Electronic Appliances

HIGHLIGHTS

■ **PROCESS AND TECHNOLOGY STATUS –** This brief discusses the main consumer electronics in terms of ownership and total energy consumption at the global scale. The most significant technologies are Televisions (TVs) and Computers. These are both global commodities where ownership (and total energy consumption) has increased rapidly over the last ten years. TVs are responsible for between 6-8% of global residential electricity consumption. In the US, Australia, Europe and the Republic of Korea it is common for households to own more than one television. Historically most TVs were cathode ray tube (CRT) display screens, but in developed countries there has been a rapid replacement with liquid crystal displays (LCDs) and to a lesser extent plasma display panels (PDP). Developing countries still tend to have a larger share of CRT technologies. The main drivers in the television market have been demand for flat screen technologies and larger screen sizes, but there is also a transition to digital television and high resolution TV, also known as High Definition (HD) TV. In 2010, the worldwide Personal Computer (PC) market had sales of 320 million units and retail revenue was more than $320 billion. The most recent available data indicates that ownership has reached 75% of US households, 85% in Japan, 57% in the EU, 80% in the Republic of Korea and 73% in Australia. In 2008 worldwide sales of desktop computers were ~138 million and laptop computers were ~126 million, but in 2009 the sales of laptop computers topped desktop computer sales due to the success of netbook PCs.

■ **PERFORMANCE AND COSTS –** In 2010, the average global energy consumption in Watts (W) for TV displays were estimated at Organic Light Emitting Diode (OLED) – 11 W; CRT – 55 W; LCD with light emitting diodes (LED) – 67 W; LCD with cold cathode fluorescent lamps (CCFL) – 72 W; and PDP – 120 W. However, these global averages do hide some of the within technology best and worst performers. Forecasts suggest that by 2014, a 40 inch OLED TV will be ~€1,050 compared to <€375 for a LCD TV. Most consumers will not buy OLEDs until they become more price-competitive, which is expected to take more than 3 years. The initial low competitiveness means that more 40-55 inch models will be released on the market compared to 30-39 inch models. There is also a price premium for increasing screen size. Whilst the price of a larger screen is generally higher for the same technology, there has been a decrease in the retail price for flat screen LCD and PDP technologies overall which is driving the market transition. PCs and laptop computers are covered by the International ENERGY STAR agreement between the EU and USA which is also adopted by many other countries including Japan. The average energy consumption in Australia has been estimated at ~121 kWh/yr for a desktop computer and ~44.4 kWh/yr for a laptop computer. In the US, energy consumption was estimated at 500 kWh/yr for a desktop computer, 28 kWh/yr for a laptop computer, 84 kWh/yr for a LCD monitor and 200 kWh/yr for a CRT monitor. Desktop computer and laptop computer prices vary depending on the specifications. It is very difficult to make any relevant price comparisons without some indication of the technology specifications. In 2005, desktop computers were on average €520 and €620 for commercial and domestic sectors, respectively [18]. The average US price for a commercial desktop computer in 2009, was very similar to the EU average at €557. The price of desktop computers has been decreasing since 2000. In the UK in 2012, desktop computers were available on the market at prices as low as €184. In 2005, laptop computers were on average more expensive than desktop computers at €990 and €1240 for commercial and domestic sectors, respectively.

■ **POTENTIAL AND BARRIERS –** New emerging TV technologies, such as OLEDs and LCD LEDs, have the potential to reduce energy consumption from TVs. The main barriers to reducing total global energy consumption from TVs include the price of these more efficient TVs; the increases in TV ownership, the number secondary and tertiary TVs and screen sizes – as energy consumption is proportional to screen area. The growth in screen size is a global issue. In 2010, the global shipment display area was 79 million m^2 forecast to increase to 104 million m^2 by 2014. The rapid turnover and demand for increased performance means computers are constantly evolving. Therefore, there is potential for tighter energy performance standards to be developed and saturate the stock in a short space of time. For desktop computers, there is also potential for upgrading components, such as hard disk drives, graphics cards and other parts. However, the development window is much shorter giving less time for impact assessments.

PROCESS AND TECHNOLOGY STATUS

Between 1990 and 2009, the world's total final energy consumption increased by 31 % [7]. Consumer Electronics and Information and Communication Technologies (CE.ICT) are among the fastest growing electricity end-uses in the residential and service sector. This rapid growth means there has been a greater focus on energy efficiency in recent years. The world's ICT market has a particularly high economic value and reached an estimated €2,000 billion in 2008. The European and North American markets both make sizable contributions to the world ICT market and annual market growth was around 4% in 2007 for both the EU and World markets [3]. According to the

Please send comments to Rachel.Mould@aeat.co.uk, Gena.Gibson@aeat.co.uk, Thomas.Ramsson@aeat.co.uk, and to Giorgio.Simbolotti@enea.it and Giancarlo Tosato (gct@etsap.org), Project Coordinators

International Telecommunication Union (2009), the most advanced countries (in terms of ownership and access to ICT) include the Northern European countries and the Republic of Korea [3].

