可靠地估算出 20 世纪大部分时间内的上升速度。

近期海平面上升的主要诱因之一是格陵兰岛（表面融化和冰山崩解）和南极冰盖的冰川融化。有人认为，当前全球海平面每年上升 3 毫米，其中约有三分之一甚至更多是由上述两种原因产生的。目前对于冰盖的影响知之甚少，是一个十分活跃的研究领域。仅格陵兰冰盖的融化就可能使全球平均海平面升高大约 7 米。冰川融化可能需要大约 1000 年的时间，但格陵兰岛的冰川融化仍可在未来 50-100 年内对海平面上升造成极大影响。

全球平均海平面是气候变化最重要的指标之一。它反映出气候系统多个不同成分的变化。精确地监测平均海平面的变化（特别是通过使用测高卫星），不仅对于了解气候，而且对于了解海平面上升引发的社会经济后果具有至关重要的意义。

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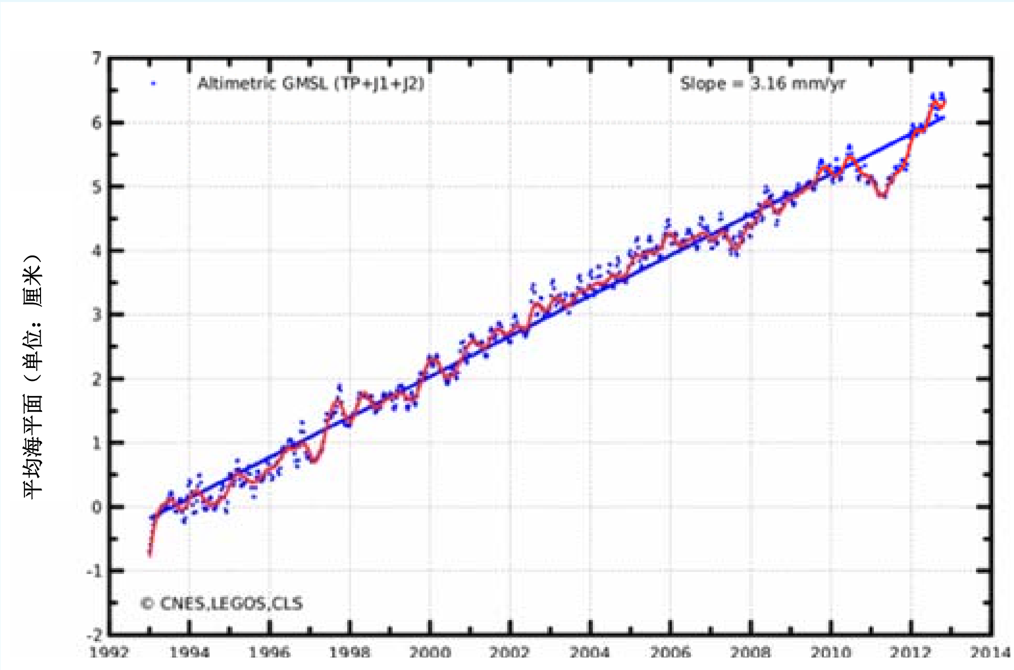
[23] http://www.aviso.oceanobs.com/en/applications/ocean.html

在二十世纪，通过分布于某些陆地海岸和众多岛屿的检潮仪测量海平面高度。对得到的数据进行分析显示，在上个世纪，海平面每年平均升高幅度为 1.7 毫米。自 1993 年 1 月以来，通过卫星测高任务来持续计算全球平均海平面（GMSL）值。通过精确确定已发射的卫星之间存在的偏置，已为协调这些卫星（Topex/Poseidon--Jason-1、Jason-2 以及 Envisat、ERS-1 和 ERS-2 等其它任务）执行了准确核实[24]以此计算高纬度地区的平均海平面（高于北纬和南纬 66 度），并通过将所有这些任务结合一起来提高空间分辨力。使用卫星测高进行海平面测量具有实现一种“绝对”测量的优势，这一测量不依赖于地壳运动，不像检潮仪，后者根据地面来测量海平面。

图 4：测高的全球平均海平面

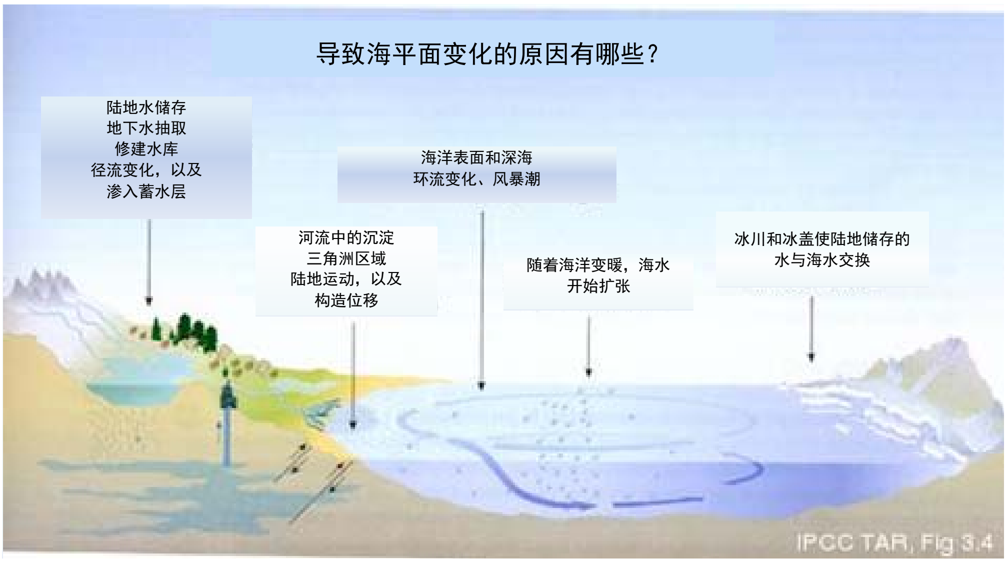


斜率显示每年的平均增长为 3.16 毫米，每年不定的部分为 0.5 毫米。应注意到，在过去的二十年中，海平面的上升幅度并不一致，某些地区（如西太平洋地区）的上升速度要比全球平均上升速度快 3 倍。

下图显示了造成海平面上升的主要物理现象。

[24] http://www.aviso.oceanobs.com/en/news/ocean-indicators/mean-sea-level/

图5：造成海平面上升的主要物理现象



借助于浮标上设置的传感器，人们发现海洋已显著变暖，特别是自上个世纪 70 年代以来。在 1993-2003 年期间，热量扩张（2003 年以来略有减速）说明了为何观测到的海平面上升了 50%（与较冷的海洋相比，较暖的海洋容量更大）。平均而言，在 1993-2010 年期间，它在造成观测到海平面上升的因素中占三分之一，相当于每年约 1 毫米。

此外，人们也知道，变暖在地理上并非是均一的，在某些地区，盐度也通过相关的密度变化影响到变暖。大陆冰块发挥的作用举足轻重，据估计，在 1993-2010 年期间，山地冰川的融化也占了海平面上升的三分之一。1993-2010 年期间，极地冰盖（格陵兰、南极）融化对海平面上升的影响约在 25%左右。就内陆水而言，测量（特别是通过 GRACE 卫星进行的测量）显示，其对近年来海平面上升的影响不到 5%。

2.2.3 地面、空基和其它系统

空基系统主要用于测试未来卫星将要搭载的有效载荷的原型，以便验证未来的工作系统，同时铭记气候变化分析需要持续的可靠、可重复且相互兼容的测量。

也采用了地面（固定和移动）系统，因为它们可补偿卫星无法进行的测量。此外，它们在校准从采用卫星方式获得的数据时非常重要。

海底电缆系统非常有用，因为卫星只能在海面，而不是海中测量海洋盐度。还需采用其他设施来获取这些无法通过卫星获取的地球物理参数。

专家们采用的物理模型不断通过地面和卫星测量进行更新—这种现象称为“仿真”，其中通过地面传感器获得的数据用卫星数据补充。但是，需要与模型进行比对，以验证所获得数据的数值范围，同时铭记，由于不正确的测量或干扰，某些情况下获得的数据是不正确的。在这些情况下，由于模型的存在，可剔除这些错误的测量。

3 信息通信技术

3.1 信息通信技术的定义及其作用

信息通信技术（ICT）涵盖一系列相关技术，包括计算机、电视、电话和充电器、上网盒、服务器和数据中心。来自欧盟委员会的一份文件（DG INFSO）提供了一个可能与 Q24/2 相关的工作定义[25]。

ITU-D 目前正在尝试对 ICT 做出可接受的定义。目前正在使用的定义如下："处理（如，获取、创建、收集、存储、传输、接收、传播）信息和通信的技术及设备"。

需要指出的是，这一定义尚在初步阶段，因为还没有经过理事会正式批准，而且可能有待进一步完善。

尽管很难从实际角度详尽地列出 ICT 对抗击和监测这些巨大气候变化的全部贡献，ICT 在以下领域内发挥有益作用：远程办公和远程会议、交通使用和日常通勤优化、电子贸易、行政程序的计算机化、尽量降低建筑能耗。ICT 可提供众多机遇，以满足降低能耗的宏伟目标。

尽管 ICT 本身需要消耗能源，但同时也为促进全球层面的环境研究、规划和行动提供诸多机遇。这其中包括监测、保护环境以及适应和缓解气候变化。重要的是要了解如何最佳地采用 ICT，以此尽量降低对于环境的影响。在课题中讨论了如下问题："阐述有关实施该课题的方法，特别要采集当前为降低总体全球温室气体（GHG）排放所采取的最佳做法方面的证据和信息，并考虑到 ITU-T 和 ITU-R 在此方面取得的进展。"第 24/2 号课题是基于世界电信发展大会（2010 年海德拉巴）通过的第 66 号决议 –"信息通信技术和气候变化"提出的，其中强调了 ICT 的使用和收益。

除此之外，在过去 20 年间，ICT 亦对许多工业部门的经济增长做出了贡献。就一般意义的经济和社会而言，ICT 在医疗、安全、培训和社会融合方面发挥着特别重要的作用。

