# Annex J: ICT – supplementary material

## J.1 PREVIOUS ASSESSMENTS

The ICT sector covers various means of communication and different IT spheres. The existing quantified assessments focus on some subsectors, such as radio spectrum, telecommunications, etc. In this section we provide an overview of several reports that aim to assess future demand of ICT services and perform some analysis of strategies to address that demand.

### *Spectrum Demand for Non-government Services 2005-2025*

A study about spectrum demand in the UK has been produced for Independent Audit of Spectrum Holdings team in 2005 (Analysys & Mason, 2005). The study forecasts demand of radio frequency spectrum for years 2005–2025, with a particular focus on 2005–2015 period. The report analyses three scenarios – high, medium and low growth, where applicable – for individual commercial wireless services: cellular, fixed-links, broadband wireless access, satellite and terrestrial television broadcasting. The results are eventually accumulated to produce overall demand forecast, which predicts available commercial spectrum running out in 2008 (high growth scenario) to 2015 (low growth).

The study makes wide range of assumptions, in particular on take-up, usage levels and technologies used within various services. The authors do not distinguish between usage demand and capacity growth in the scenarios – it is assumed that if capacity becomes available, it will be used. Finally, the authors admit that breakthroughs in new technologies or take-up of alternative technologies would significantly alter the forecasts (Analysys and Mason, 2005).

### *US GAO: Competition, Capacity, and Costs in the Fixed Satellite Services Industry*

The US Government Accountability Office (GAO) report in September 2011 analysed the satellite industry and provided demand and capacity forecasts for the years 2009–2019 (GAO, 2011). The authors expect the overall demand for satellite services to grow, fuelled by increasing use of satellites for broadband Internet access, growth in corporate networks, increase in satellite television (including HDTV) channels, as well as growth in military usage. The growth in terrestrial fibre optic networks and better technologies may reduce the demand, but overall growth is still expected.

The study references estimates by Futron (2010) about average growth in demand for satellite service of 4% annually from 2010 to 2019. It is expected that the growth will be faster in emerging markets than in western markets. The study estimates that the global capacity will not be exceeded by the growing demand (Futron, 2010).

GAO offers several options of increasing capacity, including launching additional satellite capacity, moving the satellites or hosting additional capacity in other satellites (Futron, 2010).

### *OECD: Infrastructure to 2030*

An OECD (Organisation for Economic Co-operation and Development) report has been published in 2006, which analyses the demand and future trends of telecoms infrastructure (among others) in OECD countries (Futron, 2010). The report does not distinguish data from UK from the rest of OECD countries; therefore the analysis is of larger scale than preferred for the UK infrastructure review. Finally, the demand trends are analysed in global context, including markets of developing countries, etc.

Within the ICT infrastructure, the study focuses on fixed & mobile telephony and data, as well as wireless broadband. The study recognises that the market is driven by demand, and defines a single scenario, taking into account different factors that are likely to influence demand in the future. The forecast outlines an explosion in global ICT infrastructure growth, with increasing income, decreasing service costs and tariffs, and technology developments. Finally, the study outlines trends in various ICT services, which illustrate increasing dependence on and prevalence of communications, mobility, accessibility and information consumption (OECD, 2006).

### *AEA: Adapting the ICT Sector to the Impacts of Climate Change*

A study by AEA Technology in 2009 analysed the state of ICT sector and impacts of climate change to the sector, and provided recommendations how to adapt to them (Horrocks *et al*., 2010). The report also contains general ideas about future trends within the ICT sector up to year 2100. Several quantified case studies are provided about impact of climate change (e.g. floods, temperature changes) to elements of ICT sector, such as data centres or communication lines.

## J.2 ICT ELECTRICITY USAGE IN THE UK

There has been an exponential growth of the ICT sector in the last several decades. Rapid growth and introduction of technologies that bring about discontinuities make it dangerous to predict ICT needs for energy. Remember that 40 years is long in comparison to the whole history of computing. Most reports and studies on ICT energy usage provide estimations only up to year 2020 and for similar reasons we do the same in this note.