This brief discusses the main consumer electronics in terms of ownership and total energy consumption at the global scale. The most significant technologies are as follows:

- Televisions (domestic)
- Computers (domestic and commercial)

■ **Televisions (TVs) –** A TV is a product consisting of a display and one or more tuners/receivers in a single housing. It is designed to receive, decode and display audio-visual signals, as well as reproduce sound from analogue or digital sources that are broadcast using satellite, cable or antenna signals. TVs are defined by display type; function; screen size; resolution and aspect ratio.

TVs are responsible for 6-8% of global residential electricity consumption [3], [11]. In 2010 there were an estimated 250 million TVs on the global sales market [13]. They are a global commodity and there is substantial international trade [12]. The largest TV markets are in North America, Western Europe and China [13]. There is a trend towards ownership of two or more TVs in developed countries such as the US, the EU, Australia and the Republic of Korea [1], [6], [3]. For example, in 2009 99% of US households owned at least one TV; 44% of US households had three or more TVs; 33% had two TVs and 21% had one TV [1].

The main changes in the TV market include:

- Increased demand for flat panel displays
- Market trend toward larger screen sizes
- Transition to digital broadcasting
- Shift towards high resolution

Increased demand for flat panel displays: The stock has historically been dominated by **Cathode Ray Tube (CRT)** displays. Developing countries are still dominated by CRT displays. However, in most developed countries, **Liquid Crystal Displays (LCDs)** are now the dominant technology ranging between 50-90% of new sales [6], whereas sales of CRTs in 2009 fell to less than 5% in the UK, USA, Switzerland, Austria and Australia [3]. Global LCD sales were 190 million units in 2010 and are expected to increase to 269 million units in 2014 [13]. LCDs do not emit light directly and require a backlight. In early models cold cathode fluorescent lamps (CCFLs) were used for the backlight, but these are now being replaced by more efficient light emitting diodes (LEDs) [13]. This transition is expected to happen between 2010 and 2014 [13] and LCD LEDs are expected to capture more than 75% of the global market by 2014 [11]. **Plasma Display Panels (PDPs)** had varying market shares of between 8 - 30% in 2009 depending on the country [6]. PDPs are expected to remain viable because they have 3D advantages over LCD [13]. The demand for PDP 3D TVs was 0.76 million units in 2010 and is expected to grow to 12.2 million in 2014 [13]. **Organic Light Emitting Diode (OLED)** screens are similar to plasma screens, but use organic LEDs instead of fluorescent lights in each pixel [12]. OLEDs were adopted by Sony and LG for TV models in 2007 and 2009, respectively [13]. Market forecasts for OLED screens are uncertain, but they are expected to increase globally from 1,900 units (2009) to 1.08 million units (2014) [13].

Market trend towards larger screens: Screen size describes the diagonal length of the screen. It is commonly measured in inches, ranging from 11-70 inches [5]. In 2003, two-thirds sales were small screen sizes (14-26 inches) and sales of the largest screen sizes (40-70 inches) were negligible. In 2007, sales of small screen sizes dropped to 44% (of 33 million units) and sales of the largest size bracket increased to 5.8 million [3]. In 2009, the average global screen size had increased to 32 inches [6]. Although the trend is slowing, the average global screen size is forecast to reach 34 inches in 2014 [13].

Transition from analogue to digital: TVs can either function as analogue; analogue integrated with digital or digital. There is a global shift from analogue TVs to digital TVs as digital signals do not degrade, so the picture quality is higher.

Shift toward higher resolution: Resolution describes the detail an image holds. Full High definition (HD) is when the screen has 1080 pixels or more in the vertical direction, i.e. 1080 scanning lines. Standard resolution is less than 1080 [5].

■ **Computers -** Personal Computers (**PCs**) are devices which perform logical operations and process data. They are composed of a *central processing unit (CPU)* to perform operations, *user input devices*, such as keyboards, mice, digitisers or game controllers, and *display screens* to visualise the information. Desktop computers are designed for a wide range of home and office applications [18]. Small scale servers, work stations and games consoles are designed for significantly more energy consuming functions with different usage patterns [16]. On average, games consoles consume five times more energy than mainframe computers. The computers considered in this brief are limited to those (self-contained) non portable computers used in home and office environments [16]. Laptop computers are also called 'notebook' or 'tablet' PCs. They are portable computers designed for easy transportation. A battery or other portable power supply provides power when not connected to the main supply [18].

Personal Computers are widely traded internationally and used in the same manner by end-users across the globe [12]. Personal computers, including desktop and laptop (notebook) computers, represent a large share of the ICT related energy consumption [14]. The total EU-27 annual energy consumption was 9.6 TWh/yr for desktop computers and 6.0 TWh/yr for laptop computers in 2007 [3]. In Australia, PCs were responsible for 15.8% of the ICT carbon footprint (2009), second only to data centre emissions [17].

