Evaluating the Sustainability Potential of a White Goods Refurbishment Program in Ireland

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Abstract

A sustainable national policy on white goods reuse has to ensure an integrated socioeconomic and environmental approach and this paper analyses the potential benefits and drawbacks of implementing such a policy for Ireland. The key decision factors for determining whether reuse is beneficial are examined focusing on energy usage, energy rating, energy efficiency improvements over time, energy rating of low cost household appliances and the final destination of WEEE once it reaches end of life (EOL). Comparisons are conducted between different WEEE refurbishers across Europe to ascertain the specific success factors and barriers which they have experienced. The job creation potential and the impact on prosperity for low income families are also considered. Evidence has been provided that a reuse policy for white goods adheres to the three pillars of sustainability: social, environmental and economical. The strongest indication from data presented supports reuse of white goods as a sustainable strategy. At a minimum legislation needs to change to incentivize compliance schemes and social enterprises to enter this arena.

1 Introduction

When it comes to Waste Electrical and Electronic Equipment (WEEE) whether to prioritize reuse over recycling is an on-going debate [1]. The environmental benefits of extending the life span of an appliance compared to recycling the appliance and recovering secondary raw materials are always in question. Reuse offers in some cases environmental, economic and social benefits by off-setting the environmental impact of production, creating secondary markets and providing essential appliances to low income families. Yet recycling potentially enables more energy efficient appliances to replace existing ones. But when do the potential benefits of a more energy efficient appliance outweigh the benefits of reuse?

This paper analyses the potential benefits and drawbacks of implementing a national policy for the reuse of white goods in Ireland. Examining the environmental and socio-economic aspects of white goods reuse for Ireland will enable an unambiguous informed decision to be derived. The key decision factors for determining whether reuse is beneficial are examined focusing on energy usage, energy rating, energy efficiency improvements over time, energy rating of low cost household appliances and the final destination of WEEE once it reaches end of life (EOL). Weighing up the impacts pertaining to the aforementioned factors will present an insight into the environmental sustainability of the reuse of white goods. Furthermore the sustainability from a socioeconomic perspective is explored. Comparisons are conducted between different WEEE refurbishers across Europe to ascertain the specific success factors and barriers which they have experienced as the job creation potential and the impact on prosperity for low income family are also considered.

This article is structured as follows. The next section presents a literature review. In Section 3, an environmental assessment is provided. The socioeconomic dimension is discussed in Section 4. This is followed by further discussion in Section 5. Finally, in Section 6 a summary and conclusions are presented.

2 Literature Review

Determining whether an appliance should be reused or recycled is an important issue The case for maximizing reuse is strong on many levels: It conserves embodied energy and water [2] , it is the most efficient use of scarce materials which are often lost in recycling [3-4] , it reduces the amount of transportation required in putting product back on the market [5] , it provides jobs for disadvantaged people as opposed to health problems [6], Reduces the amount of pressure on underdeveloped recycling infrastructure [7]. In the case of information and communication technology (ICT) a large body of literature has been published, supporting the case for extending the usage phase life-cycle of certain ICT equipment through reuse [8-11] .A number of lifecycle assessment (LCA) studies have been carried out in an attempt to quantify the energy consumed in production [12-13]. The high energy consumption resulting from the manufacture of PC microchips is a major factor for supporting lifetime extension, to recoup the invested energy consumed in the production process [14].The social and economic implications of personal computer reuse have also been analyzed [15]. Socially, second hand markets enable access to information technology improving education and enabling up scaling of business practices. Economically, reuse generates employment and revenue. However, for white goods (i.e. dishwashers, washing machines, tumble dryers, fridge freezers) there is a lack of literature supporting reuse outright. These analyses have been done on a product specific basis and have not considered a national policy.

