



Estimating the impact of the “digital switchover” on disposal of WEEE at household waste recycling centres in England

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ABSTRACT

Using Hampshire County Council (HCC) as a case study, this paper evaluates and discusses the estimated impacts of the so-called digital switchover (DSO) (scheduled for 2012 in Hampshire) on Household Waste Recycling Centres (HWRCs) in England and the UK. Two public surveys of Hampshire residents were used to collect data on their preparedness for and awareness of the switchover and its implications. The survey also sought to establish the quantities of televisions (TVs) and TV related devices that are ready for the DSO. The quantities of TV and related devices that are likely to be disposed via HCC's collection network have been established and compared to the County's current handling capacities for waste electronic and electrical equipment (WEEE). Best and worst case potential net disposal scenarios have been established and the latter compared to Government projections. In addition, the potential environmental, logistical, financial and legal impacts of the WEEE arising as a consequence of the switchover have been identified and discussed. The results indicate that the majority of TVs both in Hampshire and the UK are digital ready and that awareness of the switchover is high. In contrast, most recording devices in Hampshire are not ready for the DSO. Awareness of the timeframe of the event remains modest however and about half of Hampshire households were not aware that TV recording devices will be affected by the switchover. A significant proportion of waste TVs and related equipment would be taken to HWRCs in contrast to smaller items such as remote controls that would more likely be disposed with normal household waste. Projected figures for the DSO year show that if Hampshire maintained its current collection capacity for WEEE it would experience a handling shortfall of around ~100 K for TVs and recording devices, respectively. The most important finding of the study is that the UK Government may have substantially underestimated the quantities of TV and related devices that will be disposed during the switchover. The potential impacts for local and national WEEE management have been discussed. The paper concludes by making recommendations to address identified issues.

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1. Introduction

The rate of discarded waste electronic and electrical equipment (WEEE) is growing at an alarming rate, especially in Organization for Economic Cooperation and Development (OECD) countries where markets are saturated with huge quantities of new electronic goods. Globally, an estimated 20–50 million tonnes of WEEE is discarded annually, rising at a rate of 3–5% per annum (Schwarzer et al., 2005). European Union (EU) countries dispose of an estimated 6.5 million tonnes of WEEE year⁻¹ (~8% of all municipal waste); by 2015 the figure could be as high as 12 million tonnes (Goosey, 2004). In the UK, WEEE is one of the fastest growing waste streams (POST, 2007) with nearly 940 K tonnes of domestic WEEE discarded in 2003, comprising 93 million items of equipment (ICER, 2005). It is estimated that every year, households throw away around one million tonnes of WEEE including televisions

(TVs), fridges, hairdryers and computers. However, a recent study by Ongondo et al. (in press) argued that the reported global quantities of WEEE seem to be vastly underestimated.

Such large quantities of WEEE and the fact that they often contain a wide variety of materials, many of which are potentially harmful to both humans and the environment, has focused attention not only on how WEEE is handled but also on why so much of it is generated and the ways in which it can be managed. Concerns over the increasing quantities and potential environmental impacts of WEEE have led to the introduction of WEEE management policies and legislation around the world (Ongondo and Williams, 2009; Ongondo et al., in press).

Illegal shipping of WEEE to developing nations can have severe repercussions. Whilst trading, repairing and regaining materials from WEEE provides a business opportunity for emerging economies, demand and lack of national and/or lax enforcement of regulations can promote the growth of poorly controlled and risky semi-formal/informal WEEE sectors (Babu et al., 2007). Improper treatment can result in adverse environmental and health impacts.

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In the 'electronics junkyard' of Guiyu village, China, for instance, bare-handed disassembly of WEEE and inhalation of toxic dioxin fumes from melting plastics clearly poses potentially serious health hazards. Air, soil and water are contaminated by organic chemicals and metals from the disassembly of WEEE (Herat, 2007), with lead in soil and drinking water 200 and 2400 times over World Health Organization (WHO) limits, respectively (Puckett et al., 2002).

Ongoing management of WEEE within the EU is of high priority, as despite legislation, the European Commission (EC) reports that only one third of WEEE arisings appear to be collected, treated and reported according to the WEEE Directive, and that trade to developing countries appears to be widespread (CEC, 2008).

1.1. The digital switchover

A global phenomenon that may pose a significant challenge to the management of WEEE is the so-called TV "digital switchover" (DSO), which involves replacing the traditional analogue terrestrial transmission with solely digital signals. This switch to digital TV will require a widespread switch of technologies – both in the equipment that consumers use to receive TV pictures, and in the infrastructure used to broadcast them. Viewers will need to convert or upgrade their TV equipment to receive digital signals, either through an aerial, by satellite, cable or broadband. The switch not only affects TVs but also video recorders (VCRs), DVD recorders and analogue set-top-boxes (STB). Although recording devices will largely retain their functions, unless adapted by a special conversion box, these devices will not be able to record one TV channel whilst watching another (DUK, 2007).

There is concern that the switchover may impact the collection and treatment of WEEE (see Armishaw et al., 2007) as householders make the conversion, particularly if they are unprepared for the switch and upgrade equipment at the last moment. The arisings of waste TVs and related equipment due to the DSO should be carefully considered because of the potential logistical, environmental and financial impacts as well as the risk for illegal shipments of WEEE.

1.1.1. Digital switchover globally

The transition to digital TV is, at present, largely occurring in the more advanced economies of the world, with the major markets found in the USA, Japan and Europe (and within Western Europe, mainly in the UK, Spain, Germany, Italy and France) (Levia et al., 2006). The US made the switch in June 2009 and Japan is set to switch in 2011. In Europe, the EC has designated 2012 as the date by which analogue terrestrial TV transmissions will cease (DUK, 2007). A number of European countries such as Sweden and Luxembourg have already made the switch, whilst others such as Ireland, Belgium and the Czech Republic were yet to start (DUK, 2007).

Levia et al. (2006) reviewed and contrasted DSO policy in Europe, the United States and Japan. The broad policy aims of the switchover were found to be similar across these nations, with aims of clearing the spectrum, modernising infrastructure, and improving the services to the consumer, shared across the major countries studied. Where practical, region-by-region switchover policy (as adopted by the UK), was concluded to have the best potential to reduce risks of transition and assist logistics. Individual countries have had to decide whether full national coverage should be achieved by terrestrial digital transmission or whether a free-to-view satellite service as the only non-subscription option in some areas is acceptable. This has led to varied patterns. No country has opted for an all-pay system of digital terrestrial; the emerging pattern being either fully free-to-view or hybrid free-pay (Levia et al., 2006).