根据其有关无线电频谱政策项目的最新意见，欧盟无线电频谱政策组（RSPG）明确表示，欧盟频谱政策的关键目标之一是提高欧洲公民的生活质量；对频谱技术的高效使用亦可激励其它行业的减碳工作；ICT 行业可借助于更加环保的 ICT 技术来降低自身温室气体排放；在农村和边远地区，基础设施和网络共享可降低环境影响。

3.2 全球 ICT 足迹

有关温室气体（GHG）排放的准确、一致和具有国际可比性的数据对于国际社会可采取最适宜的行动来缓解气候变化的影响，并最终实现国际电联《公约》所述目标是至关重要的。就减少排放和适应气候变化的负面影响的最有效方式交流相关信息，亦可促进世界范围的可持续发展。

世界范围内由"社交网络"联系着的新一代继续推动对 ICT 硬件、软件和服务的前所未有的全球需求，并以移动和即时的方式获取信息。

[25] 信息通信技术对能效的影响，最后报告，2008 年 9 月（见第 1.1.3 节的 ICT 工作定义）

为帮助而非阻碍抗击气候变化的工作，ICT 行业须约束其自身不断增长的影响，并继续减少数据中心、电信网络以及制造和使用 ICT 产品产生的排放。

早在 2008 年，信息通信技术行业就已产生了超过 27000 亿欧元的交易额，占全球 GDP 的 6.5%。有观点认为，ICT 行业这一新形式经济组织结构的潜在动力（亦被一些人称为“第四经济”），将在今后的 10 年内占到全球经济总额的 20%。这一想法并非毫无根据。一些专家认为，包括无线电应用在内的 ICT 设备（电视和收音机、视频和 DVD 播放器及录像机、地面和卫星机顶盒等）和系统产生的碳足迹明显高于 2-2.5%（即略低于 10 亿吨二氧化碳当量）。例如，欧盟委员会在向欧洲议会提交的报告中称：“信息通信技术（ICT）目前已渗入欧洲经济的方方面面。ICT 行业自身的成功使得 ICT 产品和服务的使用约占欧洲电力消耗的 7.8%，可能在 2020 年前增长至 10.5%。”

这其中主要部分（40%）是个人电脑和数据监视器的能源需求，另有 23%的排放量来自数据中心。固定和移动电信占总排放量的 24%左右。由于 ICT 行业的增长高于其它经济部门，这一份额将随时间的推移而扩大。但是，ICT 有能力帮助寻求一项解决方案，减少产自其它经济部门的其余 97.5%的全球排放量。

因此，根据这些条件，其余的 97.5%构成了实现温室气体减排这一基本目标的巨大机遇。

ITU-D 认为，适应措施是 ICT 可协助缓解气候变化影响的重要领域之一。信息通信技术的一项关键作用在于，通过减少温室气体（GHG）排放应对气候变暖且尽管其普及使用加剧了全球变暖，（我们只要想想家庭和办公室里每夜从不彻底关闭的数以亿计的电脑和十亿多台电视机即可），但 ICT 也可以成为解决方案的主力，因为它们可以发挥监测气候变化的作用，并适应和缓解其影响。

在法国，ICT 目前电力消耗超过了 13%，如保持当前速率，则这一比例在未来几年内甚至可能接近 20%。

无论如何，ICT 的使用将继续得到普及，因此该行业有必要采取措施，立即限制并最终削减其碳排放。

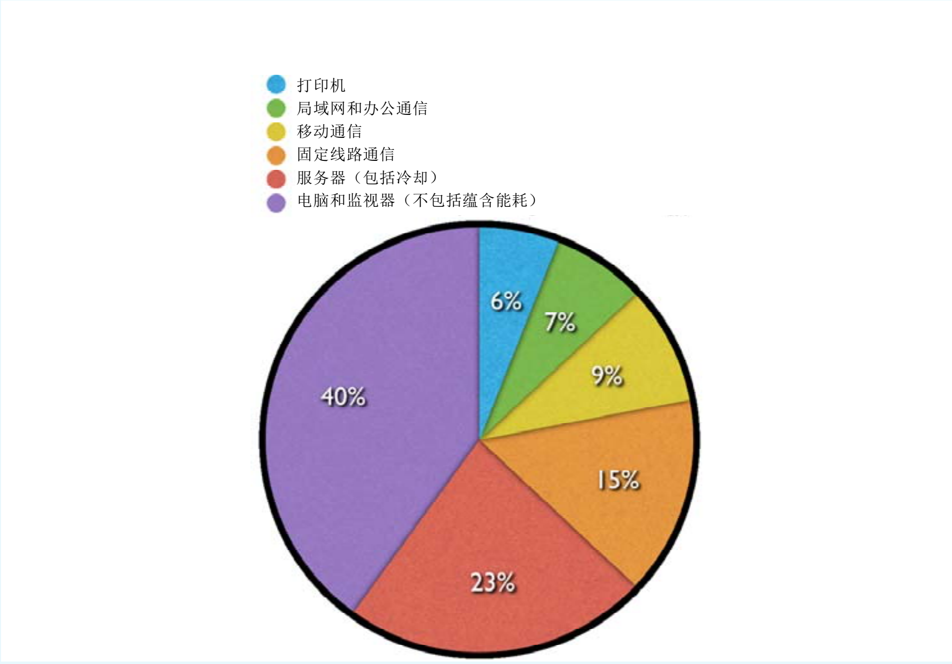
应注意到，ICT 通过多种方式导致了全球变暖，其中包括：

- ICT 用户的快速增长（如，移动电话用户数量从 1996 年的 1.45 亿增至 2007 年 8 月的逾 30 亿，并预计将于 2008 年年底达到 40 亿）。
- 许多 ICT 用户目前是一人多机。
- 不断提高的处理能力和传输能力（例如，第三代（3G）移动电话的工作频率更高，因而比 2G 电话的耗电量更大）。
- 用户倾向于保持他们的设备随时开机并储存而非删除旧数据。

下图[26]显示全球范围内各种类型 ICT 产生的 CO_2 排放的估计分布情况。

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

图 6：估计的ICT全球二氧化碳排放



节能计算是智能数字电子产品的核心特征。我们与这样一个世界密切接触，在这里这些芯片可以测量、管理和控制一系列产品的环境性能，从而改善我们日常使用的一些产品（包括计算机服务器和移动电话）的性能并减少其碳足迹。此项技术还可应用于不同工业部门，如运输、能源和基础设施。它可以帮助减少 ICT 基础设施自身的碳足迹。

当前对这一趋势新出现问题的研究包括 Carbon Trust[27]机构开展的工作，该机构正在开展降低全球能耗以及发挥新电脑系统碳减排潜力的研究。从遥感和监测中获得的效能有助于减少环境影响。日常办公室活动的技术案例包括借助传感器在无人时关闭电灯、提高空调和电梯发动机的效率或实现计算机远程控制从而确保夜晚关机。智能电器和智能网络可在这一过程中发挥作用，而且可以提供能效更高的处理方式，从而带给我们所有人一个更可持续的未来。

能效和低成本也将是研发下一代电脑系统的两项关键要素。这些要素将有助于提供价格可承受的、高效、可持续的技术，从而帮助弥合数字鸿沟。

3.3 利用 ICT 降低温室气体排放

在全球电子可持续发展推进协会（GeSI）— 推动促进可持续发展和增长的 ICT 和各种做法的国际协会在其 SMARTer 2020[28] 报告中强调了减少温室气体排放的新技术的潜在效益。ICT 的碳排放可在很大程度上被应用于非物质化（借助电子通信、无纸电子发票等手段代替

[27] http://www.carbontrust.com/

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

差旅）、改善的运输效率、工业、农业、网络和所谓智能建筑上的新技术的大规模开发所抵消。

认识到 ICT 部门到 2011 年将消耗总量达 9.1 亿吨的二氧化碳而且预计到 2020 年这些成本将达到 12.7 亿吨二氧化碳，ICT 将能够实现相当于 7 倍自身碳足迹（来自制造、IT 基础设施和使用）的减排，或者一直到 2020 年达到 91 亿吨二氧化碳以及温室气体排放总量的 16.5%。按部门分这些减排量分解到如下部门：

– 交通运输：20 亿吨二氧化碳

– 能源：17 亿吨二氧化碳

– 建筑：16 亿吨二氧化碳

– 农业：16 亿吨二氧化碳

– 工业：15 亿吨二氧化碳

– 服务业：7 亿吨二氧化碳

可以看到，最大的减排将影响交通运输（目前，交通占二氧化碳排放量的 25%）。

这对于 ICT 部门而言也是增长机会并且为全球经济带来好处，GeSi 还用 2020 年世界范围内的某些关键预估值衡量了这种做法带来的各情况：

– 创造的工作岗位数：29 500 000

– 产生的节约：19 000 亿美元

ICT 赋能应用已经展现出提高效率与节约成本间的有力关联，这造成温室气体排放的总体净减少。这些是鼓励政府部门和私营部门在众多应用和服务中引入不断增加的 ICT 使用的关键激励因素。

实现能效节约过程中政府的核心作用通过形成“以身作则”倡议的领导能力得到充分展现。政府部门倾向于成为最大的“房东”、“旗舰”和商品与服务购买者，因而首先提供实现温室气体减排的最大机会。C2ES[29]开展的研究提供了描述使用 ICT 解决方案降低能耗的大量案例研究。几项研究预计，如果得到广泛实施则有可能实现全美经济能耗降低 12-22%（如前文所释，GeSi 团体提出了总体估计 16.5%的减排因素）。一些研究讨论了云计算和数据中心整合、使用新工具推进可持续性和效率的舰队管理以及对新建筑技术的测试等问题。

宽带加强了大量其他技术的发展，所有这些技术都为我们提供改变我们生活方式，实现低碳经济的机会。因此，宽带的更大范围部署对于 ICT 赋能解决方案发挥催化剂作用至关重要。技术部门拥有虚拟化的独特能力。虚拟化一直被描述为通过技术的应用实现物理过程的脱物质化。虚拟化的好处在于传统、高冲击力和高能量过程被低冲击力、低碳技术所取代。物理过程的虚拟替代（或代理）通常使用少得多的能量（一般好几个数量级）但仍使人们能够实现同样的目的。

