

Exploring users' practices through the use phase of a television to minimise the environmental impact

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Abstract: The growing production and consumption of electronic products has become problematic in terms of sustainable development. The legal framework implemented in the European Union and Canada has focused mainly on the production and end-of-life phases to manage electronic devices, while the adverse environmental effects related to product consumption (also referred to as the 'use phase' in the life cycle) have received less attention. Considering the increasing consumption of electronic equipment by households, this paper aims to explore how these goods are actually purchased, used and disposed of by consumers in order to reduce the environmental impact of the use phase. To this end, in-depth interviews of 21 households were conducted. A case study on televisions was selected, since this device aptly illustrates many issues associated with electronic products, including frequent technological innovations, changing trends (fashion, appeal to novelty) and product price drop, as key factors of obsolescence. The paper reveals that, through technological innovations, television has received new functionalities that used to be fulfilled by many display devices, such as computers, laptops and tablets. In response to these innovations, users have changed their behaviour, causing a rise in environmental impact through the use phase. In order to minimize the environmental effects associated with the use phase, directions for supporting the horizontal policy for display devices, and for strengthening existing energy efficiency policies, are proposed to both the European Union and Canadian political authorities.

From e-waste issues to a legislative framework in the European Union and Canada

Electronic waste ("e-waste") generates one of the most dangerous categories of waste for both the environment and for human health, since e-waste contains heavy metals and complex alloys (Tanskanen 2013). The reuse and recycling of e-waste, as well as the repair

of electronic goods, is underdeveloped in Western countries and, in fact, has become complex and costly due to device miniaturization, elaborate assembly, a wide variety of electronic components and rapid technological innovation (Tanskanen 2013). Currently, e-waste is either buried in landfills or incinerated—thus polluting soil, water and air—or is shipped to developing countries. Despite conventions banning shipment to these countries, end-of-life products collected for recycling in North America and Europe are actually exported to Asia and Africa (Man, Naidu et al. 2013). This represents a less expensive method for industrialized countries to manage their e-waste (Man, Naidu et al. 2013).

In response to the growing problem of e-waste, the European Union was one of the first, in 2003, to implement the Extended Producers Responsibility (EPR), through the Waste Electrical and Electronic Equipment (WEEE) Directive (Lifset, Atasu et al. 2013). The EPR obliges producers and importers in European Union countries to reuse and recycle e-waste through environmentally sound methods. In addition to the WEEE directive, the European Commission also passed the Energy-related Products Directive (ErP) in 2005 (Cellura, La Rocca et al. 2014). This Directive addresses only electronic products, which have significant sales and trade in the European Union (indicatively more than 200,000 units). The ErP Directive defines conditions for producers and importers to design their products with less environmental risk (European Commission 2015). Its main focus is to improve the energy efficiency of electronic devices. One of the first steps was to cut standby power requirements to one watt or less for most electronic devices (Dalhammar, Machacek et al. 2014). This horizontal policy represents a genuine breakthrough, because it covers a broader cross-section of devices than individual products alone (IEA 2009).

While the EPR approach for electronic products has become an established principle of environmental policy in Canada, the ErP directive has not been implemented in Canada in

the same way as in the European Union. The Energy Efficiency Regulations focus on approximately 50 energy-using products, which must meet federal energy efficiency standards in order to be imported into Canada, or shipped from one Canadian province to another (Natural Resources Canada 2015). These regulations apply to producers and importers who import regulated energy-using products into Canada (Canada Border Services Agency 2013). Although the Regulations and ErP Directive are working to improve the energy efficiency of electronic equipment, the European approach has taken a more holistic approach, since its ultimate objective is to increase overall environmental product performance throughout the entire lifecycle (Déméné 2014).