As the switchover is in its infancy, little research has been carried out to investigate its environmental impacts. Initial reports on the switchover in the USA suggest that many householders delayed converting equipment until just prior to the switchover (BBC, 2009). This may have led to a concentrated effect, particularly as the entire nation switched simultaneously (as opposed to region by region).

1.1.2. Digital switchover in the UK

In September 2003, the UK Government announced that it was committed to switching off the UK's analogue terrestrial TV network as soon as it was practical to do so. Three years later, it announced the go-ahead for the switch to digital-only TV in the UK. This policy, referred to as the 'digital switchover' policy, would see all the 14 TV-regions of the UK move to digital TV and the analogue terrestrial signals switched off TV-region by TV-region between 2008 and 2012, in line with the EC target to cease analogue TV transmission in Europe by this deadline. Following the switch, all TV equipment will need to be compatible with the digital signal, either through aerial, cable or satellite (DUK, 2007).

WEEE management has historically been problematic in the UK as a result of the introduction of new legislation. In 2001, the implementation of the EU Regulation on Ozone Depleting Substances led to the build up of thousands of fridges at local council waste collection sites (dubbed the 'fridge mountain') as export of unwanted fridges to countries not signed-up to the Montreal Protocol was banned, and the UK Government had failed to formulate contingency plans for fridge recycling plants (Florence and Price, 2005). Development of facilities to treat this back-log led to over-capacity in the long term, unnecessary cost and embarrassment.

Recent media coverage in the UK has highlighted the risk of illegal shipping of WEEE. Greenpeace took an unfixable TV fitted with a tracking device to a Hampshire County Council (HCC) household waste recycling centre (HWRC) for recycling. Instead of being safely dismantled in the UK or Europe however, the TV was tracked to Nigeria, having been passed off as 'second-hand goods'. The investigation exposed potential loopholes in recycling programmes that might allow illicit profits to be made by the developed world's traders through dumping obsolete and hazardous electronics abroad instead of properly recycling them (Greenpeace, 2009). However, an independent audit report concluded that, in principle, the activities and operations of HCC comply with the relevant waste regulations relating to the export for reuse of CRTs and monitors (Gifford, 2009).

Proper and timely identification of the impacts of the generation and management of WEEE during the DSO should ensure adequate preparation by local authorities (LAs), and improve the effectiveness of public policy. Proper handling will also contribute to key objectives set out in the Government's Waste Strategy 2007 to divert waste from landfill, increase recycling of resources and secure infrastructure for diversion of waste from landfill and management of hazardous waste (DEFRA, 2007).

Very limited research has been carried out in the UK with regard to the DSO. However a recent Government commissioned report by the Market Transformation Programme (MTP) projected no increased arising of waste TVs and recording equipment as a specific result of the switchover (Armishaw et al., 2007). The environmental impact of consumer electronics was predicted to occur mainly from increased product ownership and functionality/size with the contribution of the DSO to this overall trend being minimal.

Increased awareness of recycling of WEEE as a result of the switchover may also prompt recycling of other household WEEE items. Many consumers do not immediately discard unused electronics as they perceive retention of value (Babu et al., 2007). In

addition, the switchover may provide a trigger for households to upgrade to newer TV and recording equipment models earlier than might have been expected (Armishaw et al., 2007). Indeed, initial assessment suggests this may have been the case in Cumbria, the first UK region to have switched (Gyekye, 2009). However significant technical innovations such as the development of high definition and flat screen TVs as well as the prevailing economic climate may impact such future decisions/investments.

Ofcom (2008a) reported that 70% of all UK TV sets were digital in June 2008, with conversion rates highest in those regions switching earliest, although 18 million sets remain analogue. BARB (2009) estimated the number of digital TV homes in the UK to have risen from 2.2 million in 2000 to 22.3 million in 2009. The number of homes with at least one TV set in the UK in 2009 is estimated as 25.9 million (of a total 26.6 million homes) (BARB, 2009) with the total number of TVs in the UK totalling 60 million (Ofcom, 2008b).

1.2. Study aim and objectives

In light of the potential logistical, financial, ethical (illegal shipments) and environmental impacts of the DSO, the aim of this research was to estimate the impact of the switchover on UK LAs' collection and treatment of WEEE. Using HCC as a case study, the study had the following objectives; to:

- Evaluate residents' preparedness for and awareness of the switchover and its implications;
- Establish the quantities of TVs and TV related devices that are digital and non-digital ready, respectively;
- Examine whether the change to digital equipment will be gradual or sudden;
- Estimate the best and worst case scenarios of the net disposal levels of TVs and related devices as a result of the DSO policy;
- Identify the quantities of TV and related devices that are likely to be disposed via LAs' collection network;
- Compare the potential TV and related equipment disposal scenarios for 2012 with current collection and handling capacities; and
- Evaluate the potential environmental, logistical, financial and legal impacts of the WEEE arising as a consequence of the switchover.

This paper presents the results from a survey that sought to estimate the likely generation of electronic waste by the residents of Hampshire as a result of the DSO. These estimates are used to predict the likely impact on Hampshire's capacity to collect and manage the WEEE under two scenarios; a best and a worst case scenario. Further, the worst case scenario is compared with a UK Government commissioned report's projected quantities of WEEE that would arise within the Meridian TV-region as a result of the DSO (see Armishaw et al., 2007). In addition, the paper also reports, discusses and evaluates residents' awareness levels and preparedness for the switchover. Finally, the paper makes recommendations for consideration by local authorities in their strategy for the DSO; these recommendations also provide signposts to other countries on how to plan for the e-waste management implications of their DSO.

2. Case study – Hampshire County Council

The county of Hampshire lies in the South East of England and is politically governed by the HCC. In the 2001 national census, it had an estimated population of 1.2 million residents living in 502,706 homes (ONS, 2001).

2.1. Waste management in Hampshire

Waste collected within Hampshire is collectively managed through an integrated waste management strategy, known as Project Integra (Integra, 2008). This partnership involves the 11 district councils of Hampshire, Portsmouth and Southampton unitary authorities, HCC, and the private waste contractor Veolia Environmental Services. The network includes 26 HWRCs as well as 9 transfer stations and 2 materials recovery facilities.