[29] 榜样式领导：使用信息通信技术实现联邦可持续目标 - http://www.c2es.org/publications/leading-by-example-federal-sustainability-and-ict

诸如宽带等一些虚拟化技术一向非常成功而且现在已经如此普遍以致它们已经改变了根本行为并催生了新的商业模式。

差旅替代技术是被引用的最重要的虚拟化应用之一。考虑到交通在发达国家造成了 25% 的二氧化碳排放，这并不令人惊讶。在差旅过程中支持视频会议是降低温室气体排放的一个显著例子。

2004 年建筑中的能源使用[30]约占英国 15000 万吨二氧化碳排放量的一半，而且用于加热、照明和居家的能源在英国占到产生上述碳排量能源的超过一半。英国政府在这一方面正处于领先地位。

除实施《建筑能效指令》外（该指令要求所有公有建筑物显示实际的能源使用），正在建设的所有新居住房屋将遵守低碳和零碳标准。目标是培育有助于压低现有建筑群排放的技术和创新。政府正引入经济刺激与监管控制的“组合拳”来帮助实现这一点而且目标是成为为交付零碳房屋设定时间表的首个国家。

有一定范围的 ICT 和相关技术在通过智能建筑技术应用实现这些目标过程中发挥重要作用。这些包括建筑和能源管理系统、计量技术、环境传感器、照明控制系统、能源审计和优化软件以及通信网络。

附件 8 提供了关于利用 ICT/无线电通信技术和系统降低能耗以保护环境并减缓气候变化的 ITU-R 第 60 号决议的案文。

3.4 管理电信网络的能耗

直到最近，在服务欠缺地点建立无线网络一直是一种成本高昂的方法，通常需要柴油发电机供电的基站，维护成本高且增加了网络的碳足迹。部署新无线基站或改装现有的基站可利用混合式发电机组电池系统、太阳能系统或太阳能-风能混合式系统等高效备选电源硬件的配置。除此以外，还可通过改变点对点电力监控和管理系统优化为全球电信网络提供电力所需的能源总量。这些新的电信部署发展趋势在发展中国家尤其重要，因为它们综合了社会、经济和环境目标。附件 5 和附件 6（案例研究 1）提供了电信网络恶劣电网（poor-grid）和离网（off-grid）配置、备选能源使用和全球能源优化等具体问题的详情。

3.5 回弹效应

回弹效应意味着对改进能效做法的干预通常导致能耗增加而非减少。

在经济和节能领域内广为人知的回弹效应的影响需予以考虑。这通常是指在引入新技术或采取其它措施降低资源使用时，产生的效果往往抵消新技术或其它措施的效益。尽管有关回弹效应的文献通常关注能耗方面的技术改进，但这一理论同样适用于自然资源的使用。

[30] 高科技：低碳：追踪气候变化的技术的地位- http://www.greenbiz.com/sites/default/files/document/CustomO16C45F97277.pdf

回弹效应[31]是指提高效率、降低消费者成本的行为导致的消费增长。它是经济学基本原理“需求定律”的引申，其中指出，如果价格（消费者感知的费用）下降，则消费通常会增加。降低消费者成本的项目或技术往往会增加消费。但这并不意味着回弹效应消除了效率增益所获得的好处。回弹效应产生后通常会出现能源节省或净拥塞减少的情况。此外，消费者可直接受益于效率提高或更好的技术。但是，回弹效应可明显改变某一特定政策或项目产生的收益性质。因此，为确保准确对相关政策或项目做出评估，重要的是说明产生回弹效应的原因。

一些减少温室气体的策略[32]可能具有回弹效应。长远看，排放会低于预估值。因而，导致改进燃料效率的测量在第一步减少排放。例如，对交通部门而言，更高能效降低每公里成本，这通常造成流动性需求的激增。出行的公里数的增加使碳排放的部分减少没有效果。建模回弹效应的最佳做法的问题是减少温室气体排放的任何建模策略的核心问题。

总体而言，该理论是一个也可适用于任何自然资源使用的有趣理论。尽管各主管部门尚未研究技术改进对能耗的影响，但他们可能会发现，为了改进准确度，可能需要在评估某个政策或决定草案时考虑这种理论。附件 9 陈述了全球电子可持续发展推进协会（GESI）[33]题为“评估 ICT 的碳减少影响”报告中发现的主要结论。

– 例如，法国电力公司（EDF）研究部未发表的研究[34]显示，当价格下降时，低收入家庭有可能提高他们家的温度。通常，当一件商品或一项服务变得更廉价时，毫无疑问他们倾向于消费更多数量。最终，从绿色技术中预期得到的生态效益有所减少，甚或在某些情况下变为负面效益。使用几种方式直接测量回弹效应。例如，在电力方面，如果由于费率降低 10%而造成消费增加 2%，那么回弹效应相当于电力消耗所产生排放的 20%。在交通领域，技术创新趋于增加里程数并增加总体燃油消耗（据估算，在 United Estates 公司这一消耗约为 20 至 30%）。

– 第二种类型的回弹效应是间接的。不像前一种情况，消费者相信已经达成了一种令人满意的服务消费水平，服务价格已经变得更低了。但是，他将花掉省下的钱，这将增加社会上的物资流转。

– 最后，ICT 的扩散形成了第三种类型的有效回弹。当使用资源方式的效率提高时，这一资源的成本就降低，从而推动开展集约利用这一既定资源的社会经济活动。

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

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

33 http://www.GeSI.org

34 “节约更多为了污染更多 - 看法”115,《外交界》杂志，2011 年 2 月-3 月期

4 适应气候变化和削减措施的影响

4.1 背景

人们将不得不一如既往地适应天气变化。适应气候变化的困难之一是我们必须准备多重影响。此外，适应和减排是密不可分的，因为它们使用相同的行动方式。

Stern review 报告旨在对气候变化经济学进行最全面阐释。它旨在检查缓解行动的成本和收益以及未来技术发展的潜在成本。结论是气候变化对全球经济构成独特挑战，但收益巨大，早期的行动变化轻易地超过了成本。有关气候变化的早期行动在经济学上是正当的，用来支持缓解，包括技术解决方案（可再生能源、断续的森林毁损、降低成本和能耗的替代或创新手段的使用……）。

STERN 报告[35]阐述如下：

> “使用正式经济模型得出的结果，此次检查估算如果我们不采取行动，现在直到永远总成本和气候变化的风险将相当于每年损失至少 5% 的全球。如果考虑更广范围的风险和影响，对损失的估算值可能提高到 GDP 的 20%或更多。与此相反，行动成本 — 降低温室气体排放以避免气候变化的最坏影响 — 可被限制在每年约占全球 GDP 的 1%。
>
> 未来 10 至 20 年出现的投资将对本世纪后半叶和下世纪的气候产生深刻影响。目前和未来几十年我们的行动可能产生对经济和社会活动构成重大破坏的风险，风险量级与 20 世纪上半叶世界大战和经济萧条引发的风险量级相当。而且将难以或无法扭转这些变化。
>
> 所以及时和强有力的行动显然是必要的。因为气候变化是一个全球问题，对其作出的回应必须是国际性的。它必须建立在有关长期目标的共同愿景并就未来十年加快行动的框架达成一致基础上，而且它必须依靠国家、区域和国际层面的相互加强方式得以建立。
>
> 如果不采取减少排放的行动，大气中温室气体的浓度可能最早在 2035 年达到前工业化水平的两倍，事实上使全球平均气温上升超过 2°C。长期来看，气温升幅超过 5°C 的机会超过 50%。实际上这一上升将是非常危险的；它相当于从末次冰期到今天平均气温的变化。世界自然地理学的此类剧变必然导致人文地理 — 人们生活之处以及人们的生活方式的重大变化”

上升 4°C 的影响在一份报告[36]中得到了全面阐释，该报告指出：

> “本报告阐明了如果地球升温 4 摄氏度，那么世界将变成何种模样，这是科学家们在本世纪末几乎一致预测到的情形，没有重大政策变化。4°C 情境是毁灭性

35 斯特恩评论（Stern Review）：气候变化经济学

36 降低热度：为何升温 4°C 的世界必须加以避免，2012 年国际重建和发展银行/世界银行

> 的：沿海城市洪水泛滥；粮食生产风险增强有可能导致更高的营养不良率；许多干旱区域变得更干旱，湿润区域更湿润；前所未有的热浪席卷许多区域，特别是热带；许多区域的水荒大大加剧；高强度热带气旋的发生频率提高；以及包括珊瑚礁系统在内的生物多样性的不可逆转损失。
>
> 而且最重要的是，4°C 的世界与当前的世界如此不同以致 前者带来了高度不确定性和新风险，威胁着我们预测和规划未来适应需求的能力。缺少应对气候变化的行动不仅有可能使发展中各国的数百万人“够”不到繁荣兴旺的生活，而且存在数十年可持续发展进程倒退的风险。
>
> 显然，我们已经相当了解我们面临的威胁。科学明确指出，人类是全球变暖的原因，而且已经开始对重大变化进行观测：全球平均变暖幅度是较前工业化水平高出 0.8°；海洋温度自 1950 年代以来升温 0.09°C 而且正在酸化；海平面自前工业化时代升高了近 20 cm 而且正在以每十年 3.2 cm 的速度上升；近十年来出现了异常多的极热浪；粮食主产区正日益遭受干旱影响。”

缓解和适应并不相互排斥。气候变化是需要采取全球集体行动的一个全球性问题。温室气体从哪里排放到大气中并没有任何差别。适应不仅事关政府行动。重要范围仍是人们为自己采取行动并负责做好应对气候变化影响的准备。

4.2 ICT 和适应性措施

适应性包括：

– 通过旨在将 ICT 综合到灾害管理战略（包括确定当地易受气候变化影响的薄弱之处）的政策，以确保有效地向居住在易受影响区域的人们发送告警讯息，同时本着透明和行使与划拨用于适应气候变化和灾害管理的资源有关的职能，鼓励采用 ICT；

– 在国际标准基础上，通过政策和措施，提供监管激励，旨在使各国和公共实体做出承诺并鼓励私营部门和消费者将其温室气体排放和能耗降低到最低水平并最合理地利用可再生能源（包括通过使用 ICT）；