From legislative framework to the study of consumer behaviour regarding the television

The legal framework, described above, focuses mainly on the adverse environmental effects related to the production and end-of-life sides, and not as much on consumption (also referred to as the life cycle use phase), with the exception of the ErP Directive, which only focuses on energy consumption during the use phase. The latter is of concern, especially taking into account researches that emphasized that the manufacture of energy efficient products is no longer satisfactory to move towards sustainable consumption patterns (IEA 2009, Cooper 2013, Agence européenne pour l'environnement 2014). Although the legal framework has enabled several improvements in product performance, the environmental impact of consumption has continued to increase (Cooper 2013). In this context, there is a need to explore how users actually purchase, use and dispose of their electronic products in order to reduce their environmental impact.

Most of the current studies have generally focused on a single sub-step of the use phase at a time. Since the effectiveness of the legal framework has been offset by the increase in consumption of electronic appliances, there is a need to undertake an exploratory study that could provide a systemic view of the environmental impact of the use phase. This paper

aims to illustrate how an understanding of users' practices can provide a sound basis from which it could be possible to strengthen existing policies, in order to minimize the adverse environmental effects associated with the consumption phase of electronic devices.

The environmental impact of an electronic device depends on its design, including the type of technology used, and the way in which consumers make use of it (frequency, intensity of use for instance) (IEA 2009). The selection of specific electronic goods was wide, and subsequently, this research is focused on the television (TV). Television aptly illustrates many issues related to the use phase of electronic devices, including the rapid succession of technological innovation, changing trends and product price drop, as key factors of obsolescence (Déméné 2014). Moreover, the switch to digital signals and the introduction of High Definition (HD) have accelerated premature end-of-life, and have therefore increased flat screen TV purchases. In this context, the TV case in households can be seen as highly relevant in identifying environmental impacts related to the consumption of electronic products.

Methodology

This research uses a case study format that is one of the five qualitative approaches to inquiry according to Creswell (2007). The exploratory and descriptive nature of a case study enables this research to deeply explore how televisions are actually purchased, used and disposed of by users. Two series of interviews were conducted among 21 households in the Montreal region for respectively scoping and targeting the users' practices, framing the environmental impact of television' use phase.

The first set of interviews was an exploratory stage, aimed at clearing the field in order to identify relevant research issues leading to a decrease in the environmental impact of televisions during the use phase. Snowball sampling was used to recruit three women and eight men. The sample was non-probabilistic and the respondents were selected according to their experiences during a television's purchase, use and disposal phases. Face-to-face discussions ranging from one hour to an hour and thirty minutes were conducted. Each conversation was audio recorded, and took place at a location selected by the participant. Given the vast amount of data collected, an analysis based on repeated listening to the discussions was the most effective way to sift through the recorded information and put aside irrelevant data.

The objective of the second series of interviews was to provide a deeper understanding of the axes observed in the first set. In this way, new respondents owning one or more flat screen TVs were recruited. Another snowball sampling was used to select eleven new participants, eight men and three women . At this stage, the questionnaire was more specific and structured around the research axes in order to find elements of responses. The interviews, ranging from one hour to an hour and thirty minutes, were conducted at the respondents' homes when agreed to. The data saturation was rapidly archived, since the second sample was a homogeneous group of participants and certain research axes had been already explored through the first set of interviews. For the data analysis, the gathering material was transcribed in full and then coded using qualitative data analysis software to perform a thematic analysis.

Findings

Although this exploratory research aims to offer a deep understanding of users' behaviour through the use phase, all of these findings need to be addressed from the perspective of a larger number of participants in further research. The common implication in all of those findings, is that television has been granted new functionalities that used to be fulfilled by many devices in constant transformation, including desktop computers, laptops, smartphones and tablets (also referred to as display devices). In response to these innovations, users have changed their behaviour, causing a rise in environmental impact through these three phases. Because of the non-probabilistic nature of the study sample, it is not possible to analyze the influence of the variables (gender, age, marital status, social conditions, geographic classification) in the participants' responses. Accordingly, any aspects of the sample diversity are not relevant to the findings, and are presented only to better contextualize the participants' world.