Management of WEEE within the UK is controlled via the UK WEEE Regulations (BERR, 2007). This imposes extended producer responsibility on producers of electronic equipment, prioritising waste prevention, reuse, recycling and recovery to minimise the volume of WEEE sent to landfill. These must be treated according to specified standards, using best available treatment recovery and recycling techniques (BATRR) and avoiding dispersion of pollutants (DEFRA, 2006). Under the UK WEEE Regulations, distributors must take financial responsibility for WEEE either by offering in-store take-back or by joining a distributor take-back scheme which funds a network of designated collection facilities (DCF). Many DCFs are LA-operated HWRCs. Although under the UK WEEE Regulations, LAs do not have a direct obligation for the management of WEEE, those that are contracted to operate DCFs bear the responsibility of managing the WEEE collected at their HWRCs. This is also the case for HCC. At DCFs, separate collection of WEEE must be maximised, segregating the categories of WEEE into five groups where possible as shown in Table 1.

HWRCs are vulnerable to over- or under-allocation for specific types of waste due to the unpredictable nature of public demand for recycling (Maynard and Cherrett, 2006). In particular, many challenges and factors affect the prediction of disposal and take-back of electrical and electronic equipment (Stuart et al., 1998). Other relevant regulations/treaties that impact the operations of HCC include;

- The Regulations on trans-frontier shipment of waste (259/93/EEC) which stems from the Basel Convention on the Control of Transboundary Movements of Hazardous Waste and their Disposal (1989) (Schwarzer et al., 2005); and
- The Basel Ban Amendment, adopted in 1995, that prohibits all exports of hazardous wastes from parties that are member states of the EU, OECD and Liechtenstein to all other parties to the Convention.

2.2. Digital switchover in Hampshire

Hampshire falls within the Meridian TV-region of the UK and is set to switch to digital in early 2012, one channel (Channel 5) having already switched in March 2009. This TV region has approximately 2.17 million households (DUK, 2009).

3. Methods

A comprehensive literature review was initially carried out to identify similar studies. Additional secondary data was obtained from the UK Office of National Statistics (ONS).

Table 1
Segregation of WEEE at designated collection facilities (adapted from BERR, 2007).

WEEE stream	Description/example equipment
A	Large household appliances other than cooling appliances (washing machines, cookers, etc.)
B	Cooling appliances containing refrigerants (fridges, etc.)
C	Display Equipment (TVs, computer monitors)
D	Gas discharge lamps (fluorescent tubes)
E	All other WEEE (phones, drills, video games, etc.)

3.1. Public surveys

3.1.1. Postal survey

A public postal survey of Hampshire residents was conducted during summer 2009 to assess their self reported actions with regard to the DSO. Self-administered questionnaires were deemed the most appropriate way to obtain this information from a representative area in a short period of time. A questionnaire was developed and piloted in consultation with HCC. Specific questions were formulated to establish residents' level of awareness of the DSO, their preparation for it (past and future), their ownership of TVs and recording devices and their disposal habits of such equipment. The final section of the questionnaire ascertained socio-economic and demographic information.

A covering letter was attached to provide information and instruction, generate interest and increase likelihood of completion of the questionnaire. A prize draw with an incentive to win shopping vouchers by returning the questionnaire within two weeks was also offered to encourage participation, as well as a pre-stamped and self-addressed return envelope.

Nine hundred questionnaires were hand delivered to households in pre-selected areas of Hampshire. These were selected to be representative of householder affluence within the UK, according to the national English Index of Multiple Deprivation (IMD) (see Henry, 2007). Three boroughs were selected as representative of areas of (relatively) high, average and low deprivation in Hampshire. One hundred questionnaires were then delivered to randomly selected homes within wards of relatively high, medium and low deprivation within each area. Households within each area were controlled to include representative numbers of detached, semi-detached and terraced properties and flats. Questionnaires were coded to enable identification by area on return.

3.1.2. Structured interviews

A structured interview survey of 105 Hampshire residents was carried out to provide an additional snapshot of self-reported behaviour with regards to WEEE disposal and to verify findings of the postal survey (interviewing having a higher response rate (see Kelley et al., 2003)). Residents indicating use of HWRCs were asked further questions on mode of transport and reasoning behind trips. Reasoning behind disposal of WEEE via the household waste bin was also explored.

The survey was carried out in Southampton city centre, deemed a representative location for a range of Hampshire residents, and stratified throughout two weekdays to maximize the range of people available for the opportunity sample. Random systematic sampling was employed with the interviewer asking every third passerby to participate (see Kelley et al., 2003).

3.2. Estimating ownership and digital status of TV and recording equipment in Hampshire

The number of TVs and recording equipment owned by the respondents were summed and from these an average for Hampshire households was obtained.

TVs and recording equipment were grouped according to their ability to receive digital TV. There were further classifications according to whether the digital signals were received via a STB or a TV with an in-built tuner (IDTV). For the non-digital ready devices, classification was according to future options for the switchover, i.e. disposal; replacement; updating; or "fate undecided". The quantities of the equipment for these different statuses were collated and projected to get the respective figures for the whole county.

Data of residents' future timings to adapt their equipment for the switchover was also collated. These were classified into four groups in relation to the timing of the switchover in Hampshire, namely, before, after, during and "unsure".

3.3. Projecting best and worst case disposal scenarios respectively for TV and recording equipment

Several assumptions were made respectively for the best and worst case scenarios in relation to the disposal of TV and recording equipment as a result of the DSO.

3.4. Comparison of worst case scenario disposal with UK Government projection

The UK Government's 2012 worst case projections for the disposal of devices in Meridian TV-region were used to compute adjusted figures for Hampshire since it falls within this region. The disposal averages for Meridian-TV households were multiplied by the number of households in Hampshire to get adjusted Government projections. These adjusted projections were then compared respectively to this study's worst case scenario figures for Hampshire (see Table 2).

Disposal projections (numbers of units) were therefore computed thus:

- "Best case scenario = replaced^a + disposed^a".
- "Worst case scenario = replaced^a + disposed^a + unsure^b + undecided^c".
- ^aNon-digital ready TV and recording equipment.
- ^bOwners uncertain when they would replace equipment.
- ^cOwners undecided whether they would keep, convert, replace or dispose equipment.

3.5. Quantities of TV and recording equipment that could potentially be disposed at HWRCs in 2012 in a worst case scenario

Based on the structured interviews, responses on the most likely disposal options for each type of WEEE were summed and percentages calculated. A worst case scenario was assumed, predicting that all devices residents proposed to give to charities would in fact be disposed at HWRCs due to low demand for non-digital equipment following the switchover. The computed percentages were used to calculate the quantities (units and mass) of devices likely to reach HWRCs based on the best and worst case disposal projections computed in Section 3.3. Tonnage estimations

Table 2

Assumptions made in calculating the best and worst case disposal scenarios for TV and recording equipment.