– 推广通过智能电网将能耗的生态影响降低到最低限度的措施（见附件 7）。

附件 6 提供了加纳国有关气候变化适应和减少的案例研究。

4.3 ICT 设备的使用寿命、循环使用和电子废弃物

电子废弃物对环境构成重大威胁。例如，一台计算机显示器可能包含达到其重量 6%的铅。全球每年产生的电子产品有 1400 万吨，其中只有 20%得到了充分的回收和处理。电子和电气设备（电视机、计算机等）含有铜铁等大量的可回收金属以及铅、水银、锌、砷和镉等重金属。所有这些金属最终都将出现在城市垃圾中。但是，高浓度的重金属使得城市固体垃圾焚烧炉的运作以及燃烧残留物的处理和回收变得复杂。电子和电气产品中大量的可回收金属在焚烧过程中流失，或只能付出高昂的成本才能回收。

也应注意到，2011 年全球生产的电子和电气产品包含了约 320 吨的黄金（相当于这种金属全球产量的 7.7%）以及 7500 吨的白银。但是，根据联合国大学（UNU）发表的预测，这些数量中只有不到 15%将得到回收。关注黄金和白银等贵重资源的浪费非常重要。2011 年

全世界生产的计算机、移动电话、平板电脑和其他电子设备包含了价值约 130 亿欧元的黄金以及价值 40 亿欧元的白银，更不用说钴和钯。

这些金属回收水平低的原因在于两种截然相反的现象：工业化国家具备进行此类回收所需的先进技术，但电子和电气废弃设备（WEEE）回收率相对较低，而在发展中国家，由于非正式回收行业的存在，该比率很高（约在 80-90%），但更倾向于回收铜、铝和钢等易于提取的金属。在绝大多数情况下，其对环境和从事该行业人员的健康带来了灾难性的影响。

例如，在法国，每个居民每年收集 8 公斤左右的 WEEE。但是，尽管该表现水平被视为很高，但其在估计的总量中只占到三分之一到二分之一。UNU 认为，改进 WEEE 中所含贵重金属的回收比率，需要相关的每个人认识到此类废弃物的价值。

总的来说，显然 WEEE 可视为一种机遇，而不是一个负担，且废弃物管理的提法应改为资源管理。

寿命末期电子和电气设备的分开收集以及对环境无害的处理减少了重金属进入未分拣的城市垃圾。铁、铜和其他金属得到回收。有问题的部件（水银开关、PCB 电容器等）被单独分解和处理。不可回收的有机化学废弃物（如混合塑料）可适当地予以焚烧。

降低 ICT 造成的污染应成为各主管部门关注的重点。

本着这种精神，多个主管部门制定了“绿色 ICT”战略，以应对以下挑战：

- 开发优化能源和资源消耗的技术方法以及用于替代的智能技术或可能方案。
- 将可持续做法的开发整合到日常活动中去（见瑞士文件）
- 在 ICT 领域提高资源效率。
- 鼓励交易商回收处理电子和电气产品。
- 确保在将由“测量用于发展的 ICT 伙伴关系”所定义指标的协助下，系统具有衡量 WEEE 数量的足够能力。
- 在 ICT 设计阶段，鼓励采用一种有助于实现更长寿命期的方法（生态设计），以便减少 WEEE 的数量并鼓励对其进行回收的项目。

4.4 世界贸易组织采取的行动

WTO（世界贸易组织）在贸易和环境委员会（CTE）框架内采取环境相关活动，这是为与气候变化相关的情况负责。

我们可以注意到 1998 年环境数据库的设立，自设立之日期就对其进行了日常更新。1994 年，《马拉喀什建立世界贸易组织协定》成员国在可持续发展与受管制贸易自由化之间建立一个清晰联系。为了确保市场开放与环境和社会目标齐头并进，《贸易与环境部长级决定》设立了 CTE，它给予其以下授权：

– 确定贸易措施与环境措施之间的关系，从而推动可持续发展；
– 做出有关是否需要对多边贸易系统条款进行任何修改的适当建议，与系统的开放、公平和非歧视性质兼容。

根据其广泛授权，CTE 已经推动确定并理解贸易措施与环境措施间的关系从而促进可持续发展。

CTE 的工作项目如下：

项目 1 和项目 5：贸易规则、环境协定和争论

包含在多边环境协定（MEAs）中的多边贸易系统规则与贸易措施之间及其争议解决机制之间的关系。

项目 2：环境保护和贸易系统

具有重要贸易影响的贸易和环境措施相关环境政策与多边贸易系统的条款之间的关系。

项目 3：税收和其它环境要求如何适应

多边贸易系统条款与环境目的费用和税收以及产品的相关环境目的需求（如标准和技术规则以及包装、标签和循环要求）之间的关系。

项目 4：环境贸易措施的透明度

涉及用于环境目的的贸易措施的透明度的多边贸易系统的条款。于 1998 年设立了环境数据库（EDB）（文件 WT/CTE/EDB/*和文件 WT/CTE/W/46、77、118、143 和 195），用于世贸组织秘书处每年编纂和更新所有政府已经通报 WTO 或已在贸易政策回顾中标注出的环境相关措施。

项目 6：环境和贸易自由化

环境措施如何影响市场准入，特别是与发展中国家和最不发达国家相关的市场准入，以及去除贸易限制和扭曲的环境效益。

项目 7：国内禁运品

国内禁运品（DPG），特别是有害垃圾的出口问题。

项目 8：知识产权

《与贸易有关的知识产权（TRIPS）协定》的相关条款。

项目 9：服务

《服务和环境贸易决定》设计的工作项目。

项目 10：WTO 和其它组织

WTO 相关机构有关与政府间及非政府组织（NGOs）关系的适当安排的输入意见。

WTO 区域贸易和环境研讨会可供发展中国家和转型经济体参会。秘书处自 1998 年开始组织这类研讨会。

目标是提高对贸易、环境和可持续发展间联系的认识，以强化贸易和环境政策制定者间的对话，并促进既定区域成员间的数据交换。

5 问卷调查：分析与建议

5.1 调查问卷中包含的问题

附件 3 包含完整问卷。

5.2 对所收到响应的分析与总结

附件本部分包含的信息由主管部门提供。在国际电联 193 个成员国中，共收回 66 份妥填的调查问卷，其中 50 由主管部门提供。

Q1 贵国政府（或公司）是否有针对气候变化的政策？

大多数国家（70%）表示他们有环境变化政策。给出的以下例子说明了主管部门使用 ICT 应对气候变化的方式：

- 一些主管部门在持续基础上使用诸如卫星等现代技术手段监控气候变化。
- 除使用对气候监测至关重要的那些 ICT 外，在气候变化背景下对 ICT 的使用本质上包括以下三类：

  1 适应气候变化的 ICT 应用。

  2 减轻气候变化影响的 ICT 应用：优先使用电子媒体（节省差旅和打印文件开支的电子邮件、电话、互联网、视频会议）

  3 可持续 ICT 部门的发展（绿色经济）：ICT 循环（设备和附件）、低功率设备。

一些国家已经启动了一项 2010-2013 年可持续发展国家战略。这并未专门涉及气候变化但事关可持续发展的所有方面。

已经采用了使用 ICT 避免实际差旅等通用原则。预计会采取一项有关 ICT 和可持续发展的全球战略，包括以下一系列行动：

- 通过推广最佳做法降低数据中心的能耗。
- 鼓励耗能少电子元件的制造和使用并为其贴上节能标签。
- 通过互联网推动生态负责型购买方式（同时注意确保这并不危及电子商务）。
- 智能电网和智能交通系统的广泛开发以及支持在这些领域开展研发从而为未来几代技术的开发铺平道路。
- 界定评估数字部门能源和环境性能的指标（遵守有关温室气体排放评估的监管义务并与欧洲数字议程框架内正在开展的工作保持一致）。
- 确保公共机构（国家、当地政府和公共机构）有倡导节约的典型做法。
- 开发必要能力。

Q2 贵国政府（或公司）目前在适应气候变化方面是否采取了具体行动？

适应涉及在当地和国家层面采取行动，适应气候变化的影响。ICT 可大力支持这种行动。实例包括遥感收集气候数据、传播海平面预报的信息、采取在海平面以上的高地修筑等

将影响降到最低限度的措施等。ICT 基础设施已用于为地震和浪潮等自然灾害提供告警。可能需要其他或新的 ICT 基础设施和业务来协助处理水和食物短缺等极端气候条件造成的问题。

应注意到，80%的主管部门表示，他们已经制定了适应政策。

一个主管部门强调了以下行动：

1 该国在保护和民防措施方面为自然灾害告警做好了准备。

2 准备并公布旨在提供规划和推广应对自然灾害所需信息的研究。

3 开发科学、技术和创新能力，确保不断改进自然灾害的告警。

4 开发落实用于监控自然灾害的系统。

5 开发落实用于监控自然灾害的 IT 模型。

6 运行准备提供自然灾害告警的 IT 系统。

7 加强强化培训能力的活动。

8 自然灾害告警。

主管部门也提到用于气候变化预测和监控的气象中心。

a) *是否已实施措施来延长ICT设备的使用寿命?*

63%的回复拥护延长 ICT 设备的寿命。

多个回复提及了电信行业可持续发展的自愿承诺宣言。于 2010 年签署的该宣言促进用户延长设备、产品和终端的有用寿命。

b) *是否已在贵国实施ICT设备的循环使用?*

实施了回收旧电话的奖励措施：

- 主要运营商收集就电话。
- 自 2010 年初起，除生态和社会奖励措施外，每个运营商向客户提供一项退还其旧电话的财务奖励措施（根据使用年限和状况定价；价格从 2 欧元到新款高端手机的 280 欧元不等）。
- 一旦收集后，这些终端全部重新使用或回收，这一流程可为社会和团结领域的人员创造就业机会。

c) *是否有针对电子垃圾管理的政策?*

多个欧洲指令规定了管理电子废弃物的总体框架：

- 2002/96/CE 指令，也称为“令，也称（电子和电气废弃设备）指令”旨在强化电子和电气设备（EEE）的回收。它要求 EEE 生产厂家和进口商涵盖收集和处理 EEE 的费用。