Purchase phase

Large flat-screen televisions

The findings show that the participants have purchased larger TVs as time goes by:

We wanted a big TV! We always wanted a larger TV. In our case, it is true that we did not need a new TV. [...]. When we have guests, it's a pleasure to put music on the TV to create ambiance. [...] They enjoyed the digital sound and picture quality [Female respondent living with her husband and two teenagers].

It's good to have a big screen TV when you watch movies. It's like a movie theatre! And it is never too big, especially when you're watching a movie. [...]. I like inviting my friends to watch a movie or play video games. [...] If you follow the exact rules for the number of metres between my TV and my sofa,

I should have taken a much smaller TV than I actually have. But now I realize that I would have taken one even bigger than that [Male respondent living alone].

After many years of use, my cathode-ray tube [CRT] television broke down for the first time. A repairman came to my home to check the TV, and decided to bring it into his workshop. I helped him carry the TV to his vehicle. My neighbour was watching us and asked me: “Why do you repair your TV instead of buying a new one?” Although my old TV was repaired in a few weeks, I finally decided to buy a new one. I felt the need to catch up with the latest innovations [Male respondent living with his wife].

Before, I owned a large CRT TV. It used to take a lot more space than my current television, but worked very well for at least 10 years. [...] My friends often laughed at me with my bulky CRT TV and did not understand why I kept it. [...]. I finally decided to buy a large flat screen last year. [...] Now, I am really pleased with my new TV. I feel like I am on the leading edge of innovation, especially when the switch from analogue to digital signal occurred [Male respondent living alone].

Five out of 11 interviewees purchased a new television during the year of the interview. For the respondents (two out of 5 people) who switched to their first flat screen TV, an ambiguity in attitudes towards technology has been identified. They declared feeling a kind of pressure from their surroundings, and also indicated the need to catch up with technological innovations. Others interviewees (three out of 5) explained that choosing a larger screen size than they had before provided a higher degree of satisfaction, especially on social occasions with friends and family.

TV peripheral equipment

After the TV acquisition, most respondents (nine out of 11 people) replaced their functional peripheral equipment with new ones, in order to take full advantage of their new TV display technology:

We are going to install a digital video recorder to enjoy high definition on our new TV. [...] When we purchased the new TV, we were tempted to buy several new devices that we already owned. [...] For instance, I was listening to a TV show on a sound system in a store [...] and was tempted to buy it, although I already had one [Female respondent living with her husband and two teenagers].

After the TV purchase, I bought new peripheral appliances because I wanted to take full advantage of my new TV. I bought a Blu-ray player and a digital video recorder. I had a DVD player. It was still working and I keep it in storage! [...] I also bought an additional sound system; that's it [Male respondent living with his wife].

I think I'll buy a Blu-ray player later, just to fully enjoy the HD technology. When you purchase a new TV, you also buy peripheral equipment, because you want to appreciate the TV's full potential in terms of display technology and sound [Male respondent living alone].

Respondents have changed their functional DVD player with a new Blu-ray player to take full advantage of their new TV display technology. The same pattern applies to sound quality, for which a new receiver and speakers were added in order to enjoy HD sound. The purchase of those peripheral appliances is also accompanied by the supply of several services attached to the development of television, such as HD programs, video-on-demand and video streaming. In order to maximize HD television (HDTV), respondents needed to

subscribe to the HD signal, which usually entails the rental or purchase of a set-top box to appreciate the highest available picture quality.

Non-electronic goods: Furniture and decorative items

In addition to the acquisition of peripheral electronic equipment, almost half of participants (six out of 11 people) have purchased other goods, such as furniture and decorative items, after a TV purchase:

It was out of the question to put the new TV in the same location as the previous one, so we moved it, but then, we needed a new sofa. Actually, we revamped a room in the basement, which was well suited for that. This room is dedicated to the exclusive use of the TV, that's what Americans would call a living room [Male respondent living with his wife and two daughters].