Best case	Worst case
The reference point in time is 2012, the year of the switchover in Hampshire	
Residents who said they would <i>replace</i> their non-digital equipment during the switchover would do so, and would also <i>dispose</i> of their replaced equipment at the same time	Residents who said they would <i>replace</i> their non-digital equipment (as opposed to replacing them) would do so <i>during</i> the switchover
Residents who said they would <i>dispose</i> of their non-digital equipment (as opposed to replacing them) would do so <i>during</i> the switchover	Residents who said they were <i>unsure</i> when they would replace their digital equipment would do so <i>before</i> the switchover
Residents who were <i>unsure</i> when they would replace their digital equipment would do so <i>before</i> the switchover	Residents who were <i>unsure</i> when they would replace their digital equipment would do so <i>during</i> the switchover
Residents who were <i>undecided</i> if they would replace or <i>convert</i> their non-digital equipment would <i>convert</i> the equipment, thus not throwing it out	Residents who were <i>undecided</i> if they would replace or convert their non-digital equipment would <i>dispose</i> of the equipment during the switchover

were based on assumed average TV mass of 31.25 kg (HCC, unpublished data) and 4.5 kg for recording devices (based on a sample of manufacturer specifications). The total percentage waste reaching HWRCs for TV and recording devices, respectively was thus computed as follows:

Disposed WEEE at HWRC = HWRC + Charity shops

The amount (units and mass) of TV WEEE projected to be deposited at HWRCs in 2012 were then compared to the latest (2008–2009) collection amounts obtained from HCC unpublished data. There were no similar comparable figures for recording devices from the HCC data.

In order to establish a baseline comparison between the potential quantities of TV and recording devices WEEE that could end up at HWRCs in the Hampshire switchover year and the current annual handling capacities for these devices, it was assumed that the current annual capacities would remain the same up to and including the switchover year (2012). The projected amounts of TV and recording devices deposited at HWRCs (as computed in Section 3.5) were then subtracted from the annual capacities for TVs and small domestic appliances (SDA) in order to determine the net impact on handling capacities.

3.6. Comparison between capacity and projected 2012 disposal of TVs and recording devices at HWRCs

The current (2008–2009) Hampshire HWRCs annual capacity (available area for storage) to handle display devices and SDA WEEE were obtained from unpublished HCC data (note that these WEEE fall under category C and E, respectively in Table 1). Display devices WEEE contain both TVs and computer monitors. To compute the HWRCs annual capacity for TVs only, the following ratio by Walk (2009) was assumed (resultant proportions were rounded to two decimal places):

TVs : Computer monitors = 3.29 : 1

There was no annual capacity figure specific to recording devices from the HCC data. The annual capacity for SDA (under which recording devices fall) was therefore used for comparison only.

In order to establish a baseline comparison between the potential quantities of TV and recording devices WEEE that could end up at HWRCs in the Hampshire switchover year and the current annual handling capacities for these devices, it was assumed that the current annual capacities would remain the same up to and including the switchover year (2012). The projected amounts of TV and recording devices potentially deposited at HWRCs in the year of the switchover (as computed in Section 3.5) were subtracted from the annual handling capacities for TVs and SDA in order to determine the net impact on handling capacities.

3.7. Statistical analysis

Chi-square tests were carried out to test for association between socio-economic variables (age, income, sex and employment status) and respondents' awareness about the year of the switchover. Similar tests were carried out to measure association between these socio-economic variables and respondents' awareness about the effect of the switchover on recording devices. The tests were limited to data that were unique to the individual and not the household.

3.8. Comparison of awareness levels in Hampshire and the UK average

The awareness data were used to make comparisons with the latest (July–September, 2008) UK averages (see DUK, 2008), namely: (i) awareness about the date for the DSO; and (ii) aware-

ness that recording devices will be affected by the switchover. The comparisons for each were done for gender and low-income level, respectively. There were no other available comparable income level data for the UK and hence it was not possible to do other comparisons.

4. Results

A total of 214 complete and useable postal questionnaires were returned (23.8% response rate). In total, 97.6% of the respondents were aware of the DSO, whilst 66.5% were aware of when the switch would occur in Hampshire. Ownership of TV sets and recording devices is quite high, with 98.5% households reporting they had one or more TV sets in the home (average 2.2 TVs per home) and 84.7% households owning at least one recording device.

Only half of the respondents were aware that recording devices will be affected by the switchover and our findings indicate that approximately 39.2% of non-digital recording equipment, at least initially, will be kept as is by their owners despite their new limitations.

4.1. Preparedness: plans for switching non-digital ready devices

The respondents report planning to convert 50.6% of non-digital TVs and 14.6% of non-digital recording devices either by a STB, replacement with a new IDTV or a conversion box. Plans were uncertain for 37.3% of TVs and 17.9% of recording devices. Timing of actions for those devices that residents planned to convert are shown in Figs. 1 and 2, respectively.

4.2. Digital and non-digital ready devices in Hampshire

The data in Table 3 shows the distribution of TV equipment in Hampshire classified according to their readiness for the switchover.

4.3. Comparison of disposal routes for TV and related equipment waste

Responses in the structured interviews survey on disposal routes of WEEE confirmed findings of the postal survey that a substantial proportion of waste TVs, STBs and recording devices would be taken to HWRCs. Smaller items such as remote controls would more likely end up in the waste bin. Table 4 shows the percentage shares of the disposal route for unwanted TV and related

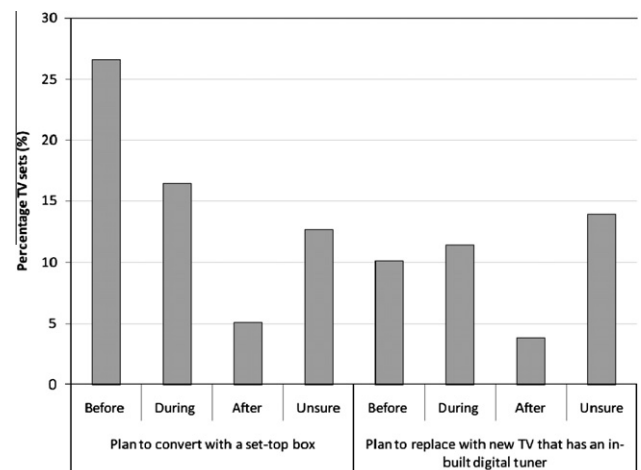


Fig. 1. Residents' plans for switching non-digital ready TVs ($n = 79$).