- 2002/95/CE 指令，也称为“RoHS（限制使用某些有害物质指令）指令”，补充了 WEEE 指令。它规定，自 2006 年 7 月 1 日起，欧洲指令所涵盖的电子和电气设备，无论是进口到欧盟还是在欧盟境内生产的，在营销时不得包含以下六种有害物质，即：
  - 铅（用于焊接）
  - 水银（用于电池 等）
  - 镉（用于电池、集成电路等…）
  - 六价铬（用于微处理器…）
  - 多溴联苯（PBB，用于微处理器…）
  - 多溴二苯醚（PBDE，用于计算机外壳…）。

Q3　是否对贵国内的全球 ICT 足迹（体现在温室气体（GHG）排放）做过估算？

ICT 行业长期以来致力于在其产品和解决方案中改进生产效率。能效近期才成为一个重要问题：在部分国家，ICT 的能耗现已超过 13%。据估计，ICT 行业约占到全球二氧化碳排放的 2.5%。

IDATE-BCG2009 年进行的一项研究表明，2008 年 ICT 行业的整体消耗占法国电力消耗的 7.3%，即 35.3 TWh/每年。尽管使用增长了，但该消耗可在 2012 年降低到 34.3 TWh/每年，到 2020 年降低到 33.9 TWh/每年。

总体而言，这相当于法国二氧化碳输出的 5%左右，估计为 554 Mt。

多份答复提及设立一个监控 ICT 足迹的全国观测站。

另一项保护环境的措施涉及确定 ICT 在实现提高累积地区能源效率和降低温室气体排放方面的潜在作用。

Q4　您是否了解可提供更佳设计和更少能源消耗的“绿色”ICT 举措？

在法国法律中，能效是 2005 年 7 月 13 日 2005-781 号法案的最重要部分，规定了能源政策的方向。该法第 3 条规定自 2015 年起，将最终的能源强度的年度削减率增加到 2%，从现在到 2030 年，增加到 2.5%。为此，国家正在调动所有公共政策手段，首先从与能效有关的（法国和欧共体的）规章开始。《能源法》的 L224-1 条规定，最高行政法院可强制生产商和用户自行且自费验证其商品的能耗水平和污染物质排放。

Q5　您是否了解所谓的“回弹效应”，这种效应会抵消绿色 ICT 或消耗能源较少的 ICT 的优势？

仅有 45%的回复表明知道回弹效应。

回弹效应在经济和节能领域众所周知。它通常指引入新技术或采取其他措施来减少资源的使用。这些回复倾向于抵消了新技术或所采取其他措施带来的好处。尽管有关回弹效应的文献通常以能耗改进技术的影响为重点，但该理论也可用于任何自然资源的使用。

这种概念可能会在气候变化领域非常具有吸引力和帮助，因为基本概念是非常相似的。它通常指引入新技术（在我们这种情况下，是绿色 ICT）或其他旨在减少资源（在我们这种情况下，指电力）使用的措施。这些回复倾向于抵消了新技术或所采取其他措施带来的好处。法国尚未研究能耗的技术改进所带来的影响，但认为应采用该理论，以便准确评估某项政策或决定草案。

Q6　　贵国农村/偏远地区内典型的恶劣天气条件有哪些？

我们发现具有以下条件的国家示例：夏季温度近 40°C，湿度大（高达 80%）；湿度小（20-30%）；猛烈的夏季暴雨并伴有大量的闪电活动；在某些情况下，严冬和酷夏接踵而至（每年温变化幅度很大）；有些地区工业气氛严峻；海区盐度高。

Q7　　贵主管部门是否使用 ICT 系统和应用程序来适应气候变化？

58%的回复显示存在气候变化的适应。

存在适应的主要领域如下：

1.　供水（见 ITU-T 关于“智能化水管理与 ICT”的技术跟踪报告）

2.　食品供应（见 ITU-T 关于该问题的技术跟踪报告）

3.　医疗

4.　基础设施维护

5.　供电

6.　天然气

7.　公路

8.　铁路

9.　机场。

Q8　　哪些 ICT 服务能够促使社区更好地适应气候变化？（例如向社区发送自动文本消息，通知水短缺和紧急供水消息等）

采用社会网络向各种组织提供社会应如何采用更绿色技术的方法有关的培训和通知。提高认识宣传是一种促使公众更好了解水资源管理与适应气候变化两者间密切关联的重要方法。

Q9　　贵主管部门使用哪些具体的 ICT 设备技术或标准来收集数据，从而监测气候变化？请选择。

有着各种收集代表着各种气候现象的主要地球物理参数的方法和技术。

- 卫星系统非常有效，因其提供了海洋盐度、土壤湿度、大气各层温度、海洋温度、平均海平面等各种地球物理学参数一系列可重复的精确且可靠的测量。例如，空间和气象机构（CNES、NASA、NOAA、EUMETSAT、ESA、ISRO、JAXA 等）在卫星地球观测项目（Jason、SMOS、Megha-tropique 等）中协同合作。所有这些卫星系统提供了各种对于研究气候变化而言非常重要的指标，且处于完全工作状态，它们提供的数据不断被空间和气象机构的专家用于研究和分析。

- 空基系统主要用于测试未来卫星将要搭载的有效载荷的原型，以便验证未来的工作系统。实际上，须不断铭记气候变化分析需要持续的可靠、可重复且相互兼容的测量。
- 也采用了地面系统（固定和移动），因为它们可补偿卫星无法进行的测量。此外，它们在校准从采用卫星方式获得的数据时非常重要。
- 海底电缆系统非常有用，因为卫星只能在海面，而不是海中测量海洋盐度。还需采用其他设施来获取这些无法通过卫星获取的地球物理参数。

如选择为“其他”，请予以说明：专家们采用的物理模型不断通过地面和卫星测量进行更新—这种现象称为“同化现象”，其中通过地面传感器获得的数据用卫星数据补充。但是，需要与模型进行比对，以验证所获得数据的数量级，同时铭记，由于不正确的测量或干扰，某些情况下获得的数据是不正确的。在这些情况下，由于模型的存在，可剔除这些错误的测量。

Q10 哪些技术和/或标准可增强贵主管部门收集气候变化相关数据/信息的能力？

ICT 行业可通过以下途径改进气候变化的数据和信息收集：

– 实施用于系统性观测的适当系统、用于海洋的监控网络和机构性信息系统，以支持决策。主要系统将用于确定易受影响的区域、为数据库提供素材，制定并落实资源保护措施并监控对城市化规则的遵守；

– 落实空气质量监控网络，包括设立多个监测 CO_2 和 CH4 的台站；

– 落实测量潮汐的网络；

– 开发和维护对应的数据库，包括与其他机构开展交流。

与空间和气象机构（包括世界气象组织）的专家进行协作，以便增强对气候演进的了解。卫星和地面测量设施是主要的信息来源。

Q11 贵主管部门使用哪些信息通信技术和标准来向有相关需求的人/组织传播气候变化信息（例如通过广播、卫星系统）？请从下列选项中选择：

通信技术和标准依赖于以下基础设施：

- 地面系统（公用固定）
- 地面系统（公用蜂窝）
- 地面系统（专用网络/专用移动无线电）
- 互动语音系统。

下一份 IPCC 报告将很快发布，这份报告是公众、科学界和决策机构获得信息的一个重要来源。除此份非常全面的报告外，还可在互联网上找到以下可靠的信息来源：

http://www.aviso.oceanobs.com

http://www.mercator-ocean.fr

http://www.esa.int/SPECIALS/Space_for_our_climate/index.html

Q12　哪些技术和/或标准可以增强向有相关需要的人/组织传播气候变化信息的能力？

ICT 是收集、存储和传播有关气象条件和气候模型数据的有力工具，而前三者对于改进我们对气候变化的了解至关重要。建立一种向用户传递气象数据的有效机制是一项基本要求。

Q13　信息获取对于需要适应气候变化的社区来说非常重要。在贵国农村/偏远地区内部属电信基础设施的挑战有哪些？请指出下列因素中影响最大的因素：

1.　电力获取

2.　备用电源的费用

3.　地形

4.　无障碍获取与交通

5.　缺乏熟练技工

6.　网络安装与维护

7.　高运营成本

8.　低用户平均收入

9.　人口稀疏且分散

Q14　贵国农村/边远地区可用的主要能源和后备能源有哪些？请从下列选项中选择：

除太阳能和风能外，农村地区仍大量使用柴油发电机。

Q15　需要何种电信/移动系统来加强农村/边远地区对于气候变化或极端天气事件相关信息的获取？

移动无线电业务大量使用。

Q16　农村/边远地区培训个人使用 ICT 来适应气候变化的教育机会有哪些？

应鼓励视频会议的方式。

Q17　某些系统是专门针对发展中国家设计的，但其中大多数系统的一些功能的效果与成本不符且/或缺乏必要的规范，不符合发展中国家的现有条件。贵国农村/偏远地区内所必需的规范和功能有哪些？