Note that there are problems with definitions – we have for example followed the widely-followed habit of including TV in ICT. It is also worth remembering that increases in deployment of ICT (and consequent increases in electricity consumption in that sector) can result in overall energy savings (e.g. reducing fuel wasted in transport).

The headline figures are that currently ICT probably consumes of the order of 10% of UK electricity; the highest figure we found would suggest growth in electricity consumption has been at a rate of growth of about 9% compound. This is unlikely to continue since much of the use is for non-essential purposes and will be price sensitive. We emphasise that all percentages are of electricity use that must be scaled to compare with overall energy use.

We believe extrapolation up to year 2050 would be unreliable and unsound. It is obvious that an industry that has shown itself to be able to reduce the energy consumption of both calculation and information storage at an exponential rate would be well placed to face increases in energy costs. Furthermore, the rate of innovation has been such that it is almost impossible to compare today's computers with those of 40 years ago; the next 40 years could see computation on biological structures that effectively consume no power.

### J.2.1 ICT electricity usage estimates

A number of reports have estimated current ICT usage of electricity and energy saving opportunities. Most reports concern electricity usage by data centres, some expand the scope to cover whole of ICT. For the ICT electricity usage analysis we aimed to average the estimates given in the reports to create a consensus trend. Some of the numbers and reasoning are provided below. Note that these should be considered rough estimations of ICT energy usage with the following assumptions.

The current worldwide electricity usage by data centres is considered to be 1.3–2% in 2007–2010 as estimated by various studies (Kaplan *et al*., 2008; Pickavet *et al*., 2008; Koomey, 2011). UK data centres usage is estimated at 2–3% of UK's electricity consumption in 2008 (POST, 2008). From these numbers we assumed our starting point to be 2% of data centres electricity usage within the UK in 2008.

To estimate electricity usage for the whole of ICT, we derive the number from similar estimates as well as from data centres usage share. The total ICT electricity consumption is estimated to be 10% of UK's electricity, or 8% worldwide, respectively (Global Action Plan, 2007; Pickavet *et al*., 2008; Akoush *et al*., 2011). Also, if we assume data centres make up about 17% of ICT electricity usage (Pickavet *et al*., 2008), our 2% above gives ICT electricity consumption to be 11.76% within the UK. These figures are quite similar so for simplicity we assume ICT to consume 10% of UK's electricity in 2008.

Recent data of data centre electricity consumption show 16.7% annual growth in 2000–2005 (Koomey, 2008), but 9.3% annual growth in 2005–2010 (Koomey, 2011). Data centre's market growth is estimated at 10–16% annually (Kaplan *et al*., 2008; Darrow and Hedman, 2009). Other reports estimate 5–12% annual data centre electricity consumption growth in the future (Pickavet *et al*., 2008; Darrow and Hedman, 2009; Greenpeace, 2010). For the rest of ICT, estimates range 5–12% for different parts of infrastructure (about 9% for the whole of ICT (Pickavet *et al*., 2008)). In our analysis we follow assumptions in Pickavet *et al*. (2008) about the growth of different constituents of ICT infrastructure:

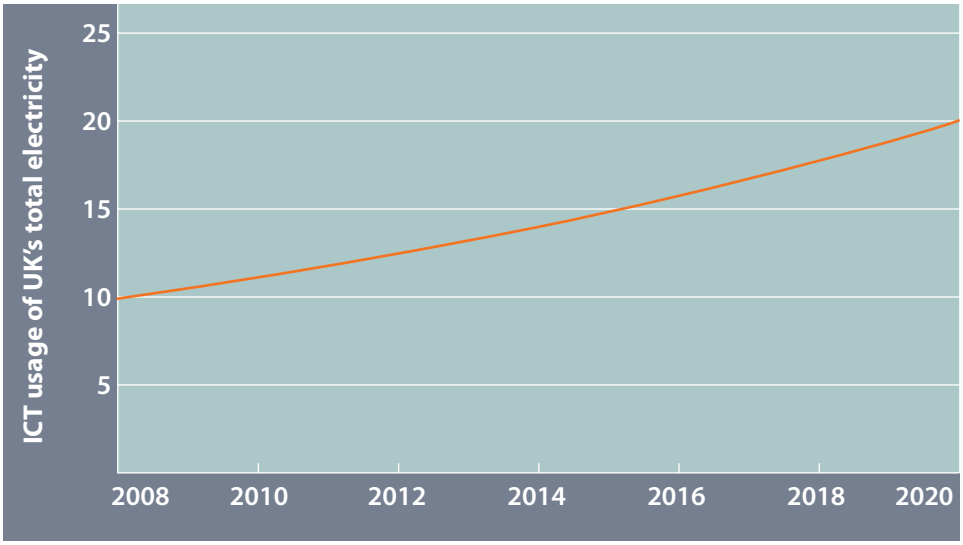
- Data centres (including servers, storage devices, network equipment at data centres, but also cooling, backup power infrastructure like UPS systems, and etc.) – 17.26% of total ICT usage, 12% of growth per annum.
- PCs/Laptops (computer screens, network interfaces in PCs) – 17.86% of total ICT usage and 7.5% of growth per annum.

- Network equipment (including datacom and telecom networks, but excluding network equipment inside data centres or built-in in PCs) – 14.88% and 12%.
- TV sets (including video and DVD players) – 26.19% and 9%.
- Other ICT equipment (audio equipment, telephone handsets, gaming consoles, printers, copiers and fax machines and etc.) – 23.81% and 5%.

Finally, we assume total electricity production growth of 3% per annum (Pickavet *et al*., 2008).

From the assumptions above, we get the following trend of estimated ICT electricity usage within the UK (Figure 1).

**Figure 1: ICT usage of total UK's electricity**




### J.2.2 Notes on ICT electricity usage in the UK based on UK government data

Note that our projections of the UK ICT electricity usage are estimated with assumptions based on worldwide forecasts. No estimations about ICT growth in the UK are currently available.

Nevertheless, some insight could be obtained by analysing available government data on the ICT electricity usage in 2010 (DECC, 2011) The proportions of different ICT constituents are similar to the worldwide ones, i.e. 15.52% of total ICT electricity usage is attributed to home computing and 49.78% to consumer electronics (TV, audio equipment, etc.). Furthermore, it could be estimated that ICT had consumed around 13–16% of the total electricity in the UK in 2010, depending on assumptions about industrial ICT usage (data centres, etc.).

While no estimations about future growth are available, there are figures about ICT usage in the domestic sector from the last 10 years. These trends hint towards slowing of the growth of electricity consumed by domestic ICT. Home computing (HC) growth slowed down from 13% to 1.5% per annum in the period 2000–2010, consumer electronics (CE) from 3.75% to ~1% growth per annum. The figures suggest a possibility that older ICT equipment is replaced by more efficient units, thus the overall growth of electricity usage is slowing down, despite continued ICT growth. These figures represent only a part of the whole ICT usage, however, and no trends are available for commercial and industrial sectors.

Furthermore, there are hints that the total electricity consumption in the UK may be shrinking (depending on different scenarios). Therefore, depending on relative rates of growth, the ICT share of total electricity usage could still be increasing significantly. However, without better figures on ICT and electricity usage, it is difficult to make accurate estimates. For that reason, we have used worldwide projections.