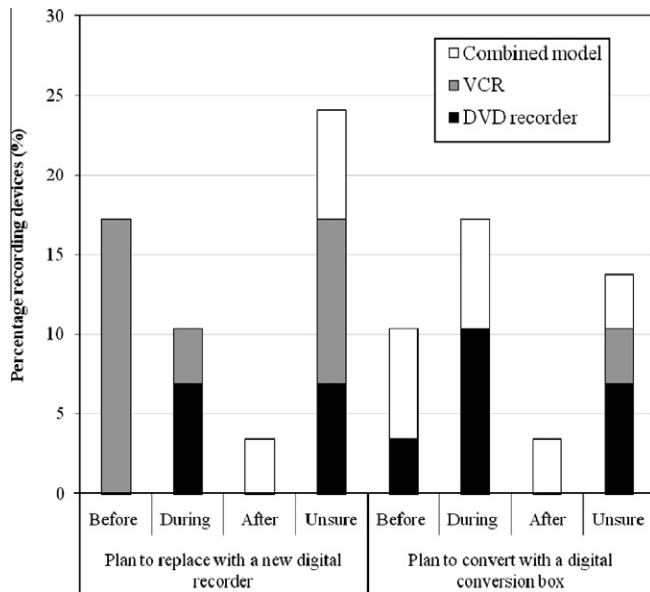


Fig. 2. Residents' plans for switching non-digital ready recording devices ($n = 73$).

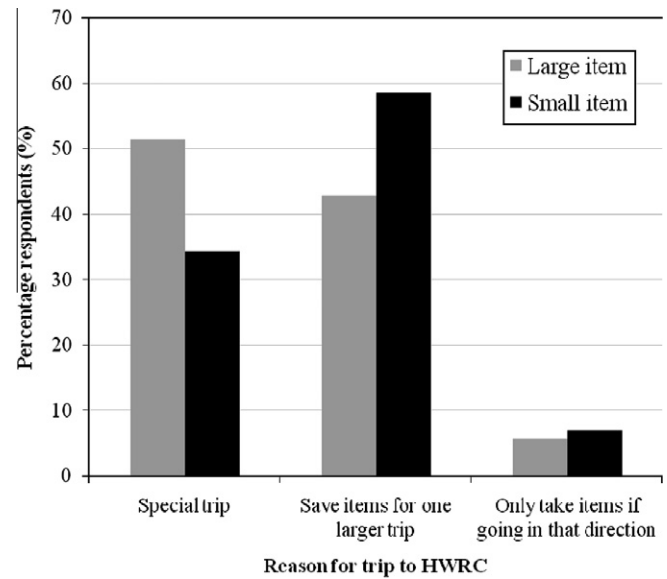


Fig. 3. Reasoning behind visits made to HWRCs to dispose of large and small WEEE ($n = 71$).

Table 3
Percentages of digital and non-digital ready devices in Hampshire.

	Digital ready (%)	Non-digital ready (%)	Estimated total number of units
TVs	66.9	33.1	1,136,961
Recording devices*	16.3	78.4	735,266

* The status of 5.3% of recording devices was unknown.

Table 4
Percentage share of disposal routes for TVs, STBs, recording devices and other related equipment ($n = 105$).

	HWRC	Council bulky waste	Charity shop	Bin	Other*
TV	50.5	8.6	10.5	2.9	27.6
STB	41.9	3.8	1.9	19.0	33.3
Recording device	42.9	2.9	4.8	14.3	35.2
Remote control	19.0	0.0	1.0	64.8	15.2
Set-top aerial	37.1	1.0	2.9	36.2	22.9
Roof-top aerial	39.0	1.0	2.9	17.1	40.0

* =Keep, sell, supplier collection, reuse network or give to a friend.

equipment. It is highly likely that charity shops will not accept donations of non-digital ready equipment prior to and during the switchover and hence these may still end up at the HWRCs.

The majority (95.8%) of respondents said that they would drive to reach their nearest HWRC. Approximately half would make a special trip to take a large item and one-third would do so for smaller WEEE (Fig. 3). The most common reason (46.5%) for disposing of items in the household bin was that they were too small to warrant consideration of other disposal options.

4.4. Best and worst case scenarios of net disposal of devices in hampshire as a result of the digital switchover policy

Table 5 illustrates the projected 2012 disposal quantities for TVs and recording devices for Hampshire and the UK. (As illustrated in Table 4, it should be noted that this WEEE may not necessarily be deposited at HWRCs). The data is classified into best and worst case scenarios. The estimates do not include replacement (and

therefore disposal of replaced product) due to end of product life or choice to upgrade to a newer/alternative model for reasons other than the switchover.

Assuming that the sample used in this study is representative, the Government projections in Table 5 for the UK worst case scenario are significantly underestimated. Using these data as a baseline, the UK worst case figures shown in the last column of Table 5 would have to be scaled up by ~100% and ~74% for TVs and recording devices, respectively.

4.5. Projected worst case scenario quantities of TV and recording equipment that could be disposed at HWRCs

Assuming the worst case (refer to Section 3.5), 61% of unwanted TVs and 47.6% of unwanted recording devices were predicted to be deposited at HWRCs. Resultant projected collections at HWRCs in 2012 are shown in Table 6. In the best case scenario collection of TVs in 2012 was predicted to be similar to current collection. However, worst case projections were more than triple the quantity estimated in the best case for both types of equipment.

4.6. Comparing HCC capacity with projected 2012 disposal of TVs and recording devices

Comparison of HCC capacity (available area for storage) with projected collection for TVs and recording devices is shown in Table 7. In the last two columns showing the best and worst case potential disposal in 2012, negative figures denote a capacity shortfall whereas positive ones denote excess capacity. Although capacity to handle waste TVs was predicted to exceed collection in the best case scenario, HCC would experience a capacity shortfall for 98,631 TV units in the worst case assuming the current handling capacity was maintained in 2012. The estimated quantity of recording devices potentially disposed at HWRCs in 2012 was substantially greater than the currently available capacity to handle all SDA WEEE in both best and worst case scenarios.

4.7. Statistical analysis

No significant association was found between awareness about the year of the switchover and the following variables: age and

Table 5

Estimated best and worst case scenarios for disposal of devices in 2012.

	Units		Government projections for worst case (Hampshire)	Government projections for worst case (UK)
	Best case	Worst case		
TVs	66,457	231,727	115,724	6000,000*
Recording devices	56,231	242,250	138,869	1,600,000*

* Source: Armishaw et al. (2007).

Table 6

Current and projected (2012) collection of TV and recording equipment WEEE at Hampshire HWRCs.

	Current collection*		Potential collection of TV-related WEEE in 2012			
	Units	Tonnes	Units		Tonnes	
			Best case	Worst case	Best case	Worst case
TVs	43,417	1357	40,539	141,353	1267	4417
Recording devices	N/A	N/A	26,766	115,311	120	519

* 2008–2009 Data. Source: HCC, (unpublished data).