Öko-institute conducted a study to determine whether washing machines with different years of construction, ranging from 1985 to 2004, should be replaced by new washing machines or should they be kept in us [16]. In the study the environmental and economic implications of an accelerated replacement of appliances were considered. Two environmental indicators were employed, cumulative energy demand (CED) and the global warming potential (GWP). The economic analysis was based on the life cycle costing in terms of total cost of ownership which included: acquisition costs, energy costs, water costs and disposal fees. The geographical scope of the study is representational for the German situation, due to different EOL management employed elsewhere. In addition, the study did not take into account the deterioration rate caused by the degrading of parts. Five alternatives were analysis. (1) Extended use of a washing machine manufactured in 1985, (2) Extended use of a washing machine manufactured in 1990, (3) Extended use of a washing machine manufactured in 1995, (4) Extended use of a washing machine manufactured in 2000 and (5) Extended use of a new washing machine manufactured in 2004. Depending on the age of the washing machine under consideration and the evaluation criteria (GWP, CED, economic), different conclusions were drawn. It was shown that when focusing on the CED analysis that the optimal substitution times for washing machines in 1985, 1990 and 1995 were approximately 2, 3 and 5 years respectively. For the GWP analysis the substitution times for washing machines in 1985, 1990 and 1995 were approximately 3, 5 and 8 years respectively. From the economic perspective the payback period is larger, with a 6 year amortization for the 19 year old washing machine. Results of the study showed the environmental and economic payback time frames differ significantly.

Devoldere et al, develops this theme further by analyzing the trade-off between the total cost of ownership (TCO) of different energy grades of washing machines looking at both environmental and economical aspects [17]. TCO is a methodology and philosophy which looks beyond the price of a purchase to include many other purchase related costs [18]. The TCO is an important element as the demand for washing machines from reuse centers is higher than the available supply. Consumers perceive the lower cost refurbished machines to be the cheaper alternative. Therefore in principle only washing machines with an equal or lesser TCO than a newer machine should be resold. The analysis was conducted for washing machines of different energy grades (A+ to C), examining the difference in electricity usage over the lifecycle and also whether reuse is always the better alternative to the purchase of new products. The eco efficiency indicator 99 method was used to measure the environmental impact of materials production, material processing, transportation, use phase and disposal. Results included a sensitivity analysis which took into account the decreased efficiency due to worn out parts and also technological advancement in new products and showed that in certain scenarios the economic and environmental objectives of reuse centers can be violated by extending the product life cycle. The possible scenarios outlined were

- Scenario 1: Both environmentally and economically beneficial compared to the purchase of a new washing machine.
- Scenario 2: Environmentally or economically beneficial compared to the purchase of a new washing machine.
- Scenario 3: Neither environmentally nor economically beneficial compared to the purchase of a new washing machine

For A+ and A rated washing machines Scenario 1 and Scenario two applied for up to 12 years. For lower grade machines, Scenario 3 applied after 4 years of use. The results concluded that the energy rating and age of the appliance are critical for determining whether it is environmentally or economically beneficial to conduct reuse. Similar results were found by Dewulf et al in separate study for fridges using the same methodology [19].

As this discussion is about the improved energy efficiency of new appliances against older reused appliances it is also relevant to survey the literature on the projected future trends of the energy efficiency of new appliances. Truttmann and Rechberge, analyzed the electricity consumption of 8 household appliances from 1990 to 2005 and predicted future energy consumption demand for these appliances from 2005 to 2020 [20]. From 1990 to 2005, high gains were made in the efficiency improvements of all appliances. For example, the refrigerator profile exhibited a reduction from 800 kWh/year in 1990 to 450 kWh/year in 2005, corresponding to a percentage efficiency increase of 43.75%. Significant gains in efficiency were also shown for dishwashers and washing machines over the same period. These improvements correspond to the market penetration rate of 'A' rated appliances. Due to technological limitations, the differential energy consumption improvement of newer white goods will be considerably lower relative to the current 'A' rated appliances on the market. In Truttmann and Rechberge's paper for the washing machine case, the energy usage was predicted to be 290 kWh annually in 2005 compared to 210 kWh annually in 2020, showing a percentage efficiency increase of 27.5 %. Similar marginal gains were also estimated for dishwasher and refrigerators.

3 Environmental Assessment: Decision factors for reuse

Based on the literature review, the decision factors deemed important for determining whether reuse is beneficial as a national policy include the use phase energy, the penetration of 'A' rated appliances, energy efficiency improvements over time, energy rating of low cost appliances and final destination of WEEE. These are discussed in the following paragraphs.

Decision factor I: Use Phase Energy

In order to determine whether reuse of white goods is environmentally beneficial a direct comparison to recycling is necessary. Examining the environmental burden white goods have over their entire lifecycle, provides insight into which life cycle phases contribute most significantly. Furthermore examining the impact of extending the usage phase through reuse is important. On one hand reuse extends the product's useful life avoiding a certain level of the burden associated with the manufacturing phase and EOL treatment. On the other hand, energy consumption differentials between the appliance being reused and similar appliances currently available for purchase need to be considered. The following sections address these questions.