The room has been redecorated in order to have this cozy corner, this little cinema area. So, we put in curtains to isolate it. We bought the armchair and then the stuff [Female respondent living with her husband and two teenagers].

The aesthetic quality of our interior space has been greatly enhanced following the purchase of the new TV. [...]. After the TV acquisition, we decided to redesign the TV corner. We bought a stand and a new sofa. We have also changed the colours by buying a new carpet and cushions for the sofa [Female respondent living with her husband and two children].

The interviews revealed that participants have redesigned their interior space to complement their new television. While four respondents rearranged and redecorated their usual television area to accommodate the new TV, two decided to relocate the TV area.

Whether the television is located in a new space or in the same location as before, current interior arrangements have prompted furniture purchases such as a sofa or television stand, and also new decorative items, such as curtains, cushions or carpets.

Use phase

Convergence of TV and display devices

Through technological innovations, users have progressively changed their practices during the use phase:

I plug my computer into the TV. I put a CD in my Blu-ray player and I listen to the music through the television speakers. If I have a party, I plug my “playlist” into the TV and let the music run [Male respondent living with his wife].

We have plugged my camera onto the TV to watch movies that we recorded, and look at vacation photos [Female respondent living with her husband and two daughters].

I have a hard drive, which is connected to my television. So we look at photos [Female respondent living with her husband and two teenagers].

I download TV shows on my laptop, then I watch them on my TV screen. The thing I do the least with my TV is watch TV! I have connected my laptop and my TV on the same network [Male respondent living with a roommate].

I have a cousin who bought a new computer. He has no TV but when he needs one, he uses his computer. He has a Blu-ray player on his computer, so

he can watch movies or go online for TV content [Male respondent living alone].

The interviews reveal that almost half of the participants (five out of 11 people) use their television for activities that were formerly handled by desktop computers and laptop. The same pattern applies to computers, laptops, smartphones and tablets, which are used by seven out of 11 people to watch TV content. The television and the other display devices have very similar features, especially with respect to recent technological innovations and the Internet. Through those innovations, few interviewed households (two out of 11 people) have initiated the convergence of the television and computer or with other display appliances by keeping only one of the two and discarding the other, but the majority (nine out of 11 people) still own these two devices and more, because of the influence of social patterns in which these devices are still dedicated to different uses.

Energy consumption of complex set-top boxes (CSTB) and TVs

The interviews revealed that nine respondents out of 11 paid no attention to the energy consumption of CSBs and/or TVs when selecting a model:

[The energy consumption] it's not among the first factors of selection, because the first criteria [for a TV] will rather be the picture quality [...]. I have a CSTB, but I do not know if it is an energy-consuming device [Male respondent living alone].

There are too many parameters [on the TV] that I want to consider before looking at energy consumption [...]. I think that TV consumes more energy than this device [CSTB] [Male respondent living alone].

This [the energy consumption of TV] was a detail and not what led to my purchase! It would be several variables, such as the size and the price of the TV [...]. For the CSTB, my TV provider offers only one model I suppose [...]. I have to admit that I did not really examine if there are other models. This device [CSTB] probably consumes a lot of energy, since it is functioning 24/7 [Male respondent living with his girlfriend].

In an odd way, there is only the TV consumption that bothers me. For the other peripheral equipment like CSTB, I do not really care [Male respondent living with his girlfriend].

For the television, most respondents (nine out of 11 people) do not pay attention to energy consumption, since they consider price, screen size and picture quality to be the most important decision factors. A female respondent living with two children explained that she is concerned by the issue of energy consumption for household appliances, but not for the television or peripheral equipment. In the same perspective, other participants emphasized they are not really aware of the CSBs' energy consumption. Only one respondent supposed that CSBs can be an energy-consuming device, while most do not question their energy efficiency.

Disposal phase

Consumers appreciate owning products on the cutting edge of technology, which leads to a growing number of obsolete electronic devices and physical media in households:

I have a CRT television and DVD player. They are both still working. I was willing to donate my CRT television, but nobody wants this obsolete technology. For now, it is in the closet [Male respondent living with his wife].