视频会议是必要的，如用于改善教育。

5.3　拟议的建议

提出了作为第 Q24/2 号课题输出文件的建议书。提出如下建议：

建议

1 各国制定导则/最佳做法并实施政策和相关措施以促进 ICT 的使用，应对气候变化挑战；

2 提供支持以帮助各国更多地投资气象监测服务从而防止可能具有毁灭性的极端事件，因为预报成本相对较低且有助于减缓洪水、干旱和热带气旋造成的严重灾难；

3 为帮助各国投资技术，它们需要了解更多关于气候变化的一般知识，并更好地获取和理解（卫星和地面）提供气象资料；

4 各国制定培训项目从而更好地使用所有监测数据；

5 在真实数据基础上开发一个项目，展示减少能耗的效果以及 ICT 的效益；

6 有必要采取创新型 ICT 战略从长远应对气候变化适应和缓解；

7 由于可能需要在不同气象条件下（炎热天气、高湿度等）操作，帮助各国开发更能负担得起的以及更有力且可靠的绿色 ICT 就变得急迫起来；

8 各国间在气象数据监测方面更好地开展合作，使用 ICT 缓解气候变化。

进一步建议

1 采取适当措施在国家、区域和国际层面建立有利环境以鼓励 ICT 部门、气象研究和国际电联成员国极端事件预测的开发和投资；

2 各国将 ICT 和气候变化领域研究作为一项优先事项和紧急任务继续推进。

5.4 智能电网实现更加高效的电力分配

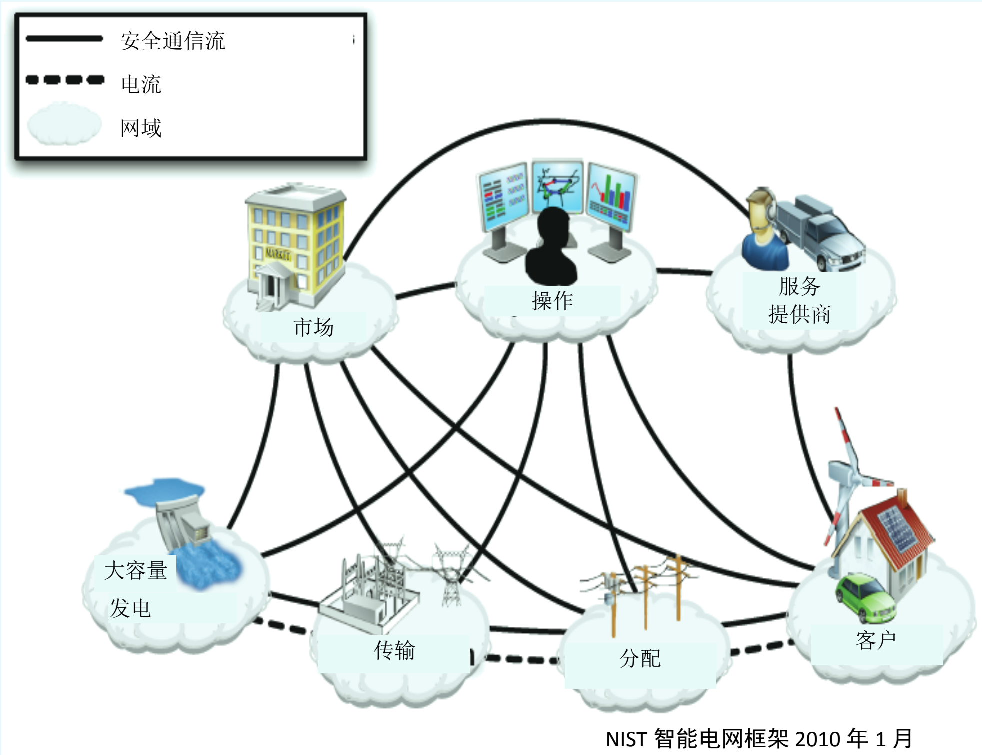
附件 7 全面研究了智能电网概念。

国际电联电信标准化部门官方术语表述如下。

“智能电网”是一种通过传感器和控制设备与信息和核心网络相连的双向电力输送网络。这支持电力网络的智能和有效优化。

下图展示了概念模型。

图 7：智能电网概述



基本上，智能电网是一种使用信息通信技术以一种自动化方式获取信息，从而改善电力生产和分配有效性、可靠性、经济性和可持续性的电网。[37]收集的信息允许决策机构实时做出了解内情的决策。之所以被称为“智能”电网是因为数字技术使得生产者与其消费者之间可在电网帮助下就控制、计算机、自动化及其它新技术开展双向通信从而以数字形式对不断变化的电子需求做出快速回应。[38]

智能电网给予我们一个以对经济和环境均有益的方式改善能源行业的机会。智能电网的好处是巨大的：更有效的电力传输、出现电力故障后更快的回复供电、降低的运行和管理成本以及随之而来的更低的消费者电力成本、降低的高峰用电需求、提高的可再生能源整合力度、更高的高峰期输电安全性、由于提高的可靠性造成的更少生产力损失、消费者在优化系统运行方面发挥作用的可能性，以及整个电力供应系统环境影响的显著降低。

智能电网能够在高峰用电期削减电力使用。此外，一种动态定价方式鼓励在用电高峰期自愿减少能耗。

[37] 智能电网，维基百科，见: http://en.wikipedia.org/wiki/Smart_grid#cite_note-1, 2012 年 12 月 7 日。

[38] 智能电网，Smartgrid.gov,见：http://www.smartgrid.gov/the_smart_grid#smart_grid, 2012 年 12 月 11 日。

智能电网有弥合下列组件间差距的潜力：

– 通过大规模可再生能源整合实现电力的可持续和低成本生产；

– 农村地区运行的微电网和孤岛模式；

– 通过电网监测提高效率；

– 借助需求响应机制实现电力的可靠和更廉价供应；

– 满足低成本客户具体需求并降低抄表和计费相关的行政成本的新商业模式。

ICT 是更高效电力系统和发展中国家电气化的推动者。智能电网中的根本挑战是在整合所有旨在以可持续方式解决能源独立性和老化电网现代化问题的那些新技术，实现能源独立性且确保供需平衡：

– 注入传输系统的公用事业范围内的可再生能源；

– 注入分配系统的分布式能源（DER）；

– 插电（混合）电动车（PHEV）；

– 需求侧管理（DSM）；

– 消费者参与；

– 存储以弥补某些可再生资源随时间形状改变的缺陷；

– 支持上述技术和应用，要求提供将检测和控制联系在一起的现代、灵活且可扩展通信网络；

– 智能电网的真正“关键”促成因素是提供整个电网从生成到加载过程中的普遍性双向数据通信网络。

国际电联[39]公布了一份完整报告，着眼于能效讨论 ICT 在智能电网中的作用，设想的最终目标是阻止气候变化。

通信和电力行业间的“联盟”仍未建成，但由于建设一个新的 ICT 基础设施造价非常高昂所以联盟会得以建成。

电信行业和服务提供商在智能电网中发挥着非常重要的作用。基于云的托管能源服务提供商借助现有宽带接入技术将提供到家服务。宽带接入能在需求方管理中发挥作用。

另一个融合动力是，智能电网提供的服务不是在安装量表处结束而是进入用户家中。智能电表的许多方面与家庭网络的可用性有直接关系而且消费者参与在需求侧管理项目中很关键。

这也将通过新能效标准塑造用户电子行业的未来。电网通常跨越国际或司法边界，但应用和设备必须交互操作，不考虑那些边界。智能电网的电信/电力/CE 融合将推动出现产品的新回音系统 而且这必须在国际标准组织主持下实现。

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

6 结论

气候变化

气候变化如今已经是一个无可辩驳的事实。没有减少温室气体排放的进一步承诺和行动，世界温度有可能较前工业化气候提高超过 3°C。自 1850[40]以来地球从未如此炎热过。从 1850 起，与 1961-1990 年期间确定的平均气温相比，地球平均气温已经上升了 0.8°C，而在过去五十年上升了 0.6°C。为了避免对我们的社会构成毁灭性影响，科学的建议在 21 世纪结束前温度上升不超过 2°C。

即使目前的缓解承诺得到彻底执行，仍有约 20%可能性到 2100 年温度升幅超过 4°C。如果做不到这些承诺，4°C 气温升幅可能在 2060 年代出现。到 2100 年，这样一个升温幅度和相关的 0.5 到 1 米的海平面上升幅度将不是终点：进一步升温超过 6°C，海平面上升数米，有可能在未来几个世纪出现。

预计二氧化碳引起的气候变化将持续许多个世纪，如果排放在任何时候及时停止。在使地球升温的主要介质中此类极端持续性是二氧化碳所特有的。长期效应主要由二氧化碳控制。

因此，监管全球社区已经承诺将升温控制在 2°C 以下以防止“危险性”气候变化，而且小岛屿发展中国家（SIDS）和最不发达国家（LDCs）已经将 1.5°C 的全球升温视为超过此升温幅度将会对其自身发展构成严重威胁的一个临界值而且，在某些情况下，生存，当前政策的总和——存在并已经做出了承诺——将很有可能导致升温幅度远高于此。的确，现在的排放趋势似有可能将世界置于在本世纪内向 4°C 升幅迈进的“不归路”上。

此外，由于极端事件造成的损害程度有所提高，极端事件的强度亦有所增强，我们的社会变得更脆弱。

卫星和地基传感器已通过测量温度和海平面上升等关键地球物理参数，提供了这种现象的科学证据。鉴于这种现象的主要成因是人类的活动，信息通信技术可为实现向资源高效和服务型社会转型，同时减少二氧化碳排放提供解决方案，尤其是以下行业的机会最大：建筑、交通运输业和制造业。ICT 行业拥有通过使经济增长与能耗脱钩来缓解气候变化的巨大潜力。个人计算机（PC）、互联网和移动通信的使用已证明了这一点。

国际电联的角色

国际电联在对监测、适应和缓解等问题做出回应的气候变化政策中扮演着重要角色。就监测而言，主要工作在国际电联无线电通信部门内完成。就适应而言，国际电联的关键活动之一是在成员国制定国家应急电信计划和实施早期预警系统过程中协助其开展减灾工作。通过其有关应急电信的专门项目，国际电联电信发展部门回应洪灾和其它自然灾害并向数个成员国提供应急通信设备以便进行更好的协调。在缓解方面，国际电联一直积极推动提高 ICT 能效并制定一系列方法，评估可通过智能技术使用实现的减排。

[40] 《探索》，2013 年 2 月期，气候变暖 3，第 44 页

ICT

ICT 行业的 CO_2 排放量约占全球总排放量的 2%。ICT 解决方案可促使在很大程度上减少非 ICT 行业产生的其余 98%的 CO_2 排放量。

ICT 解决方案的应用可实现向资源高效和服务型社会转型，同时减少二氧化碳排放，尤其是以下行业的机会最大：建筑、交通运输业和制造业。ICT 行业拥有通过使经济增长与能耗脱钩来缓解气候变化的巨大潜力。个人计算机（PC）、互联网和移动通信的使用已证明了这一点。

ICT 在将自身排放降低到最小程度方面面临着一个重大挑战，即在此方面需要通过并实施旨在提高网络和服务能效的新标准。与此同时，很显然，只能通过广泛应用 ICT 等措施才能实现全球温室气体排放的减排。