Life Cycle Assessment

A life cycle assessment (LCA) of the individual household appliances (refrigerators, freezers, washing machines, dish-washers and dryers) allows the full range of environmental impacts attributable to these products to be determined. LCA takes a holistic viewpoint, assessing the raw material production, manufacture, distribution, use and disposal including all intervening transportation [21]. There are numerous LCA indicators with different levels of complexity, for example: ecological footprint, climate footprint, eco scarcity, cumulative energy demand (CED), ECO-indicator and many more. CED is the LCA indictor selected for this research for the following reasons:

- CED is the most commonly used LCA indictor for electrical and electronic equipment (EEE), used in literature [22].
- CED has a close correlation with the other indicators and is recommended as screening indicator for environmental performance (e.g. Ecoindicator 99 correlation with CED , R^2=.81) [22].
- CED represents the direct and indirect energy use throughout the life cycle of the appliance.
- CED requires substantially less information in the inventory analysis compared other indicators [23].

CED Analysis for White Goods

A CED analysis was compiled from various sources in the literature for the 5 largest electricity consuming household appliances namely, refrigerators, freezers, washing machines, dryers and dish-washers [17, 20, 24-28] . The CED is broken into four stages: (1) Raw Material Processing & Manufacturing, (2) Use Phase, (3) Collection & Disposal and (4) Recycling & Processing. For the use phase, energy consumption and length of ownership trends are taken from the Association of Home Appliance Manufactures reports “Major home appliance saturation and length of ownership”[24] and “Major Appliance Annual Trends 1989-2009”[25]. From these analyses, the use phases estimated for the appliances is roughly 14 years for refrigerators and freezers, 11 years for washing machines, & dryers and 10 years for dish-washers. The average number of loads/cycles per year is estimated to be 392 loads for a washing machine and 215 cycles for a dishwasher.

From Figure 1, it is evident that the use phase dominates, exceeding 86% of the total lifecycle energy burden for all appliances [20] [17, 26]. Production represents less than 8% of the total life cycle impact [27], Collection & Disposal, 3%, and the recycling phases amount to less than 1% [28]. The next section will further examine use phase data to consider its environmental impacts and how these might change into the future