Table 7

Hampshire's capacity to handle potential TVs and recording devices disposed at HWRCs in 2012.

	Units	
	Annual capacity ^a	Potential disposal in 2012
		Best case Worst case
TVs	42,722 ^b	2183 –98,631
Recording devices	(10,441) ^c	–16,325 –104,870

^a Source: HCC, (unpublished data).^b Computed from display devices annual capacity.^c SDA annual capacity; for comparison only.

gender. Similarly, no significant association was found between awareness about the effect of the switchover on recording devices and the following variables: age, income, and employment status. This suggests that the UK-wide communications strategy was quite successful.

4.7.1. Association between income and awareness about the year of the switchover

The data summarised in Table 8 shows that there is an association between income and awareness of the year of the switchover. This is significant at the 0.05 level with a p -value = 0.011.

4.7.2. Association between employment status and awareness about the year of the switchover

As shown in Table 9, there is a significant association at the 0.05 level with a Yates' corrected p -value of 0.04, between employment status and awareness of the year of the switchover. Yates' correction was applied since this was a 2×2 table. More than expected people in employment were unaware of the year of the switchover.

4.7.3. Association between sex and awareness that recording devices will be affected by the switchover

The summarised data in Table 10 demonstrates that there is an association between sex and awareness that recording devices will be affected by the switchover. This is significant at the 0.05 level with a Yates' corrected p -value of 0.007. Yates' correction was applied since this was a 2×2 table. More males than females were aware that the DSO will affect recording devices.

Table 8

Chi-square results for association between income level and awareness about the year of the switchover. (Expected counts are printed below observed counts. Chi-square contributions are printed below expected counts).

	Low income	Middle income	High income	Total
1	64 58.53 0.512	42 51.88 1.881	35 30.59 0.634	141
2	24 29.47 1.016	36 26.12 3.735	11 15.41 1.260	71
Total	88	78	46	212

Chi-square = 9.037, DF = 2, p -value = 0.011.

Key: 1 = "yes"; 2 = "no".

Table 9

Chi-square results for association between employment status and awareness about the year of the switchover (expected counts are printed below observed counts. Chi-Square contributions are printed below expected counts).

	Working	Not working	Total
1	66 76.33 0.733	72 64.67 0.832	138
2	44 36.67 1.467	25 32.33 1.663	69
Total	110	97	207

Chi-square = 4.695, DF = 1, p -value = 0.030.Yates Chi-sq = 4.076, DF = 1, Yates p -value = 0.04.

Key: 1 = "yes"; 2 = "no".

4.8. Comparison of awareness levels in Hampshire and the UK average

4.8.1. Awareness level about the year of the switchover

Tables 11 and 12 show the results of the awareness of the switchover year comparisons for Hampshire versus the UK average classified according to sex and low-income, respectively.

4.8.2. Awareness of effect of switchover on recording devices

Table 13 shows the percentage of low-level income earners who were aware that recording devices will be affected by the switchover for Hampshire and the UK, respectively. The average for Hampshire is higher than that of the UK.

Table 10

Chi-square results for association between sex and awareness that recording devices will be affected by the switchover (expected counts are printed below observed counts. Chi-Square contributions are printed below expected counts).

	Male	Female	Total
1	63 52.97 1.901	36 46.03 2.187	99
2	44 54.03 1.864	57 46.97 2.144	101
Total	107	93	200

Chi-square = 8.097, DF = 1, *p*-value = 0.004.

Yates Chi-square = 7.31, DF = 1, Yates *p*-value = 0.007.

Key: 1 = “yes”; 2 = “no”.

Table 11

Awareness of the switchover year: Hampshire versus the UK average classified by sex.

	Male (% aware)	Female (% aware)
Hampshire (2009)	66	72
UK average (DUK, 2008)	27	31

Table 12

Awareness of the switchover year: Hampshire versus the UK average classified by low-income level.

	Low-income persons (% aware)
Hampshire (2009)	76
UK average (DUK, 2008)	27

Table 13

Awareness of the effect of the switchover on recording devices: Hampshire versus UK average classified by low-income level.

	Low-income persons (% aware)
Hampshire (2009)	58
UK average (DUK, 2008)	34

5. Discussion

5.1. Awareness and preparedness for the switchover

Ownership of TVs and recording devices in Hampshire appears to be high. This corresponds to the figures reported by BARB (2009) on the numbers for the whole of the UK, i.e. 97.4% of households were considered “TV homes” in 2009.

Preparation for the switchover appears to be well under way in Hampshire homes. The high level of awareness regarding the event can be attributed to the success of the Government campaigns to educate the public about this important event. This awareness corresponds to similar levels for the UK average (see DUK, 2008). Conversely, Hampshire residents’ awareness about the timing of the switchover was only modestly high. This is probably due to the event being relatively “far” in the future. Importantly though, if residents do not know when the switchover will take place, they might not plan for it and leave it until the last minute to convert/replace their devices. On the other hand, they may benefit from the mistakes/experiences of others as reported in the media. We do, however, expect awareness to rise nearer to the event with increased promotion and advertisement, help programmes by Digital UK (an independent, not-for-profit organization, established by the public sector broadcasters and multiplex operators to lead the implementation of switchover) and

the activities of the Digital Switchover Help Scheme (see DCMS, 2009). Comparatively, it has been reported that up to 50% of those interviewed in the first four switchover regions were unsure of the date when analogue services will be switched off in their area (DUK, 2008). This underscores the need for strategic communication and education.

There is a moderately high level of uncertainty regarding the likely timings of actions to convert equipment (see Figs. 1 and 2). The reason for this may probably be attributed to a tendency by people not to be overly bothered by planning for a future event. In addition, for all intents and purposes, their devices are still functioning so there is no real impetus to change the status quo. If decisions about non-digital devices are made during the switchover a peak in disposal may occur. For instance, initial reports on the DSO in the USA (which occurred in June 2009) suggest that a high proportion of decisions were made at the last minute, with a rush to purchase STBs and new TVs at the time of switchover (BBC, 2009). If non-digital ready devices were disposed of at the same time, this would have the potential of overstressing the WEEE management systems in place. Arguably, it is better not to leave such decisions until the last minute.

5.2. Digital and non-digital ready devices

In Hampshire, the majority of TVs are digital ready with the estimated percentage close to the national figure of 70% reported for June 2008 by Ofcom (2008a). We can therefore postulate that for Hampshire, there will not be a sudden rush to convert TV equipment. However, if the remaining non-digital ready devices are disposed of close to or during the switchover, this would pose a potential issue for waste generation and management. With focused public education about the need to switch early such a situation can be avoided.