PCs became available on the market in the 1980s [18]. Since then, computer ownership has increased rapidly. In 1997, only 35% of US households owned a computer [1]. However, by 2009 75% of US households owned at least one: 41% had one computer and 35% had two or more computers [1]. An estimated 296 million PCs were in use in the US in 2010 [19]. By 2008, 57% of EU households owned at least one computer [3], [4], with highest penetration rates in the Netherlands (90%), Denmark (85%) and Sweden (82%) [3]. In other parts of the globe, the percentage of households with at least one computer was 85% in Japan; 80% in the Republic of Korea; 74% in Hong Kong (China); 73% in Australia and 3.7% in India (2007 figures) [4]. In 2010, there were estimated to be 1.4 billion PCs in use worldwide [19].

In most OECD countries, there is a switch taking place in offices from desktop computers to laptop computers, whilst the number of desktop computers grew by 7%, the laptop stock grew by 60% [3]. In the EU, the commercial stock was estimated to be 48.5 million desktop computers, 59.3 million laptop computers, 13.3 million CRTs and 41 million LCDs [3]. In Australia, there were an estimated 6.4 million desktop computers and 1.7 million laptop computers. The EU household stock was estimated at 111 million computers (49.6 million desktop computers and 61.2 million laptop computers). In Australia, household stock was estimated to include 8.8 million desktop computers and 4.5 million laptop computers (2009).

In 2008 worldwide sales of desktop computers were ~138 million and laptop computers were ~126 million, but in 2009 the sales of laptop computers topped desktop computer sales due to the success of netbook PCs [19].

In 2010, the worldwide PC market had sales of 320 million units and retail revenue was more than $320 billion [19], with sales in Asia expected to overtake Northern America by 2015 [19].

In 2012, desktop computers retained 40% of sales in Europe, the Middle East and Africa [20]. In the first quarter of 2012, sales of PCs in Europe, the Middle East and Africa grew by 6.7% compared to the year before. This contradicted Gartner predictions that the global market would shrink [20]. This increase was linked to the release of Microsoft Windows 7 [20]. In the emerging markets, growth was slower than expected in China and India and as a whole Asia and the Pacific regions performed below expectations [20].

The PC industry is very competitive and has a good record of adapting to emerging technologies and market trends. The main drivers for technology replacement in the market include:

Internet: Since the 1990s computers have become a means to access the internet. Internet applications are the main driving force for the computer industry. Over the next ten years, the cellular based communications network, broadband and internet access devices will grow further [19].

Small handheld devices: There is a continuous increasing trend of computer functions becoming integrated with small hand-held devices, such as mobile phones, with increasing memory and internet connection as standard. Telephony is not discussed in this brief [18].

Laptop computers: As mentioned above there has been large expansion in the EU laptop market, while the desktop computer market is levelling out with a steady volume of replacements (except in some new member states where there is continued growth) [18]. There are benefits associated with desktop computers which will prevent a complete transition. Benefits include better computing power; larger hard disks; greater flexibility, e.g. components such as graphics cards and hard drives can be exchanged [18].

Expansion of flat panel monitors: Similar to the TV market trend, there has been replacement of **Cathode Ray Tube (CRT)** monitors with flat panel monitors, such as **Liquid Crystal Displays (LCDs)** in a very short period of time. **LCDs** have improved picture and brightness over CRT displays. The EU installed CRT monitor base was projected to be less than 2 million by 2010 [18]. The technology development of monitors is driven by the demand for better resolution and performance for showing moving pictures. Emerging technologies include LED-backlights and OLEDs.

Software replacements, including both operating systems and application software: The specifications of new operating systems are often above the performance capabilities of a large proportion of the installed stock, thus acting to drive replacement of computers, where operating systems are updated [18]. This was seen recently with the release of Microsoft Windows 7 [20].

New memory technologies: There has been a fast evolution in flash memories which in the short term will provide possibilities for energy reduction by partly replacing hard disks [18].

Media pads and tablets: This category is expected to expand rapidly in the next five years. The computer industry will be larger than previously expected because of demand for this sub-group [19].

The long term trend is that low power processors are being integrated into increasing numbers of electronic devices. This has been demonstrated already by the success of the 'smart phone' with its combined internet, camera and telephone functions. There is also debate about whether the 'smart TV' or a central communication unit capable of both computer and TV functions will increase in market share in the future.

PERFORMANCE AND COSTS

■ **TV Performance –** An increase in the number of TVs per household, especially in emerging markets, and the average screen sizes is expected in the years to come [13]. In the short term however, global TV electricity consumption is expected to decrease slightly by 2020

Please send comments to Rachel.Mould@aeat.co.uk, Gena.Gibson@aeat.co.uk, Thomas.Ramsson@aeat.co.uk, and to Giorgio.Simbolotti@enea.it and Giancarlo Tosato (gct@etsap.org), Project Coordinators

because of large-scale technology transitions and improvement in TV energy efficiency.