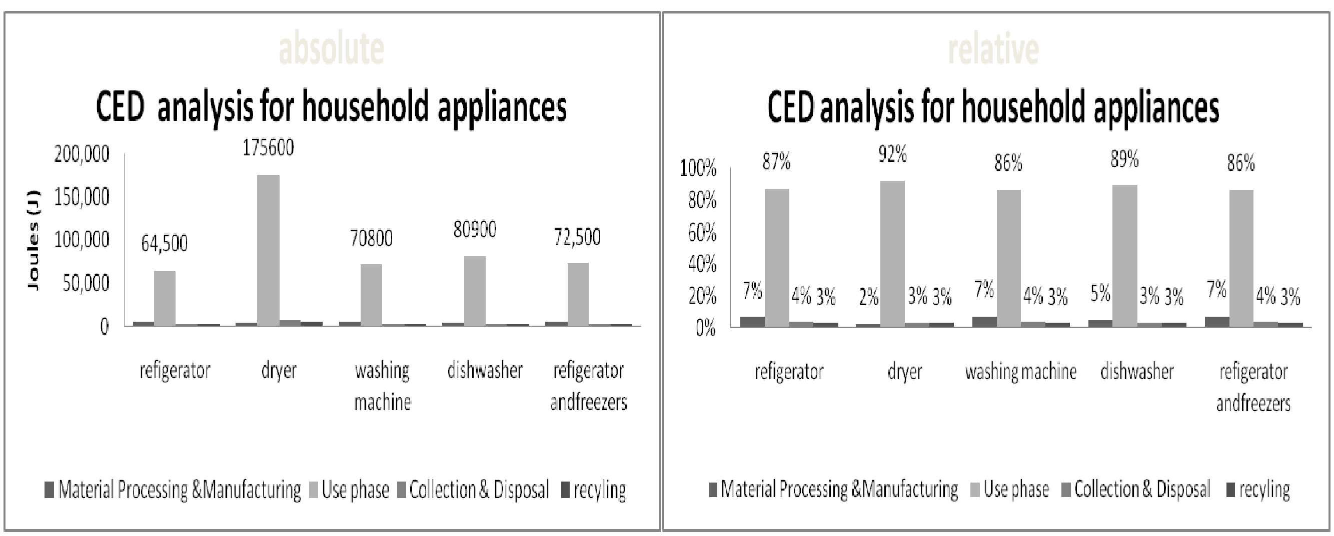

Figure 1: Cumulative Energy Demand of Household appliances

Limitations of CED Analysis

The use phase of the 5 main household appliances has been shown to dominate in terms of the overall lifecycle energy burden. This use phase is largely dominated by electricity, which has both fossil and renewable dimensions. These have radically different environmental impacts and the reason that CED correlates so well with so many other indicators is due to the impact of fossil fuel combustion [22]. Current CED analyses in the literature do not consider the generation portfolio associated with the electricity supply. However, generation from renewable sources continue to play an increasingly significant role in electricity production. These sustainable resources can offer energy with little environmental impact dramatically changing the outcome of the lifecycle profile. In order to produce a CED profile that reflects the true impact of the appliance, the use phase should be split into two categories, CED from Renewables (CED-R) and CED from Fossil Fuels (CED-F).The CED-R will be deducted from the total use phase energy demand, isolating the CED-F. Results from such analysis, will vary significantly depending on how the electricity is generated. Each country employs different energy generation techniques with varying emissions making use phase CED analysis very much a country specific calculation

Ireland's energy mix

As with other European Union members, Ireland's strive towards higher penetration of renewable energy has been driven by necessity to achieve overall reductions of green house gas emissions (GHGs) with the promotion of energy from renewable sources. Furthermore, Ireland's resilience against fluctuations in foreign fossil fuel markets has continued to weaken since the mid 1990's, hitting an all time low in 2007 with imported fuels accounting for 91% of annual consumption [29]. These factors have shaped government policy to maximize exploitation of Ireland's indigenous renewable energy from wind, wave, tidal, and biomass sources.

As a result, Ireland's electricity generation from renewable sources (RES-E) has increased from 2% in 1995 [30] to approximately 14.4% in 2009 [31] and is set to increase to upwards of 40% by 2020 [32]. Wind generated electricity has surpassed hydro power as the dominant contributor to Ireland's RES-E and is planned to contribute up to 72% of the 2020 target [33].

Renewable and fossil Sources in the Use Phase

The use phase for the five main household appliances is broken into Fossil-CED(CED-F) and Renewable (CED-R) for Ireland in Figure 4. This split enables a more in depth analysis of the use phase impact. Data for the projected yearly electricity mix is sourced from the SEAI national energy forecast white paper from 2010-2020.