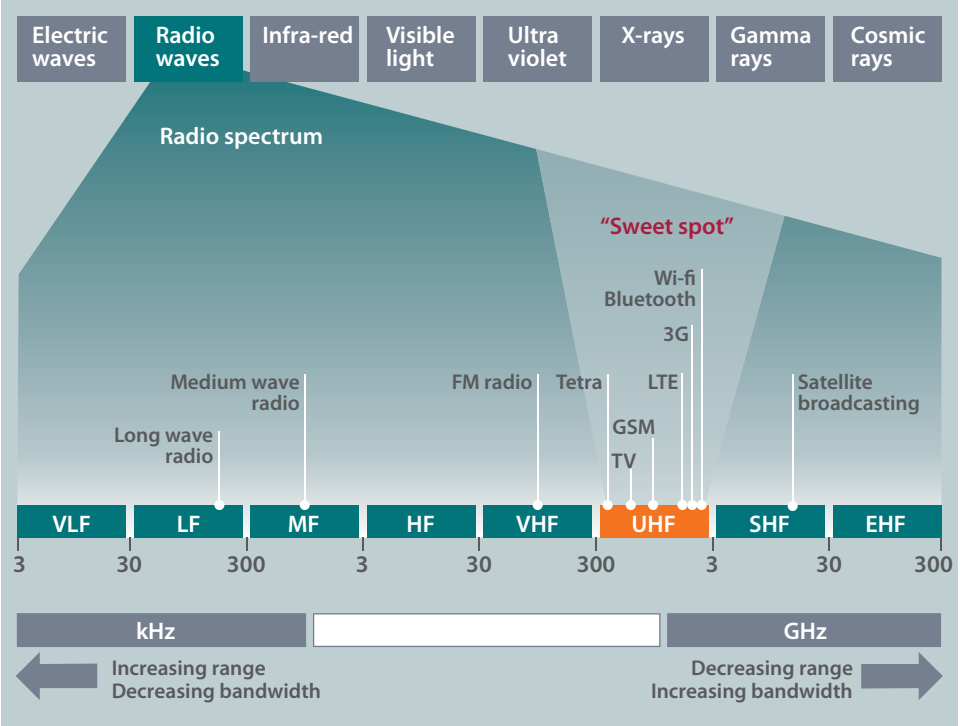
### J.2.3 Factors affecting ICT growth

The change in technology and usage patterns in ICT significantly affects adoption of ICT and therefore ICT electricity usage. There are a number of factors that can affect the figures, and therefore estimates above should be used only as a guide.

Below we provide several ideas about what could affect ICT electricity usage now and in the future.

- In general, despite different historical changes, the rate of ICT growth has been and continues to be high (often resulting in exponential rates of availability and discontinuities).
- Improvements in power consumption efficiency in the PC era have seen performance per kilowatt-hour doubling every 1.5 years (Koomey *et al*., 2011). However, this is just about cancelled by capacity growth according to Moore's law. Furthermore, total power consumption continues to grow as per Jevon's paradox.
- Current changes in ICT that would decrease electricity usage:
  - » Change from spinning disks to flash storage.
  - » Sharing via 'cloud computing' could avoid huge over-availability where organisations have data centres for peak demand that are used only a fraction of the time.
  - » Asynchronous circuits (draw power only when actually computing).
  - » Desktop PCs are being replaced by laptops, which typically use 1/3 to 1/5 of the power of a comparable desktop (Koomey *et al.*, 2011).
- The average Power Usage Effectiveness (PUE) of data centres worldwide will decline from around 2.5 in 2010 to 1.2 or less by 2020 (less is better efficiency) (Daley and Wheelock, 2010).
- Possible future changes to decrease electricity usage:
  - » Many sorts of distributed computing use tiny devices that consume minute amounts of power that might be harnessed without conventional power input
  - » Biological computing
- Changes that will increase electricity usage:
  - » Increasing number of PC/laptop ownership. In 2011, 77% (Ofcom, 2011) of homes in the UK own a PC/laptop – expecting PC/laptop ownership to be universal and more.
  - » ICT device cost is decreasing and they are becoming more accessible to consumers, which will increase the number of ICT devices.
  - » Investment into data centres is popular – large funds available for investment to data centres.

Figure 2: Spectrum usage (DCMS, 2011).



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