Power consumption varies between technologies and depends on the brightness of the picture and the data stream being processed by the tuner and operational mode of any devices integrated into the TV [12].

Common parameters for measuring the performance of TVs include Unit energy consumption and Unit energy efficiency. **Unit energy consumption** describes the electricity input in Watts, often further defined as the energy consumption during on-mode compared to stand-by or off-modes. On-mode consumption (W) provides the most appropriate indicator of likely national consumption [5]. **Unit energy efficiency** is the energy consumption per unit of screen area (Watt/dm^2) where dm^2 is a measure of diagonal screen size squared [5]. An alternative developed in Europe for energy labelling is the Energy Efficiency Index (EEI), calculated as:

EEI = on mode consumption/(20+4.3224 x screen area), where screen area is in dm^2 (1 dm^2 = 100 cm^2)

The EEI metric indicates the overall efficiency regardless of screen size. Lower EEI means better efficiency with the most efficient products around 0.3 and worst around 2 [6]. Historically, CRT technology has achieved the best EEI (0.78 in 2007), followed by LCD (0.99 in 2007) and PDP (1.28). Since then, relative efficiencies have changed with the emergence of new technologies; CRT was the worst (0.725 in 2010), followed by CCFL-LCD (0.467 in 2010), PDP (0.436 in 2010), LED-LCD (0.356 in 2010) and OLED (0.247 in 2010) [13].

On-mode consumption varies across technology types. In 2010, the global averages were estimated at 55W for CRTs; 72W for LCD CCFL; 67W for LCD LED; 120 for PDP and 11W for OLED [13]. The additional tuners required for high definition terrestrial reception might add 1-5 W to on-mode power demand [6]. PDPs had an average on mode power rating more than twice that of LCDs in 2009 and the efficiency appears more than 35% less than LCDs. Given this it is likely that an increase in PDP sales would significantly increase total TV energy consumption [6]; however, there is evidence to suggest that PDP market share is now declining [13].

Average **standby consumption** from benchmarked countries has fallen from 4.4 W (2000) to 1.5 W (2007) [6]. Some countries are on track to achieve a standby consumption of <1 W, such as the Republic of Korea, Austria, Switzerland and the UK. However, rapid-start modes are becoming available, which have significantly higher stand-by consumptions of ~17 W [6].

However, these averages hide some of the best and worst performers. In a 2010 IEA benchmarking study, the best on-mode performance was a 14 inch LCD screen (16 W), whereas the highest power demand was seen in a 63 inch plasma screen (750 W) [6]. There is potential for significant energy consumption reductions if the market moves towards Best Available Technologies. A number of LCD LED technologies available today have lower energy consumption and there is some evidence that a shift is occurring. For example, between 2008 and 2009, the average power demand for benchmarked countries fell for all screen technologies (8% for LCD; 13% for plasma screens and 7% overall) [6].

The **shift to digital broadcasting** is fairly advanced in Europe where it will be completed for all Member States by the end of 2015 [3]. It is expected that equipment for reception, decoding and interactive processing of digital broadcasting and related services will make a substantial contribution to electricity consumption in the near future. An integrated digital tuner, essential for operation of digital TV, results in only a few watts (1-5 W) additional consumption per TV set [5], [6], [12]. Set top boxes contribute up to 10 TWh per year to electricity consumption [3].

The growth in **screen size** is a global issue because energy consumption is proportional to screen area [5]. In 2010, the global shipment display area was 79 million m^2 forecast to increase to 104 million m^2 by 2014 [13] (see Process and Technology status for more on market trends). In the EU there is some evidence that the growth trend is slowing. Between 2007 and 2009, there was 3% growth in screen size for LCDs and 2% growth for PDPs [6] - equivalent to a 4-6% increase in annual energy consumption. Emerging technologies, such as LED back-lit LCD screens and OLED screens, with improved energy efficiency could offset the impact of increasing screen size in the future [6]. The LED backlights are regarded as one of the best options for meeting new energy standard requirements for TVs [13].

Many new technologies have **higher resolution**. High resolution can increase energy consumption, but improvements in silicon and system design are expected to achieve energy consumption similar to typical standard definition TVs [6].