ICT 肯定能够帮助减缓气候变化，绿色 ICT 增加规模经济效益而行业利益攸关方能够进行创新。商品和服务的陈旧过时必须消失，设备的使用寿命应当得到延长而且产品的修复能力应当减少原材料的系统使用。最后，与绿色 ICT 相关的回弹效应不应当导致商品和服务的过度消费从而避免能源和原材料的过度使用。

一些国家（尤其是发展中国家）仍需要帮助来应对气候变化。本报告对 ITU-D 的下列战略目标做出响应：

– 促进基础设施的可用性，并为电信/ICT 基础设施发展及安全使用创造有利环境。此处所述的 ICT 可执行多种功能：地球观测、向专门的中心传输观测数据以及交换信息，以便将实际运输降低到最低限度。

– 与公有和私营利益相关方开展合作，将信息社会产生的效益扩大给各成员国，促进将电信/ICT 的使用融入更广泛的经济和社会中，作为全球发展、创新、福利、增长及生产力的推动力量。

– 鼓励与公众有关的、监控和交换温室气体排放数据的 ICT 研究和开发活动（移动应用及相关技术）并促进有关 ICT 使用的知识和技术交流，以便加强可持续环境建设。鼓励通过为应对气候变化的行动纲领划拨的公共资金为此类研究和开发活动提供资金。

– 通过鼓励电气产品（它们多半是稀有和/或有毒金属的大用户）的回收促进“绿色经济”的发展。

– 能效做法节约下来的能源的增加将被能源消耗的增加所抵消，这个概念就是所谓的回弹效应。有证据显示，截然不同类型的能效技术造成了过去能源需求的增加。回弹效应在某些国家相当高而且适用于许多部门：例如交通、移动通信。预计回弹效应仍居高位且有可能需要制定能源政策考虑由于回弹效应造成的能源节约方面可能出现的损失。

在有关气候变化的国际谈判中，政府部门在哥本哈根已经就限制气温升幅最高到 2°C 达成共识。只要更好地控制温室气体排放，这一目标还是能够实现的。我们有责任限制气温升高而且我们希望本报告提及的各种问题在一定程度上能够有助于此目标的实现。

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

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- Kit d'information sur les changements climatiques, juillet 2002 ; http://unfccc.int/essential_background/background_publications_htmlpdf/climate_change_information_kit/items/305.php
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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

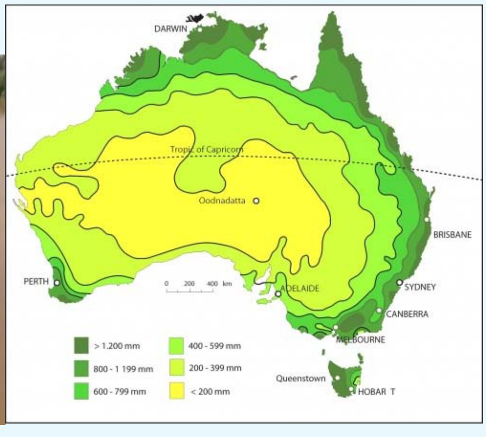
Oceans absorb from 80 to 90% of the heat from the atmosphere. Without them, the planet would warm much faster. An increase in air temperature that would normally take hundreds of years does take while dozens. The oceans absorb carbon dioxide from entering the water where it dissolves to form carbon dioxide, 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)

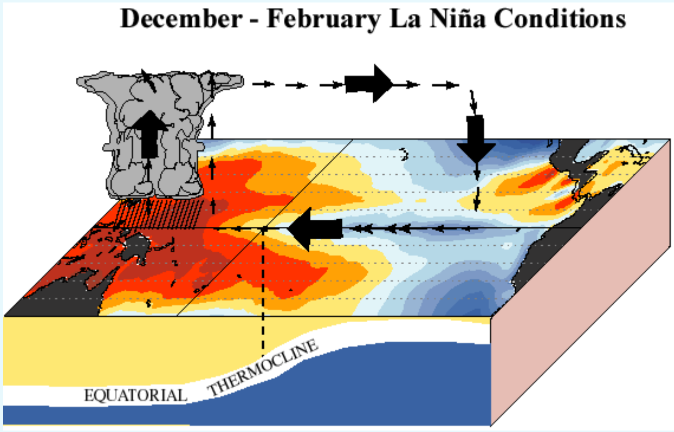
Meteorological services in Australia have announced that the floods that killed ten people between November 2010 and January 2011 were due to the La Niña weather phenomenon, which has been the source of the wettest year ever recorded in Queensland since meteorological records are established. In contrast 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.

Question 2: On-going actions about adaptation to climate change

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 ...);

Question 3: computation of the ICT footprint

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.

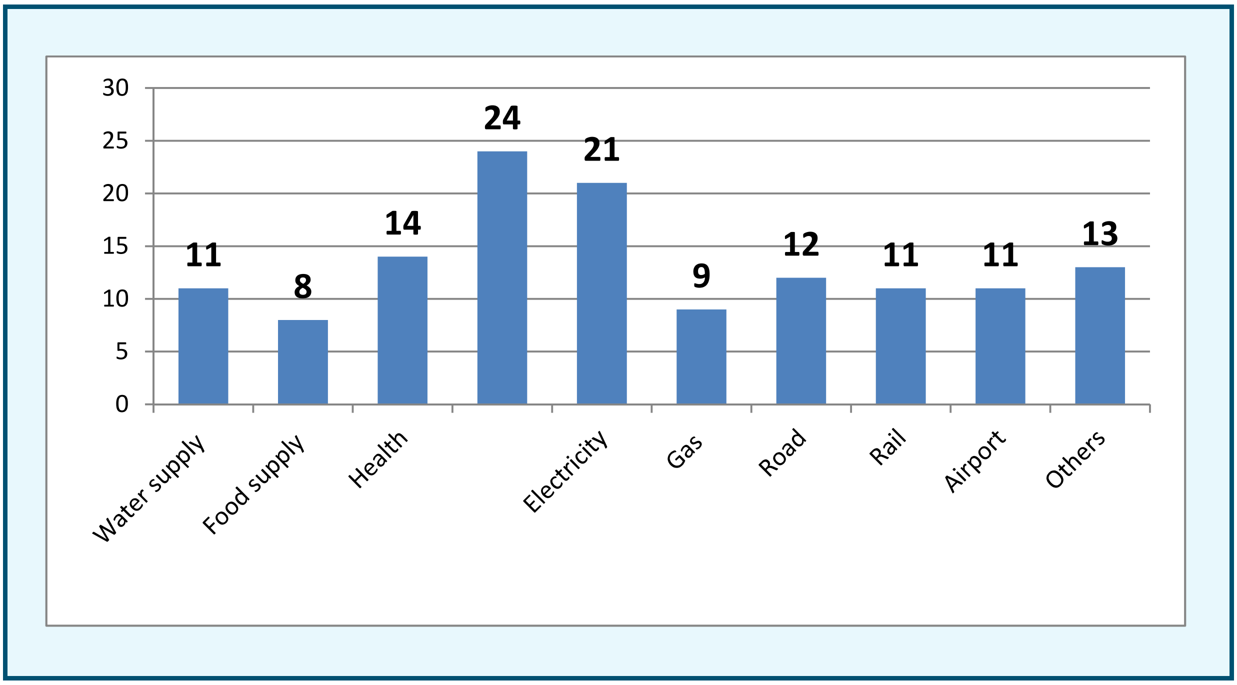
In Qatar: Desert climate with occasional sand storm, occasional flooding in urban area.

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?

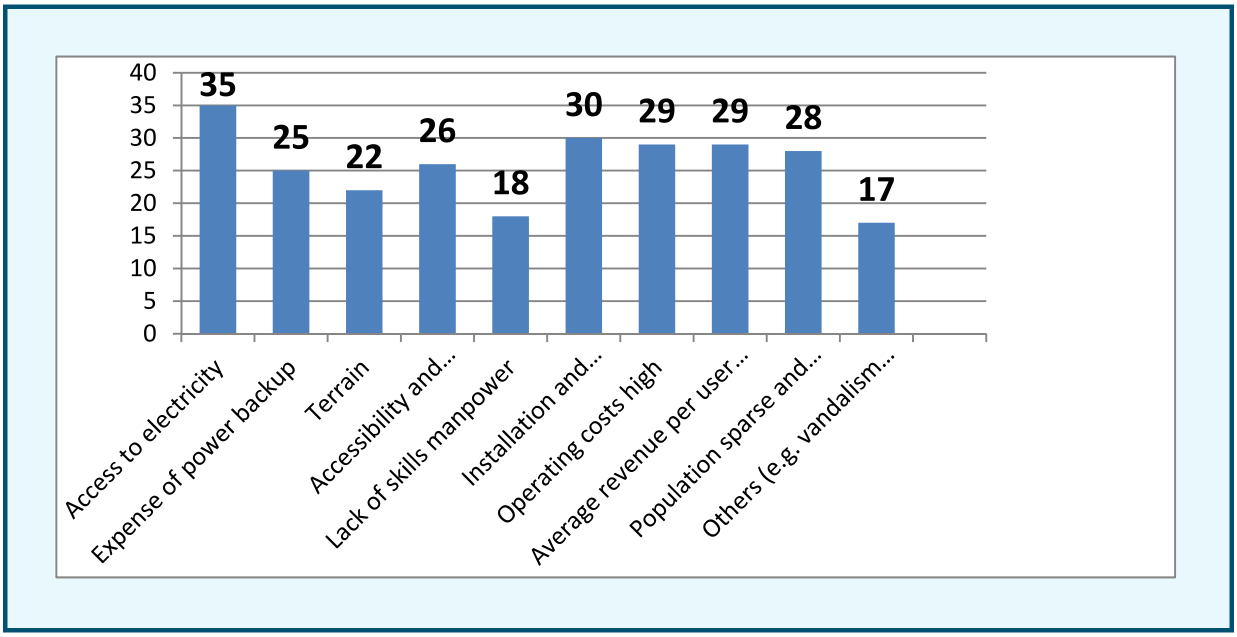
It seems that there is a need of a single/international standards to transmit climate change information.