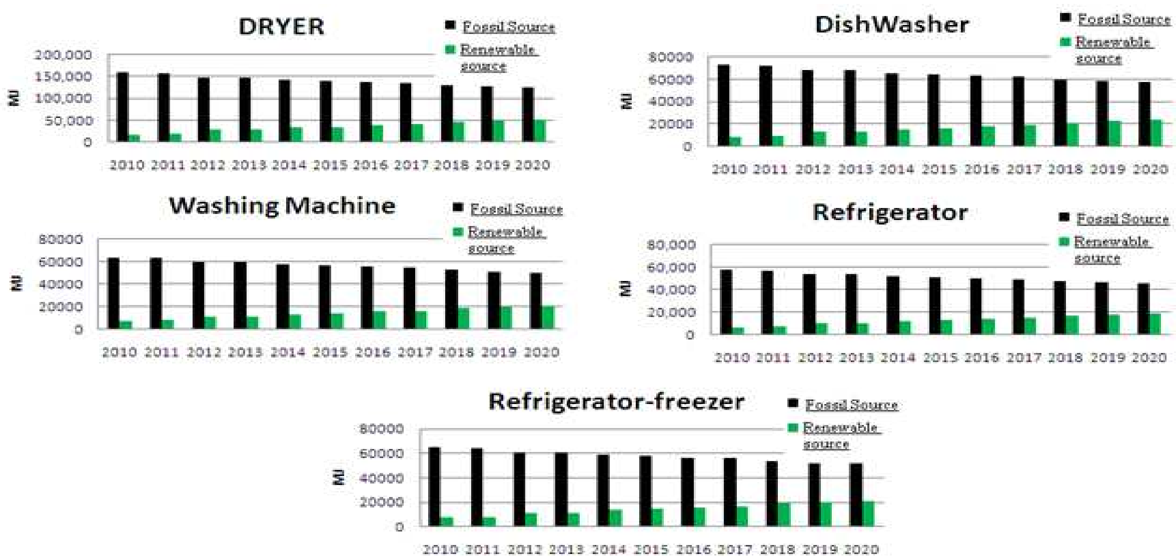

Figure 3: Cumulative Energy Demand -Renewable and Cumulative Energy Demand -Fossil for 5 main household appliances

Assuming the electricity use is evenly distributed in time, the use phase impact in 2010 is reduced by 10% compared to the equivalent CED study neglecting the electricity mix. With future developments in renewable energy generation, the use phase impact will be reduced by about 29% by 2020 in Ireland. For the washing machine, this shows a 20,000 MJ reduction in the use phase impact and a further 50,000 MJ reduction in the use phase impact of a dryer. The use phase still remains the dominant factor over the life cycle but is significantly reduced when the electricity mix is accounted for in the CED analysis

Decision factor II: Penetration of 'A' rated appliances

From a legal standpoint, appliances are labeled based on their energy consumption demand and are rated from A-G, with Category A being the most efficient and Category G being the least. The penetration rate of A/A+ rated appliances has significantly increased since 1995. A paper published by Sustainable Energy Authority of Ireland (SEAI) and data sourced from ODYSSEE in a 2008 report "Energy in the Residential Sector" examined the penetration rate of 'A' rated appliances, for the top four domestic appliances (i.e. dishwashers, washing machines, freezers and refrigerators) in Ireland from 1995 to 2005 [34]. At the outset, penetration rates of A rated appliances were below 10%, but with the introduction of the Household Appliances: Energy Consumption Labeling Directive (92/75/EEC) an increase in the penetration rate of A rated appliances was seen annually. The European Union (EU) harmonized national measures relating to the publication of information on the consumption of energy and of other essential resources by household appliances, thereby allowing consumers to choose appliances on the basis of their energy efficiency. This in turn has had direct impact on the penetration rates of A rated appliances with 70% penetration for fridges and freezers and over 90% penetration for washing machines and dishwashers by 2005. Further directives such as the ecodesign directive in 2005 (2005/32/EC) and the recast of ecodesign directive in 2009 (2009/125/EC) for establishing a framework for the setting of ecodesign requirements for energy-related products, should also improve the penetration of the more energy efficient appliances. This large stock of 'A' rated appliances currently in use indicates a large pool of appliances that would be suitable to be the refurbished appliances of the future

Decision factor III: Energy Efficiency improvements over time

As discussed in the literature review, Truttmann and Rechberge predicted the future energy consumption trends the electricity consumption of 8 household appliances from 2005 to 2020 [20]. These predicted trends indicate lesser gains in energy efficiency improvements over time. Marginal gains from replacing appliances in the future are inevitable, once systems have achieved an 'A' grade certification in efficiency. These diminishing returns over time remove the justification for early product replacement or dramatically increase the length of amortization once appliances have reached a sufficiently high rating.

Decision factor IV: Energy rating of low cost household appliances

A survey was conducted of 6 large white goods retailers in Ireland. The survey focused on the five main household appliances in this study (dishwasher, washing machine, tumble dryer, refrigerator and freezer) examining the energy rating of the least expensive on the market. Emphasis is placed on the energy label of cheapest new appliance on market, as this is generally the target market for refurbished appliances.

Retailers (Ireland)	Dishwasher	Rating	Washing M	Rating	Dryer	Rating	Refigerator	Rating	Freezer	Rating
Currys	CDWTT11	A	C100WM10	A	White Knight	D	Indesit	A	Currys	A
Harvery Norman	Finlux	A	Finlux	A	Whiteknight	D	Samsung	A	Hisense	A
Dixions	Indesit	A	Hotpoint	A	hotpoint	C	Hotpoint	A	ìnsesit	A
DID electrical	null	NA	Thor	A	ZANUSSI	C	Thor	A	thor	A
Argos	Haus	A	Haus	A	White Knight	D	Becko	A	Argos	A
Pixmania	Bosch	A	Thor	A	ZANUSSI	C	Thor	A	servein	A