I don't think we're going to throw it out [videocassette recorder]; it still works well! [...] We have a big box with several VHS cassettes and we keep them in case we want to watch a movie [...]. Honestly, we do not know what we can do with our functional unused products. They are stored in a corner of our home. I know for the computers, I can bring them to Bureau en Gros, which has a reuse program [Female respondent living with her husband and two children].

For material such as videotapes, I try unsuccessfully to donate them. [...]. I put them directly to recycling when there is a program that manages them! Often, I throw them in the garbage when there is no infrastructure [Male respondent living alone].

Those findings reflect the ongoing increase in unused electronic devices in homes. The storage of functional items reduces the reuse possibilities, since households store them for several years without using them. More than half of respondents (six out of 11) admit to keeping their functional CRT televisions and media players, even if they had already purchased a new product fulfilling the same function. The first half of users expect to use them again, while the other half unsuccessfully tried to donate them. Other participants (five out of 11) did not know what could be done with their unused but functional devices and physical media.

Discussion

Through the findings presented above, the discussion will bring elements of a response to the three following issues identified in the literature review: 1) to understand factors leading to the proliferation of electronic products in households; 2) to investigate the consumer behaviour that shapes growth in energy consumption; 3) to examine consumer

disposal behaviour regarding electronic equipment, in order to identify an environmental way to better manage e-waste. Directions are also proposed to strengthen existing policies in order to minimize the environmental impact of the TV.

Factors leading to the proliferation of electronic products in households

Proliferation of televisions and peripheral equipment

The findings reveal that TV technological innovations, the supply of several services related to the advent of HD, and the switch from analogue to digital, have resulted in the disposal of CRT TVs and the purchase of larger flat-panel TVs, as well as of both electronic and non-electronic goods. Today, electronic products are increasingly multifunctional and require many other purchases to fully benefit from and maximize their additional features. The main consequence is that users own an increasing number of electronic devices and accessories. As highlighted in the interviews, after acquiring a television, consumers are prompted to buy goods, including electronic products, furniture and decorative items. Those purchases are typically intended to harmonize the setting and all of the equipment, both aesthetically and technologically.

In the literature, such a phenomenon of multiple purchases is well known as the Diderot effect, in honour of its first observer, the French philosopher Denis Diderot (McCracken, 2001; Park, 2005). Defined as “[a] force that encourages the individual to maintain a cultural consistency in his/her complement of consumer goods” (McCracken, 2001, p.126), the Diderot effect has already been associated with several consumer goods such as cars, clothing, furnishings and cosmetics (McCracken 2001, Shove and Warde 2002), but never with electronic devices. Beyond television, the Diderot effect can be observed across many other electronic goods. For instance, the smart phones can be hooked up to accessories,

such as a Bluetooth headset, a car charger or a dock station. In this context, technological innovations have created a favourable environment for the purchase of larger flat-panel TVs and the implementation of the Diderot effect.

Proliferation of display devices, even in the convergence context

Coupled with several display devices, including desktop computers, laptops, smartphones and tablets, TV use has changed along with technological innovations (Jenkins 2006, Kackman, Binfield et al. 2010, Benson 2013). This study emphasized that users' practices have changed, since they can plug a variety of other devices into the television, and have redesigned their interior space. While the television has become a multitasking device, the findings show that users own more appliances (i.e. proliferation of televisions and others display devices). With an increasing diversification in product functionality, the number of electronic products per household would have been expected to decrease, leading to significant environmental benefits. Nevertheless, the opposite pattern has generally occurred with consumer electronics, since nine out of 11 users interviewed still maintain several display devices in their home. As a matter of fact, the more technological advances there are, the more multitasking devices consumers own, and the more appliances they buy. The merger between display appliances, such as television, computer, laptop or tablet might not decrease the environmental impact as expected, because the parallel development of specialized and multitasking devices has increased consumer expectations and the number of household electronic appliances.