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:

- Alcatel-Lucent, Strategic White Paper "Eco-sustainable wireless service", 2009; www.alcatel-lucent.com/alternative-energy/
- Greetouch, ICT Industry Combats Climate Change, 2010; www.greentouch.org/index.php?page=how-the-ict-industries-can-help-the-world-combat-climate-change
- C. Grangeat et al, "A Solution to Dynamically Decrease Power Consumption of Wireless Base Stations and Power them with Alternative Energies", Telecommunications Energy Conference (INTELEC), 2010
- Joel Brunarie et al. "Delivering Cost Savings and Environmental Benefits with Hybrid Power", Telecommunications Energy Conference (INTELEC), 2009
- WRI, WBCSD, GeSI, Carbon Trust, joint press release titled "New initiative announced to help ICT industry measure carbon footprint", 8 March 2011

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

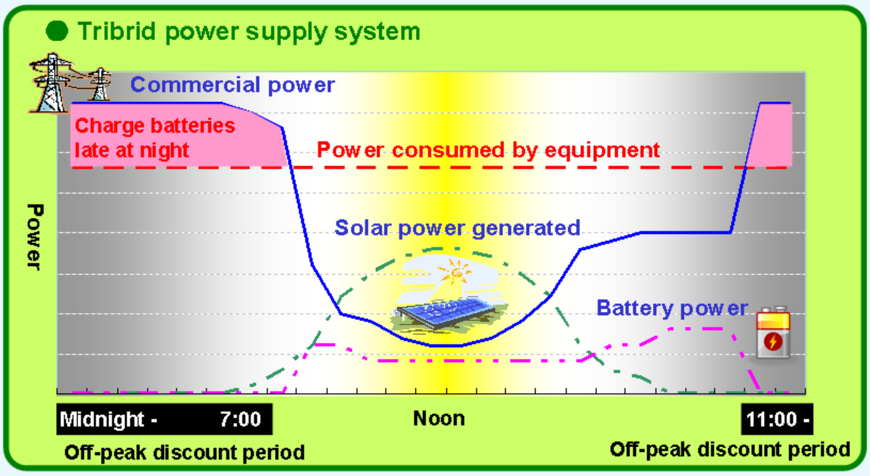
Crucial concern should be provided to reduce electric power consumption by systems and facilities used for the provision of telecommunications services and to cut carbon dioxide emissions as a general telecommunications carrier. Mobile base stations ("base stations") account for approximately 60% of 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

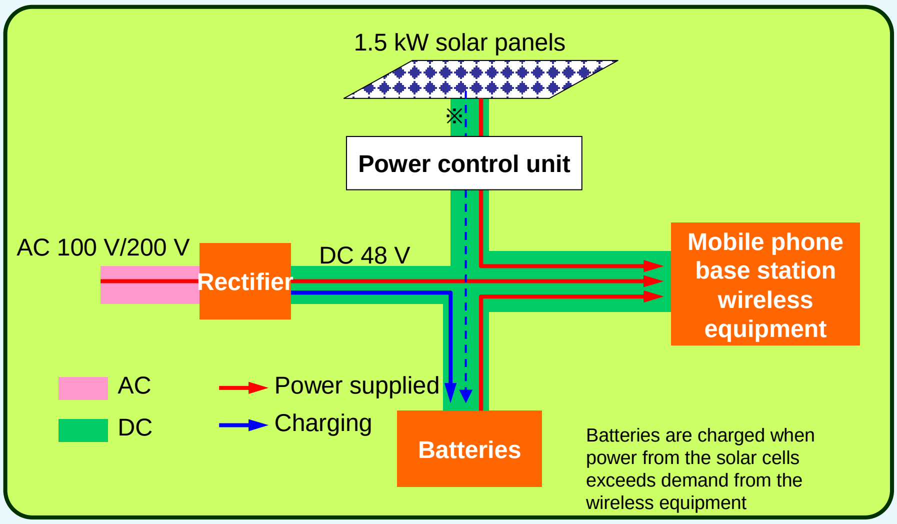


Figure 6.3 shows the screen shot of the tribrid power control monitor. It shows the power supply from solar panels to the wireless equipment and the excess power charged in batteries. Only a very small amount of commercial power is being used.

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[1] 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) the evolution path for Ghana will be on a much lower emissions trajectory, saving energy cost and

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

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.[2] 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.[3] The demand growth is the leading cause of major blackouts in developing countries.[4] 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.[5] 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.[6] 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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[2] National Academy of Engineering, Greatest Engineering Achievements of the 20th Century, available at: www.mae.ncsu.edu/eischen/courses/mae415/docs/GreatestEngineeringAchievements.pdf, December 12, 2012

[3] Litos Strategic Communication, The Smart Grid: An Introduction, available at: http://energy.gov/sites/prod/files/oeprod/DocumentsandMedia/DOE_SG_Book_Single_Pages%281%29.pdf, December 12, 2012

[4] J. Woudhuysen, J. Kaplinsky, P. Seaman, How to make blackouts a thing of the past, available at: www.spiked-online.com/site/article/12942/, December 18, 2012

[5] The Automatic Earth, India Power Outrage: The Shape of Things to Come?, available at: http://theautomaticearth.com/Energy/india-power-outage-the-shape-of-things-to-come.html, December 18, 2012

[6] ITU, Boosting energy efficiency through Smart Grids, 2012, 6, available at: www.itu.int/ITU-T/climatechange/report-smartgrids.html, January 22, 2013

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.[7]

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.[8] 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 demand.[9] 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,

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[7] Energy.gov, Smart grid

[8] Smartgrid.gov, The Smart Grid

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

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.[10] 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.[11]

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.[12]

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.[13] 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.[14] A good practical example of how renewable sources can be included in power supply are Ghana, which is already providing 50 per cent of its electricity this way,[15] and Spain, where renewable technologies provide more than 40 per cent of the daily demand on certain

10 Smartgrid.gov, The Smart Grid

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

12 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

13 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

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

15 ITU, Information and communication technologies (ICTs) and climate change adaptation and mitigation : The case of Ghana, 2012, available at: www.itu.int/dms_pub/itu-t/oth/4B/01/T4B010000020001PDFE.pdf, 19 November 2012

days.[16] 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.[17]

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.[18]

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.[19] 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.[20] 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.[21]

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.[22] 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.

9.2 References:

- GeSI, *Evaluating the Carbon-Reducing Impacts of ICT – An assessment methodology*, September 2010
- Le Monde diplomatique
- France, Centre d’analydse stratégique, *Pour une consommation durable*, janvier 2011
- Buluş, A., Topalli, N., Energy Efficiency and Rebound Effect: Does Energy Efficiency Save Energy?, July 2011

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[23]) 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 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:

[23] 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.

- *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.

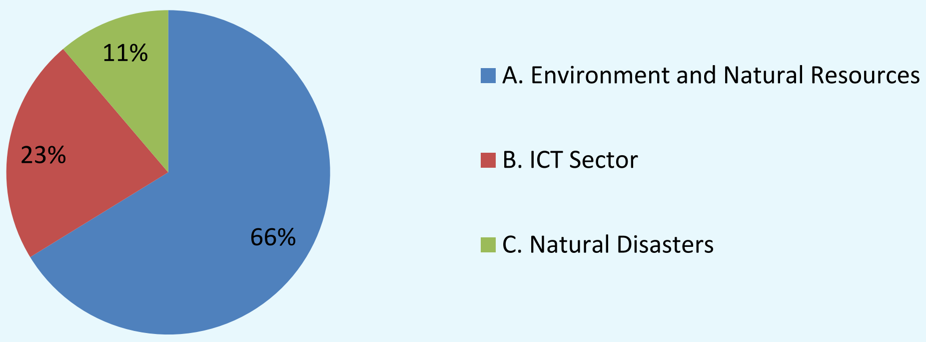
B. Greening the ICT sector

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;

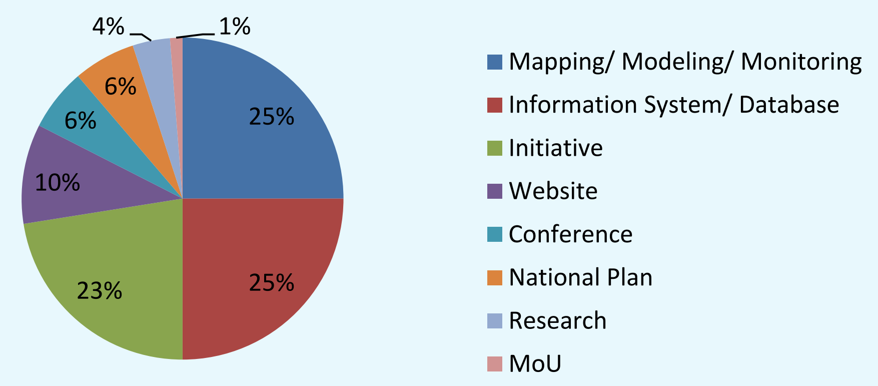
5 Events and Conferences: Organization of a public event (workshop, Events and Conferences or similar) for consultation, exchange of information, or discussion related to objectives pursuant action line C-7, e-environment;

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.

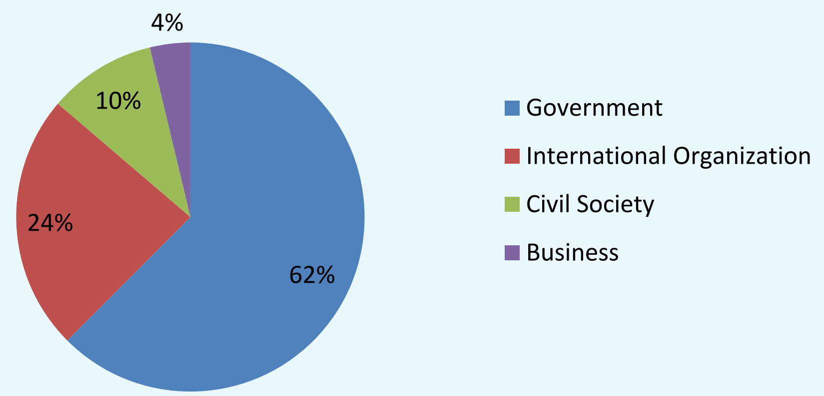
8 Memorandum of Understand (MoU): Signature of agreements to promote cooperation between entities.

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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