Table 1: Energy rating of the cheapest new appliance on the market

From Table 1, it is shown that for dishwashers, washing machine, refrigerator and freezer, the cheapest appliances available are 'A' rated. This exhibits the dominance of 'A' rated appliances on the market for low cost household appliances. For tumble dryers the energy efficiency scale is calculated using the cotton drying cycle with a maximum declared load. The energy efficiency index is in kW·h per kilogram of load. Predominately there is little difference between dryers on the market, requiring constant energy consumption for heating and motor elements. Therefore the vast majority of dryers on the market are rated ‘C’ and ‘D’.

Decision factor V: Final destination of WEEE

A concern associated with refurbished IT is the export of such equipment to developing economies. Once IT equipment reaches the end of its useful life it sometimes falls into the informal recycling market [35]. Developing countries are potentially benefiting in the short term but the people involved could incur long term health and environmental consequences due to the lack of formal recycling controls in these regions [15]. In Ireland the flow of white goods after the refurbishment stage would be regional, with minimal illegal leakage due to the nature and size of the appliances making logistics expensive. This removes many of the concerns associated with WEEE ending up in the informal recycling channels in the developing world.

4 White Goods Reuse before Recycling: Socioeconomic Assessment

The criteria which indicate improvement in socioeconomic matters include metrics such as levels of employment, improved standard of living and reduced social exclusion among others [36]. Job creation resulting from reuse industries and employment creation for the long term unemployed merits investigation. The following sections provide further discussion on these social indicators. A comparison is made with successful reuse models from other EEE refurbishment categories in Ireland. This follows with a survey of white goods refurbishment facilities in the UK and Belgium that aims to identify the potential barriers and success factors for the industry. Finally a cost analysis compares the potential gain from conducting white goods reuse with the scrap metal value received from recycling practices.

Increasing Quality of Life by providing refurbished White Goods to Low Income Families

The global recession has significantly impacted the Irish economy. In 2009, almost 25% of households was in arrears on one or more of the following items: utility bills, rent or mortgage payments, hire purchase agreements or other loans/bills [37]. This compares with a rate of approximately 10% in 2008. Enforced deprivation, which refers to, the inability to afford basic specific goods or services, has also increased over the same period from 13.8% in 2008 to over 17% in 2009. This in turn affects individuals ability to purchase basic necessities such as white goods. Figures published by the Central Statistics Office (CSO) on the income and living conditions in Ireland for 2009 showed 0.6 % of individuals were unable to afford a washing machine, 6.5% of individuals were unable to afford a clothes dryer and 8.6% of individuals were unable to afford a dish washer. Providing low cost white goods could potentially lessen the strain on low income families. An important consideration is to ensure that the total cost of ownership (TCO) is reduced by providing refurbished appliances. Short term economic gains due to price reduction, could be quickly negated by the long term costs due to higher energy consumption.

Comparison with Successful Reuse Models in Ireland

When contemplating white goods reuse indicators are necessary to show that is would be a viable and sustainable business. Successful reuse models for ICT already exist in Ireland, for example Rehab Recycle. The company was established in Ireland in 1984, primarily to create employment opportunities for people with disabilities, opened a ICT refurbishment facility in 2006 in Tallaght, Dublin. Rehab Recycle are an accredited Microsoft's Authorized Refurbisher (MAR), providing high quality low cost personal computers (PCs) and software to schools and charities. Since the initiative was started in 2006, Rehab has placed 27,000 pieces of refurbished IT equipment back in use. The organization conducts both refurbishment and recycling of WEEE and from June 2009 to May 2010. Analysis has shown that reuse of business to business (B2B) IT generated 15 times more revenue than general e-waste recycling per ton. This figure was calculated using Rehab Recycle financial statements in Tallaght from June 2009 to May 2010 focusing on the profit and loss analysis of the reuse and recycling practices.

Consumer attitudes and acceptability towards different reused products vary. A survey conducted by Flash Eurobarometer gauged EU citizen's perceptions, attitudes and practices concerning resource efficiency, waste management and recycling [38]. A thousand sources were used for each country within the EU 27. Results shows Irish peoples willingness to buy second-hand electronics is 42% compared to 28% for second-hand textiles. Currently there are over 400 textile reuse shops actively selling within Ireland. This suggests a large market for second hand electronics, which is currently underutilised.