The consumer behaviour that shapes growth in energy consumption

Towards a horizontal policy for display devices

Considering that television and all display devices are now in flux, with their respective roles increasingly conflated, political authorities should move towards a horizontal policy. The

horizontal measures define targets covering several product groups (IEA 2009, Dalhammar, Machacek et al. 2014). This approach could provide the advantage of lighten existing the regulatory procedures, like energy efficiency policies, by avoiding legislating for each type of product. As mentioned in the introduction, this horizontal policy has successfully been implemented for standby power for most electronic devices. Beyond the standby mode, there are other opportunities for the electronic products to establish interesting horizontal implementing measures. As Dalhammar, Machacek et al. (2014) suggest: “the Ecodesign [Erp] Directive can complement the horizontal rules in the WEEE Directive through setting requirements related to maximum disassembly time, or rules that deal with toxic substances that can pose a barrier to cost-efficient recycling practices (p.20).

While opportunities exist, the horizontal rules could be tricky in certain area of electronic equipment, such as materials that often applied for specific purposes and product uses varies greatly (Dalhammar, Machacek et al. 2014). To circumvent these issues, it could be preferable for requirements in vertical implementing measures to take priority over those in horizontal ones (Dalhammar, Machacek et al. 2014). In the case of energy efficiency policies, the main challenge remains how to gather display devices in order to allow the implementation of the horizontal policy. Common features shared with other display devices could define, such as content nature, screen size and portability. In spite of certain difficulties, horizontal implementing measures may become relevant in the future. For display devices, the IEA (2009) stated: “[p]erformance-based measures can also more readily accommodate issues of convergence, such as the decreasing separation between televisions and computer monitors. In this case, a policy measure which targeted displays and other common elements irrespective of whether they were eventually used in a monitor or television would be more realistic [...]” (p. 271).

Directions to support television's energy performance

Political authorities should strengthen existing energy efficiency policies relating to television size, in order to make additional energy savings possible. Indeed, these study results emphasize a steady increase in television size among households. In the European Union member countries, there are no specific policies for large televisions, except for the regulation N°642/2009, called ErP Directive (presented in the introduction) or “Ecodesign Requirements,” which defines standards relative to the size of a television; that is, the larger the television, the higher the allowable consumption will be. In Canada, only television off and standby modes have been subject to Energy Efficiency Regulations (exposed in the introduction). Currently, no energy consumption standard has been defined for power-on mode.

Accordingly, the existing legal framework, which was intended to promote energy savings, does not suit current television usage. The increase in television size and in their numbers per household offsets the choice of less energy-consuming flat-screen technology. Current policies rely on standards relative to size, but to be effective with regards to large televisions, absolute standards should be adopted. Current regulations will not prevent increases in energy consumption, as long as the legislative gap regarding larger televisions remains. Political authorities should focus on the increasingly popular televisions, 40 inches and up, in order to strengthen existing energy efficiency policies.

Directions to support the energy performance of complex set-top boxes

The proliferation of TVs and peripheral equipment in homes make energy savings difficult. In the case of TV peripheral equipment, set-top boxes (STBs) converting an incoming TV broadcast signal to one that can be seen on a screen, continuously consume energy in both

power-on and standby mode, since they are designed to receive information 24/7 (European Economic and Social Committee 2014). These devices have one of the highest levels of energy consumption among all peripheral equipment. In the European Union, standards have already been set for standby mode power for simple STBs through the Erp Directive. Instead of a mandatory measure for complex STB (CSTB), the European Union has reached voluntary agreements and a voluntary Code of Conduct with manufacturer groups in order to improve energy efficiency (IEA's 4E 2014). In Canada, the Energy Efficiency Regulations (see section 1) do not take into account STBs and CSTBs. Only, premium efficiency CSTBs are differentiated in Canada through Energy Star certification (IEA's 4E 2014). Beyond these voluntary measures, there is a need to legislate for the CSTBs in order to encourage producers to adopt a high standard of energy efficiency in Western countries, which are significant consumers of CSTBs.