The low levels of conversion/upgrade of recording equipment may be a reflection of the low level of awareness that this equipment will be effected by the DSO. It remains to be seen how demand for digital ready recording devices and/or conversion boxes will be in the future especially when compared to hard disc recording devices or similar. We expect, however, that analogue VCRs will be retained for a time to play back old recordings.

5.3. Disposal routes for TV and related equipment waste

According to the data in Table 4, it seems that the majority of people would use HWRCs to turn in most of their unwanted TV and related equipment, with the notable exception of remote controls. It is probably unlikely that individuals would intentionally leave behind remote controls when they transport the main items to which they belong to the HWRCs. A more probable situation is that people are prone to forget the remote controls either at home or in their vehicles whilst at the HWRCs. Irrespective of the explanation, it is significant that almost 65% of unwanted remote controls are thrown in the bin with other household waste. This is consistent with Darby and Obara’s (2005) finding that 97% of small WEEE is not recycled. Since convenience is key to the success of recycling schemes (e.g. Martin et al., 2006), increased ease of recycling of such WEEE could increase diversion. Although residents reported higher rates of diversion to HWRC for the other TV-related WEEE, the figures should be treated with caution as reported behaviour about recycling is sometimes exaggerated (see Williams and Kelly, 2003). In this respect, the fate of recording devices should be given careful consideration given their high projected disposal amounts in the worst case scenario illustrated in Table 5.

5.4. Best and worst case disposal scenarios

The findings indicate that the DSO may prompt the generation of significant quantities of unwanted/waste TVs and recording devices in Hampshire in 2012. Though the disposal figures for the best and worst case scenarios in Table 5 are based on a number of assumptions, they are still telling, especially for the worst case scenario. Compared to the best case scenario, the quantities have tripled and quadrupled for TVs and recording devices, respectively.

Perhaps of more concern to HCC are the specific amounts of waste TV and recording devices that could eventually end up at HWRCs as shown in Table 6. In this case as well, the worst case scenario figures are considerably higher than those in the best case, approximately three times and four times as much for TVs and recording devices, respectively. The assumption that TV and related equipment donated to charities will be redirected to HWRCs around the switchover year should not be treated lightly. One of the reasons for the “fridge mountain” crisis was that retailers ceased their takeback services for refrigerators hence increasing the burden on LAs to handle that WEEE stream (see Florence and Price, 2005). Similarly, the amounts of TV and related equipment currently “absorbed” by charities for reuse could end up being disposed at HWRCs. Such a scenario would have potentially serious impacts on the handling of such WEEE as well as potential environmental impacts. For instance, if people were to be informed that charity shops would no longer accept their non-digital TV and related products donations, the temptation to bin or fly-tip such WEEE would probably increase. It would therefore be prudent for HCC to develop effective strategies to try and avoid a worst case scenario.

At the national level, the implications of the Government significantly underestimating the disposal quantities of WEEE during the switchover are profound (see Table 5). Such underestimation would affect infrastructure, services provision, financial resources and possibly have environmental consequences. If our estimates are correct, adequate strategic plans need to be put in place to address the issue. However, since the timing for the switchover for the regions are staggered, there is room for adjustment for those regions yet to convert. Whilst we recognise the assumptions made for computing the best and worst case disposal scenarios, and the relatively small sample size used, our results are based on recent and real data on peoples’ intentions. Conversely, the Government study was based on a forecasting model that relied on historical stock and sales data and was conducted during 2006 (see Armishaw et al., 2007). This time lapse between the two studies may have a bearing in the dissimilar results. In addition, our use of adjusted projections for Hampshire might have contributed to the discrepancies. Further empirical regional studies are required to address this apparent anomaly between the results.

5.5. HCC capacity versus projected disposal of TVs and recording devices

The results presented in Table 7 imply that an annual capacity shortfall of nearly 100 K items of waste TVs would be experienced in the worst case scenario in 2012. Though it is unlikely that disposal rates will be constant throughout the year, it is still sensible to have mechanisms in place to cater for such an occurrence. In the best case situation, HCC would be able to handle arising waste TV with ~2 K TV items worth of capacity to spare. However, problems may still arise if disposal is concentrated around the month(s) of the switch. For SDA, the findings suggest a capacity shortfall for the number of units generated since the contribution of recording devices alone in both best and worst case scenarios exceeds the total handling capacity for SDA, especially for the worst case. If our estimates are correct, this has important ramifications for the

handling of this WEEE stream, logistically and financially. Similar to TV WEEE, if disposal is going to occur, it is likely that this will be staggered over several months. Given the reported uncertainty regarding retention of recording devices despite their limitations after the DSO, accurate conclusions on the impact on handling capacity for SDA are difficult to draw. Further research is required in this aspect.

Caution should be exercised in the interpretation of these future handling capacity estimates. The assumption that the current HCC capacity to handle WEEE would remain the same through to the DSO year precluded some important considerations such as any future site expansions that would increase handling capacity or increased frequency of collections. Under the UK WEEE Regulations, producer compliance schemes (PCS) are responsible for the collection and treatment of WEEE collected at HWRCs. Hence, in the event of increased WEEE deposits at HWRCs, LAs can request extra collections as need arises (DTI, 2007). Despite these issues, we believe the estimates are still useful and should be treated as indicative of what could happen were the status quo maintained and are therefore useful for planning for eventualities.

5.6. Effect of income, employment and gender on awareness

Fewer than expected middle-income earners actually knew when the switchover will occur in Hampshire (see Table 8). This is in contrast to the low-income earners where more than expected numbers were aware that the switchover is taking place in 2012. One possible explanation might be that low-income earners are concerned about the potential financial costs they would incur as a result of the switchover and were hence more aware about the event. The costs are associated with replacing and/or upgrading TV equipment in readiness for the switch. An additional reason could be that the low-income earners would probably not replace their non-ready equipment immediately, waiting to convert at the last minute. They would therefore most likely be aware of when they would need to convert. Their middle-income counterparts on the other hand may not be presently concerned and/or have probably already converted. We postulate therefore that the UK Government’s communication strategy for the DSO has been successful, albeit impacting low-income earners more than the rest.

From the results in Table 9 it can be concluded that fewer people in employment than expected were aware of the year of the switchover. In contrast, the results indicate that more than expected numbers of unemployed people were aware of the DSO year in Hampshire. A possible explanation is that comparatively, unemployed persons will more likely have more time to watch TV and access the internet which are important media for the promotion and advertisement of the DSO. In addition, for pensioners who are 75 years of age, there are targeted DSO related help programmes (see DCMS, 2009).