It is also important to compare TV **usage patterns** between countries. Many countries calculate annual energy consumption for TVs using assumptions about the amount of time the TV is in the on-mode each day. In addition consumption in stand-by modes may be added to the figure. In order to make sense of these energy consumption figures, the usage patterns for each mode must be considered if direct comparisons are to be made between countries [12]. The global average number of viewing minutes decreased slowly between 2005 and 2007 from 233 min/person-day to 229 min/person-day. However, in 1995, the global average number of viewing minutes was only 205 min/person-day, so there has been a 30 minute increase since then [3]. Between 2005 and 2007, viewing minutes decreased in the UK, remained constant in Italy and increased in Germany, France and Spain, but all these countries had average viewing minutes in the range 200-230 min/person-day [3]. The EU average is approximately 240 viewing min/person-day [8], and 31% of the EU-27 population spent more than 150 min/day watching TV, whereas 40% spent less than 90 min/day (2008) [3].

■ **TV costs –** The TV market is highly globalised and TVs sold across different regions are very similar [13].

The TV market is one of the few markets where technology demands are a stronger driver than price. The cheapest TVs are **CRTs**, although mass production is expected to stop in the next couple of years. More affordable LCDs are expected to replace CRTs. **LCD CCFLs** are expected to continue to hold approximately 20% of the market in developing markets. In developed countries a transition is taking place from LCD CCFLs to **LCD LED** displays irrespective of the price difference [13]. Major brands are expected to provide newly designed LED backlit LCD TVs at lower prices in emerging markets [13]. This can be achieved by lowering the maximum luminance level and colour reproduction capability in LCD panels resulting in lower power consumption without additional cost [13]. LCD LED-edge backlit TVs have lower manufacturing costs than direct backlit LED TVs, so are expected to be the mainstream technology by 2014 [13]. In the UK**, PDPs** in the larger size bracket (>53 inches) are available at the cheaper prices (~€450). The top price for this size range is similar for LCD and PDP technologies at around €2400 [10]. PDPs are expected to decline as the production costs of 3D LCD TVs becomes more competitive [13]. The more efficient **OLED** TVs with screen sizes over 30 inches are expected to commercialise in 2012, but initially they are not expected to be cost competitive against the LCD TV [13]. Forecasts suggest that by 2014, a 40 inch OLED TV will be ~€1,050 compared to <€375 for a LCD TV [13]. Most consumers will not buy OLEDs until they become more price-competitive, which is expected to take more than 3 years [13].

There is a price premium for **increasing screen size.** Whilst the price of a larger screen is generally higher for the same technology, there has been a decrease in the retail price for flat screen technologies overall [8].

■ **Computer performance –** ICT appliances (such as PCs, laptop computers and monitors) are covered by the International ENERGY STAR agreement between the EU and USA which is also adopted by many other countries including Japan [12]. Japan regulates computer energy performance through Top Runner requirements. China is also developing Minimum Energy Performance Standards.

Many countries determine performance of computers within particular use **duty cycles**. The off-mode is the lowest power level where the unit is connected to the mains electricity supply but is unresponsive to the user. Sleep mode is a low power mode from which the computer can quickly become 'awake'. Idle mode is where activity is limited to the basic applications that the system starts by default. Active state (on-mode) includes active processing, seeking data from storage, memory or case and includes idle time waiting for further user inputs before entering the lower power sleep mode. Since 2008, many parts of the world have adopted a 'conventional duty cycle' for desktop computers this assumes 55% of time in off-mode; 5% in sleep mode and 40% in idle mode. For laptop computers, the 'conventional duty cycle' assumes 60% of time in off-mode; 10% in sleep mode and 30% in idle mode [15], [16].

The performance of computers is commonly expressed in terms of **Typical energy consumption** – the electricity input in Watts (W) is scaled by the typical usage model or duty cycle to calculate typical annual electricity use during a representative period of time, measured in kilowatts per hour (kWh) [16].

The major components that draw power from a typical computer are as follows [2], [16]:

- Central processing unit (CPU), an electronic circuit that executes computing programs and functions;_
- Random Access Memory (RAM) that allows stored data to be accessed at any order;
- Hard disk drive;
- Optical drive;
- Graphics processing unit (GPU);
- Ethernet network card;
- In laptops, additional energy is used in the LCD display monitor.

The average energy consumption in Australia has been estimated at ~121 kWh/yr for a desktop computer and ~44.4 kWh/yr for a laptop computer [17]. In the US, energy consumption was estimated at 500 kWh/yr for a desktop computer, 28 kWh/yr for a laptop computer, 84 kWh/yr for a LCD monitor and 200 kWh/yr for a CRT monitor [2].

■ **Computer costs –** Desktop computer and laptop computer prices vary depending on the specifications. It is very difficult to make any relevant price comparisons without some indication of the technology specifications. In addition, the last EU benchmarking study [18] was conducted in 2007, so there is a lack of publically available EU price data after 2005.

In 2005, desktop computers were on average €520 and €620 for commercial and domestic sectors, respectively [18]. The average US price for a commercial desktop computer in 2009, was very similar to the EU average at €557 [2]. The price of desktop computers has been decreasing since 2000 [18]. In the UK in 2012, desktop computers were available on the market at prices as low as €184.