Reuse of White Goods in the EU

Reuse of white goods is common practice in many EU countries, where it is predominately carried out by social enterprises. Bryson in Northern Ireland and Kringerwingle in Belgium are examples of social enterprises conducting white goods refurbishment on different scales. As part of this study both of these organizations were visited and semi-structured interviews conducted. Bryson employ a skilled workforce for the technical requirement of refurbishment and an unskilled workforce for collection and delivery services. Kringerwingle employ predominantly an unskilled workforce, providing employment and training opportunities for those distanced from the labour market. Within the UK and Belgium, reuse of WEEE counts towards recycling targets as part of the WEEE directive (2002/96/EC), which both organizations have identified as a contributing factor to their success.

One of the key success factors for Bryson is the means by which it sources and segregates white goods with potential for reuse. Bryson sources white goods predominantly from civic amenity (CA) sites but also from retailers within Belfast in cooperation with the compliance scheme European Recycling Platform (ERP). They have developed a highly successful three tier cherry picking system, for white goods evaluation and refurbishment. The steps include:

1. Initially white goods are segregated from other WEEE at the CA sites by CA staff
2. Bryson employees inspect white goods on site recovering machines with possible potential for reuse
3. Machines are assessed technically at the Bryson facility, where refurbishment is conducted when it is technically feasible.

Bryson works closely with the CA sites from whom they have arranged collections. On site staff are educated and informed of the storage requirement for white goods with possible potential for reuse. From April 2010 to March 2011, Bryson processed 6395 machines of which 4605 (3333 CA, 1272 retailer) appliances were refurbished. This accounted for just under 1% of WEEE in Northern Ireland by weight.

One the key success factors for Kringerwingel is also the collection system. Kingerwingel have 33 reuse centers, 100 outlets and 8 WEEE refurbishment centers. WEEE is sourced from three collection points: house hold collections (~70%) reuse centers (~15%) and municipalities (~15%). All WEEE collected is processed at the 8 refurbishment centers and resold through their outlets. In 2005 a reuse rate of 11% for refrigerators and 20% for large household appliances was achieved from their input sources. Kingerwingel has attributed the following 3 aspects to their commercial success

1. The <u>branding system</u> for the shops, 'De Kringwinkel' is a recognized brand throughout Belgium. It aims at distinguishing these shops by guaranteeing them a common logo, organization and presentation.
2. An initiative called 'Revisie', a <u>quality label</u> for electronic appliances. 73 % of the WEEE-reuse centers that have been accredited are using the 'Revisie' label. The aim is to offer safe and reliable second hand electric appliances.
3. The incorporation of the European Foundation for Quality (EFQM) model is designed for helping organizations in their drive towards being more competitive. Regardless of sector, size,

structure or maturity, organizations need to establish appropriate management systems in order to be successful. 55% of the reuse network has currently employed this model.

One of the major constraints experienced by both organizations is the unpredictability in supply of the right mix of appliances. In order to be cost effective, there is a minimum amount of throughput necessary to maintain viability. Access to sufficient volumes of used equipment at good quality is imperative for survival of the industries. This is also supported by the recent StEP white paper "Best Practices in Re-use, success factors and Business for Re-use operating models [39].

Ireland consumer acceptance and willingness to buy second-hand electronics (42%) correlates closely to the UK (46%) and surpasses Belgium (31%)[38]. This highlights the potential for a viable refurbishment market in Ireland

Job creation potential of reuse and recycling

A recent literature review by Cascadia Consulting Group found that the field of "recycling and economic development" had a lack of quantitative data on employment [40]. Looking more generally at reuse and recycling the US EPA estimated that 10,000 tons of materials create 1 job at the incinerator, 6 jobs at landfills, 36 jobs at recycling centers, and 28-296 jobs for the reuse industry [41]. It concluded that recycling and reuse represent a significant facet of the U.S. economy that contributes to job creation and economic development. In Ireland, Rehab Recycle analyzed the job creation variation between PC reuse and the e-waste processing that conducted at their facility in Dublin from June '09 to May '10. This analysis showed that reuse of B2B IT generated 10 times more employment per ton than the recycling of an equivalent amount of e-waste..