The significant relationship between sex and awareness about the effect of the DSO on recording devices (see Table 10) is probably due to males being generally more preoccupied with electronic gadgets around the home. In comparison to the UK average, people on a low income in Hampshire seem to be more aware that recording devices will be affected by the switchover (see Table 13). The reasons behind this large difference are not immediately clear.

5.7. Awareness levels for Hampshire versus the UK average

The reasons behind the huge differences in awareness about the DSO dates for UK and Hampshire (see Tables 11 and 12) are not immediately apparent from the data. One explanation that can be advanced is that there has been a long time lapse between the date when the UK study was conducted and the present,

meaning, the effects of advertisement about the switchover have borne fruit. In addition, one TV-region has since converted to digital TV since the UK study on whose data this comparison is based was conducted. This event may have increased awareness levels. For both the UK and Hampshire, it is important to bridge the gap between awareness of the DSO in general, and when the event will actually occur.

A second explanation for this is probably related to how the question regarding the year of the switchover was framed. In this present study, the question was asked with respect to Hampshire whereas for the UK-wide studies, the question was framed with respect to the TV-region. Many people might not be aware of the TV-region they fall into and/or are ambivalent about it. If this is true, the indication may be that sex and low-income have no bearing in the inconsistency between the Hampshire and the UK results. One consistency though, between the results for Hampshire and the UK, is that more females than males were aware when the switchover is occurring.

There is no clear explanation for the large difference in the Hampshire and the UK averages concerning awareness of the DSO effect on recording devices. In this case too, it might be possible that the difference stems from increased awareness as a result of DSO communication campaigns.

5.8. Other potential impacts of the switchover

5.8.1. Potential environmental and logistics impacts

A considerable proportion of residents would make a special trip to dispose of single items (Fig. 3). Increased transportation to and from HWRCs as a result of increased WEEE may result in higher carbon emissions due to increased vehicle movements. Maynard and Cherrett (2006) reported that although increased recovery of materials through separation (as encouraged by the WEEE Directive) is of environmental benefit, it results in increased numbers of journeys made by householders and service vehicles to recycling facilities, and thus increases transport effects associated with HWRCs. Residents' disposal habits will be important in this aspect. Use of council bulky waste collection for example, or specific WEEE collections (if offered), may reduce emission effects in comparison to many individual trips to HWRCs made by individual householders.

If residents are not educated on the importance of recycling WEEE, significant proportions of TV and related equipment WEEE may be disposed with household waste, principally small items. This may lead to contamination of landfills with hazardous components as well as landfilling of resources which could otherwise have been recycled. CRTs in particular pose specific threats due to leaching of lead and heavy metals, especially when crushed (ICER, 2004).

The switchover may also have other environmental impacts, not related to generation of WEEE. Increased energy consumption (and thus contribution to climate change) has been identified as a potential environmental impact of the switchover (DCMS and DTI, 2005). Advances in technology may reduce this however. For instance, modern LCD TV screens use less energy in comparison to CRT screens (Huisman and Magalini, 2007).

If more WEEE than expected is disposed during the switchover, this might impact the storage of these items. Potential consequences of such a scenario include break-ins to steal the WEEE, a strain on financial resources and site management issues (see Bridgewater and Anderson, 2003).

5.8.2. Legislative issues

The handling of WEEE from the switchover will need to comply with the normal WEEE legislative issues. However, there is a danger that the switchover might lead to illegal shipments of WEEE or

“fly-tipping” by individuals or unscrupulous contractors. This may prevent reuse and proper treatment/recycling of WEEE and allow the escape of hazardous elements to the environment. Greenpeace (2009) recently demonstrated the potential for illegal shipment of waste to developing nations. Build up of WEEE as a result of the DSO must not be allowed to increase opportunity for this. Such a build up might occur if more than anticipated quantities of WEEE arise and this is ineffectively managed.

6. Conclusions and recommendations

This paper has estimated the impacts of the DSO in Hampshire. It has been established that majority of the residents were aware of the DSO although the corresponding figures for awareness of the timing of the event were somewhat lower; this gap needs to be bridged. About half of the residents were not aware that the switchover would affect their recording devices. Potential problems this might cause have been discussed.

Whereas majority of TVs are digital ready, recording devices are not. For TVs, we can assume that the change to digital is not going to be sudden. For recording devices, this may well be the case but the results are not conclusive.

Considering best and worst case scenarios for disposal during the switchover, there is a large distinction in the total amount of equipment disposed with estimates showing that the former scenario is desirable.

This paper has also identified and attempted to quantify TV-related waste that would be disposed at HWRCs as a result of the switchover. Due to gaps in the data, the results are not conclusive. However, they are indicative of the likely amounts of such waste that can be expected at the collection centres.

In addition, the paper has provided insights into legal, logistical and environmental aspects of switchover related WEEE and highlighted some key issues for consideration and possibly further research.

In a broad sense, the Government communication strategies about the switchover have been highly effective. However, it seems these efforts have mainly impacted low-income earners. In addition, awareness about the effect of the switchover on recording devices is rather low.

The Government estimates for the disposal of devices during the switchover seem to be highly underestimated. The implications of this have been discussed in the paper.

Our key recommendations for the UK Government as well as local authorities whose regions are yet to switch to digital TV are:

- The UK Government may have significantly underestimated the amounts of devices that will be disposed during the DSO. If this is the case, it needs to revise its projections and put in place adequate plans to cater for increased quantities.
- The UK Government needs to strategically adapt its communication strategy to effectively reach everyone regardless of their economic status.
- More effort should be spent on educating the public regarding the effect of the switchover on recording devices.
- Local authorities need to be cautious about the projections for the disposal of devices during their switchovers. It is in their best interest to plan for a worst case disposal scenario in order to be effectively prepared.
- Local authorities need to ensure that all their residents are aware of the year of the switchover. This will help the residents to plan for this event. For HCC, this is especially true about the middle-income earners. Strategic advertising could be put in place to target this sector of the population.
- Local authorities should make all their residents aware that recording devices will be affected by the switchover.

- Local authorities need to investigate their residents' plans with respect to their non-digital ready recording devices. For HCC, a huge majority of these devices remain unconverted and therefore pose a potential issue if all are disposed, especially during the switchover.
- More effort and strategies to educate the public on the appropriate disposal of small WEEE is needed.

There are important lessons to be learnt from this study that would be useful for other countries that are yet to make the switch to digital TV. Lessons learnt from the UK 'fridge mountain' experience underscore the importance of putting in place adequate preparations for singular large scale events that could trigger the generation of large amounts of WEEE.

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