In 2005, laptop computers were on average more expensive than desktop computers at €990 and €1240 for commercial and domestic sectors, respectively [18]. The price of laptop computers has been decreasing since 2005. In the UK in 2012, laptop computers were available on the market at prices as low as €238.

The price declines have been considerable in the last two years [19]. This has resulted in revenue growing slower than the growth in unit sales [19].

POTENTIAL AND BARRIERS

■ **TVs -** Few regions have regulated TVs for energy efficiency [12]. Until recently, the energy consumption of TVs was considered low to moderate, but technology transformation over the last 5 years has changed this assumption [12].

The European Commission published a set of mandatory Eco-design Regulations (EC No 1275/2008) covering standby and off-modes of electrical and

electronic household and office equipment in 2008. The Regulations came into force in January 2010. A second tier of requirements is to be enforced in January 2013. China introduced a Minimum Energy Performance Standard (MEPS) in 2005 with revisions made in 2009. It is comparable to an early European Index System and the maximum permitted EEI for 2009 is not exceeding 1.0 (using IEC62087 Edition 1 which covers CRT technology) [12]. Australia and New Zealand also introduced MEPS in 2009 (using the IEC62087 Edition 2 approach) [12]. In Japan, Top Runner specifies requirements for TVs in terms of an energy target and label. Static images are used for the determination of energy consumption [12]. In the US, new ENERGY STAR requirements based on maximum on-mode power consumption are to be introduced from May 2012 (version 5) [12]. India is developing a voluntary star rating for TVs [12]. In Europe, the Eco-design Directive requirements also include MEPS [12].

As described earlier, new emerging technologies, such as OLEDs and LCD LEDs, have the potential to reduce energy consumption from TVs. The best LCD screens on the market now appear significantly more efficient than CRT technology. Recent improvements to LCD screens include: a polarising filter to improve backlight efficiency by 10%; modulating Compact Fluorescent Lamp (CFL) backlighting, which can save 30% compared to standard LCD and LED backlighting, which is more efficient still and avoids the use of mercury [6]. Data has shown that within a technology type there can be a range of energy efficiencies, which might be attractive for the introduction of energy labelling and minimum efficiency standards.

In addition, power management features will become increasingly important in future. TVs will have the ability to manage their own energy consumption and that of associated equipment [12]. This will be particularly important given the increase in ownership trends and increases in energy consumption associated with increases in screen sizes.

Barriers that might hinder this transformation include:

Price: The initial purchasing decision is influenced to a large extent by price of the TV. This means that price premiums would be a significant barrier for energy efficient technology. However, there is evidence that in the TV market, 'design', which includes the demand for larger flat screen TVs, has outweighed price in the buying decision [8]. CRT TVs are cheaper than the larger flat screen devices, but their market share has nevertheless declined to a few percent in developed countries.

Screen size: Screen size directly influences on-mode energy consumption; as screen size increases so does energy consumption. Whilst there is some evidence that the increasing size trend is slowing, it is likely that larger screen sizes will continue to be popular in future. This demand will offset some of the technical energy efficiency improvements.

Secondary devices: The numbers of secondary devices in households are increasing across the globe, prolonging the life of TVs. Usage patterns vary to the primary device (usually in the main living room) [8], but represent additional energy consumption. In the past, time spent watching TV was about sharing time and space with the family. However, as the number of units increases, it is becoming more about individual preferences with family members watching different programmes [8] on different TVs in separate rooms. The age and efficiency of secondary TVs will have an effect on overall energy consumption.

Energy efficiency programs: there are relatively few energy programs in force globally that cover on-mode energy consumption of TVs. Those in force use different test procedures and different energy efficiency metrics and many were developed before the publication of IEC62087 Edition 2 [12]. This may hinder the delivery of global energy consumption reductions.

■ **Computers -** One reason for the rapid development of PCs is that standard components are made by a number of sub-suppliers [18]. Most computers are replaced not because they are broken, but because they have been superseded by technology with better performance. As such there are business opportunities for a number of different actors. In terms of energy efficiency, this is both a potential and a barrier.

It is a potential because the average lifetime of computer equipment is short; ~6 years for desktop computers and 4 years for a laptop computers [18]. The rapid turnover and demand for increased performance means computers are constantly evolving. Therefore, there is potential for tighter energy performance standards to be developed and saturate the stock in a short space of time. For desktop computers, there is also potential for upgrading components such as hard disk drives, graphics cards and other parts. Industry indicated that around 2% of consumers (mainly private consumers not businesses) upgrade components [18].

It could be a barrier because the development window is much shorter giving less time for impact assessments. For example, the market demand might be for increased technical performance, e.g. better graphics processing units (GPUs) that increase energy consumption.