Households, which pay operating costs, could also improve energy consumption by purchasing or renting lower energy consumption CSTBs. As mentioned in the findings, the participants are not really aware of the CSBs' energy consumption. Given the fact that TV providers do not sustain operating costs, CSTBs' energy consumption is not taken into account when it comes to selecting a model to propose to consumers. It would be relevant for the consumer to be provided with information about CSTBs' energy consumption, whether the consumer decides to rent or purchase this device. Currently, the energy labelling scheme, presented in the introduction, is already compulsory in the European Union and in Canada for certain electronic appliances, but does not include the CSTB (Ressources naturelles Canada 2014, ADEME 2015).

Consumer disposal behaviour regarding electronic equipment

Which alternative for obsolete and functional electronic products?

Technological innovations have accelerated the purchase and replacement cycle of electronic products, leading consumers to deal with an unwanted number of obsolete and functional electronic goods. It seems rather difficult to find new owners for obsolete equipment, such as CRT televisions and media players as highlighted in the findings. While recycling is a preferable option for broken electronic products, what could be done with the functional, but unused electronic devices? The findings reveal that more than half of respondents (six out of 11) store their functional CRT televisions, even if they had already purchased a new product fulfilling the same function.

Some research proposed to resell functional and obsolete products from Western nations, such as desktop computers, laptops and televisions, to the reuse market in developing countries including Mexico and the Philippines (Kahhat and Williams 2009, Yoshida and Terazono 2010, Kahhat 2012). This method offers electronic equipment at a low price to local people. These imports to emerging nations could be an alternative to extend the lifespan of electronic products, but should be framed by regulations to prevent the shipping of e-waste. More studies are needed to evaluate the environmental, economical and social impact associated with the importation of functional and obsolete electronic devices from developed to emerging nations. Kahhat, Kim et al. (2008) proposed that: “[e]nhancement of recycling infrastructure in destination countries using a transferable recycling fee imposed on those imported used computers in the country of origin” in order to support the end-of-life of electronic products in developing nations.

From physical media to the absence of physical media

No European and Canadian policies so far deal with physical media end-of-life, such as DVDs, VHS cassettes, CDs and other minidiscs, which represents a recycling challenge

(especially the VHS cassettes), given the diversity of materials involved and the necessary human resources to recycle physical media. Recycling programs for all media end-of-life need to be developed, since the Blu-ray will soon end up in landfills after being displaced by a new kind of media. During the last number of years, several online services have been developed in the form of data centres and servers allowing video-on-demand and streaming. These services could accelerate the Blu-ray's end-of-life, and the switch from physical media to the absence of physical media. On the one hand, this transition could be beneficial in environmental terms, but on the other hand, it also implies the disposal of a large amount of physical media that so far have not been well managed. Recycling programs for all media end-of-life need to be developed considering the present situation.

Conclusion

Through technological innovations, users' practices have changed, since they can plug the television in to other devices, and have redesigned their interior space. While the television has become a multitasking device, it would have been expected to decrease the number of electronic goods in homes. However, this study shows that for the television, technological innovations have encouraged the Diderot effect, leading to the consumption of both electronic and non-electronic goods. In fact, the more technological advances that occur, and the more multitasking devices that users own, the more appliances they buy. The findings also emphasized the growing number of unused televisions, peripheral appliances and physical media (DVDs, videotapes) stored in homes, and point out the need to find a sustainable alternative that could optimize the reuse of obsolete devices that no one in developed countries wants any more. In response to these environmental issues, the paper suggests directions for supporting reflections and actions, among political authorities, to reduce the environmental damages related to the use phase, such as horizontal policies for display devices, the establishment of energy consumption standards for large TVs and

CSTBs, and the need to provide consumers with information about energy consumption by CSTBs. However, more studies are needed to evaluate the impact of these guidelines before to implement them.

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