References and Further Information

1. U.S. Energy Information Administration. 2011. Annual Energy review 2010 [Oct 2011]
2. U.S. Department of Energy, energy savings potential and RD&D opportunities for commercial building appliances, December 2009
3. Electricity Consumption and Efficiency Trends in European Union – Status Report 2009. Paolo Bertoldi and Bogdan Atanasiu, http://re.jrc.ec.europa.eu/energyefficiency/pdf/EnEff_Report_2009.pdf [2009]
4. International Telecommunication Union: "Measuring the Information Society. The ICT Development Index", 2009, ISBN 92-61-12831-9, http://www.itu.int/pub/D-IND-ICTOI-2009
5. International Energy Agency (IEA), 2011 4E Product definition: TVs [pdf]: http://mappingandbenchmarking.iea-4e.org/matrix?type=product&id=2 [Jul 2009].
6. International Energy Agency (IEA), 2011 4E Benchmarking document: TVs [pdf]: http://mappingandbenchmarking.iea-4e.org/matrix?type=product&id=2 [Oct 2010].
7. EEA, Final energy consumption by sector, calculated from Figure 2 (CSI 027/ENER 016) http://www.eea.europa.eu/data-and-maps/indicators/final-energy-consumption-by-sector-2/final-energy-consumption-by-sector-7
8. EuP Preparatory Studies “TVs” (Lot 5), Final Report on Task 3, “Consumer behaviour and local infrastructure”, (August 2007) Frauenhofer Institute
9. Top ten website, prices taken on 9th April 2012, based on a TV with screen size <70cm and >130cm for Switzerland http://www.topten.eu/
10. Price runner, UK prices taken on 9th April 2012, http://www.pricerunner.co.uk
11. Super-efficient. Org, TV summary, http://www.superefficient.org/en/Products/TV.aspx [Apr 2012]
12. Collaborative Labeling & Appliance Standards Program (CLASP), Opportunities for Success and CO2 Savings from Appliance Energy Efficiency Harmonisation, part2, chapter 10: TVs, http://www.clasponline.org/ResourcesTools/Resources/StandardsLabelingResourceLibrary/2011/~/media/Files/SLDocuments/2011-03_HarmonizationStudy/CLASP_HarmonizationStudy_Part2.pdf [Mar 2011]
13. Lawrence Berkeley National Laboratory, “TV Energy Consumption Trends and Energy-Efficiency Improvement Options”, http://www.superefficient.org/Products/TV/~/media/45B254FF5DF246D7A0FA8838F0EB90EB.pdf [Jul 2011]
14. Super-efficient. Org, Computer summary, http://www.superefficient.org/Products/Computers.aspx [Apr 2012]
15. International Energy Agency (IEA), 2011 4E Product definition: laptop computers [pdf]: http://mappingandbenchmarking.iea-4e.org/matrix?type=product&id=7 [Apr 2010].
16. International Energy Agency (IEA), 2011 4E Product definition: desktop computers [pdf]: http://mappingandbenchmarking.iea-4e.org/matrix?type=product&id=10 [Feb 2011].
17. Australian Computer Society (ACS): Carbon and Computers in Australia, http://www.acs.org.au/attachments/ICFACSV4100412.pdf [Apr 2010]
18. European Commission Preparatory Study for Eco-design Requirements of EuP: Lot 3 Personal Computers (desktop computers and laptop computers) and Computer Monitors, [Sep 2007] http://extra.ivf.se/ecocomputer/downloads/Eup%20Lot%203%20Final%20Report%20070913%20published.pdf
19. http://www.etforecasts.com/products/ES_pcww1203.htm
20. www.pcpro.co.uk/news/374059/pc-sales-bounce-back-in-europe

Table 1 – Summary Table – Key Data and Figures for TVs

Technical Performance	EU	UK	Switzerland	Australia	Republic of Korea	US
Average screen size (cm) [6]	78 (2009)	82 (2009)	88 (2008)	85 (2008)	94 (2008)	-
On-mode total consumption) (W) [6]	141 (2009)	141 (2009)	171 (2008)	179 (2007)	-	208 (2007)
Energy Efficiency Index[1] [6]	0.99 (2009)	0.92 (2009)	0.99 (2008)	1.01 (2007)	-	0.94 (2007)
Market Share – %						
Cathode Ray Tube (CRT) [6]	3 (2009)	5 (2009)	2 (2008)	0 (2008)	23 (2008)	0
Liquid Crystal Display (LCD) [6]	86 (2009)	89 (2009)	98 (2008)	72 (2008)	47 (2008)	88
Plasma Display Panels (PDP) [6]	11 (2009)	6 (2009)		28 (2008)	30 (2008)	11
Stock/Usage						
No. of units per household [6]	-	2.24 (2009)	1.35 (2007)	1.28 (2007)	1.48 (2008)	2.86 (2009)
Viewing minutes per day	240 (2007) [8]	218 (2007) [3]	223 (-) [6]	438 (-)[6]	414 (-)[6]	-
Screen size and performance of global TV models and projections for 2014 [13]	2010			2014 (with efficiency improvement scenario)		
	EEI	Average screen area per unit (m^2/unit)	Average on-mode power (W)	EEI	Average screen area per unit (m^2/unit)	Average on-mode power (W)
OLED	0.247	0.06	11	0.183	0.73	61
PDP	0.436	0.59	120	0.314	0.63	92
LCD LED	0.356	0.39	67	0.239	0.34	40
LCD CCFL	0.467	0.31	72	0.322	0.29	47
CRT	0.725	0.13	55	0.653	0.12	47

Table 2 – Summary Table – Typical Retail Prices[2] for TVs

Country/Technology	Western Europe	UK	US	Switzerland (BAT)	
	Price [8]	Price [10]*	Price [13]	Price [9]	Energy Efficiency Index1 [9]
CRT	€281 (2005)	-	-	-	-
LCD CCFL (>53 inches)	€985 (2005 typical LCD)	€1075 - 2380 (2012)	€896 - 2092 (2010)	-	-
LCD LED (>53 inches)		-	-	€3100** (2012)	0.26 (2012)
LCD CCFL (<35 inches)		€236 - 3641 (2012)	€145 - 374 (2010)	-	-
LCD LED (<35 inches)		-	-	€344** (2012)	0.28 (2012)
PDP (>53 inches)	€2411 (2005 typical PDP)	€440 - 2379 (2012)	€793 -1708 (2010)	€5825 (2012)	0.75 (2012)
PDP (<35 inches)		€1190 (2012)	€382 (2010)	-	-

*Notes: Prices for UK were taken from the Price Runner website and represent a sample of minimum and maximum prices for the technology types on 9th April 2012.
** Prices for Switzerland were taken from the TopTen website and represent the best available technology (BAT) for LCD-LED screens as compared to the less efficient PDP. Energy Efficiency Index provided to illustrate this.

[1] Indicates efficiency regardless of screen size; calculated by comparing the product to a notional market average TV of the same screen size.
[2] Using the conversion factors from the Coinmill website on the 9th April 2012 (1 Swiss franc = 0.83 Euro, 1 USD = 0.75 Euro and 1 GBP = 1.19 Euro)

Table 3 – Summary Table – Key Data and Figures for Computers

Global Computer Ownership	EU [3], [4]	US [1]	Japan [4]	Republic of Korea [4]	Australia [4]
% of households with computers	57 (2008)	75 (2009)	85 (2007)	80 (2007)	73 (2007)
Stock (installed base) millions	US Commercial [2]	Australia Domestic [17]	Australia Commercial [17]	EU Domestic [3]	EU Commercial [3]
Desktop computer	60.4 (2008)	4.5 (2009)	6.4 (2009)	49.6 (2007)	48.5 (2007)
Laptop computer	47.6 (2008)	8.8 (2009)	1.7 (2009)	61.2 (2007)	59.3 (2007)
LCD Monitor	51.3 (2008)	-	-	13.7 (2007)	41 (2007)
CRT Monitor	13.5 (2008)	-	-	49.6 (2007)	13.3 (2007)
Technical Performance	EU				
On-mode power (total consumption) (W/m^2) [18]	Average	Min	Max		
CRT Monitors	760	281	1087		
LCD Monitors	290	184	617		
Power Consumption in Watt [18]	Idle mode	Sleep mode	Off mode		
Desktop computer	78.2 (2005)	2.2 (2005)	2.7 (2005)		
Laptop computer	32 (2005)	3 (2005)	1.5 (2005)		
Average – Unit Energy Consumption (kWh/yr)	US [2]	Australia [17]			
Desktop computer	500 (2008)	121 (2010)			
Laptop computer	28 (2008)	44.4 (2010)			
LCD Monitor	84 (2008)	83.7 (2010)			
CRT Monitor	200 (2008)				

Table 4 – Summary Table – Typical Retail Prices for Computers

Country/Technology	Europe*	US	UK**
	Price [18]	Price [2]	Price [10]
Desktop computer (domestic)	€620 (2005)	-	€184 - 6150 (2012)
Desktop computer (commercial)	€520 (2005)	€557 (2009)	
Laptop computer (domestic)	€1240 (2005)	-	€238 - 4700 (2012)
Laptop computer (commercial)	€990 (2005)	-	
CRT monitor (domestic)	€73 (2005)	-	€77(2012)
CRT monitor (commercial)		€83 (2009)	
Flat panel monitor (domestic)	€201 (2005)	-	€30 – 44800*** (2012)
Flat panel monitor (commercial)		€142 (2009)	

* Notes: The last computer EU benchmarking study was completed in 2007, ref [18], which explains the use of 2005 prices.
** Prices for UK were taken from the Price Runner website and represent a sample of minimum and maximum prices for the technology types on 9th April 2012.
***There are a small number of very expensive monitors on the UK market, these are not errors.