5 Discussion

A sustainable national policy on WEEE reuse has to ensure an integrated socioeconomic and environmental approach. In a report published by the Irish government entitled "sustainable development – A strategy for Ireland" they underlined the fact that traditional policies must be replaced by an integrated approach to environment and development issues, if growth is to be achieved in parallel with, rather than at the expense of, environmental quality [42]. Ensuring sustainable development within national policy is increasingly recognized as the key to managing this economic and environmental interdependence. Based on the research undertaken in this study, there follows a discussion on how this relates to the development of a re-use sector in Ireland.

Environmental

From the environmental perspective the use phase analysis of domestic appliances demonstrated the importance of considering the energy generation mix when determining the life cycle impacts. The use phase predominately consists of electricity; therefore the electricity generation portfolio which is country specific has to be evaluated accordingly. Ireland's commitment to the development of renewable infrastructure is dramatically changing the environmental impact of the use phase for appliances. By 2020 Irelands renewable electricity capacity will reach in the region of 40% of total supply, reducing the use phase impact by an equivalent amount. This, in conjunction with the increased penetration of 'A' rated appliances is shifting the balance of the CED from the use phase gradually to the extraction and production phase where the transition to renewables is occurring at a much slower rate, and indeed in some regions the balance is moving in the other direction [43]. Reuse offsets the production of new appliances, developing a more sustainable and environmentally beneficial alternative to production. Recycling is still a key part of the process once an appliance has reached a useful threshold, but on environmental grounds there appears to be a strong case to support a widespread adoption of reuse of large house hold appliances in Ireland.

Socio economic

Reuse of white goods, if conducted through social enterprises, will create more employment than an equivalent amount of recycling for those most vulnerable to unemployment for example youth, disabled and unskilled workers. It is critical that social safety nets effectively reach these groups and support them in their transition to work, encourage attainment of higher wages, and work to avoid long term detachment from the labour market. The social enterprises previously discussed include Rehab, Kingerwingel and Bryson and each of these have demonstrated the ability of such enterprises throughout Europe to engage with reuse. Based on this a special role for the social economy in reuse policies should be considered. Furthermore the potential to increase prosperity and bridge the social divide, by providing low cost high quality white goods to low income families is a significant factor, specifically under Ireland's current economic crisis and the increased potential of households becoming at risk of poverty. From the economic perspective reuse of IT has been shown to be 10 times more profitable than general e-waste processing per ton. The economic case for white goods reuse is strong, but economies of scale is a factor, with constant supply of the right material a necessity to insure an adequate level of through-put for maintaining viability. White goods reuse creates an opportunity and incentive for the government to foster the growth of social entrepreneurship in Ireland as part of its economic development agenda, through a national policy. Yet there are a few critical aspects which must be considered when considering White goods reuse policy. These include (1) Role of the compliance scheme, (2) Reuse operational standards and (3) Energy rating for reused appliances and are discussed in the remaining sections

Role of the compliance scheme

In Ireland, compliance schemes are not for profit organizations founded by producers of electrical and electronic appliances in order to comply with the legal obligations imposed by the WEEE Directive 2002/96/EC. They play a pivotal role in the viability of reuse as they control the supply and EOL treatment of WEEE. Currently there is no significant incentive for compliance schemes to conduct reuse within Ireland, as reuse does not count towards their recycling targets. Legislation must be amended in order to create incentives and obligations for compliances schemes to conduct reuse where it has been shown to be sustainable from social, economic and environmental perspectives. The transposition of the recast of the WEEE directive into national legislation would be an ideal opportunity to do this. Indeed the European Councils current position foresees that previously established objectives for recovery and recycling are increased by 5%, with re-use of whole appliances counting towards recycling target [44-45].The Illinois Electronic Products Recycling and Reuse Act (Public Act 095-0959) is a good example of an aggressive pursuit of reuse [46]. In this program the weighting factor, of covered electronic devices, towards their targets for conducting reuse is tripled if they are donated for reuse by the manufacturer to a primary or secondary public education institution or to a not-for-profit entity whose principal mission is to assist low-income children or families or to assist the disabled in Illinois. Regular reuse counts for double the weighting factor towards their targets

Reuse operational standards

Reuse operations should be regulated. Reuse organizations must operate on an equal playing field to recycling operators in terms of reporting, accountability and traceability. Unregulated reuse of WEEE opens the potential for leakage of waste from properly controlled recycling (also known as sham reuse) including uncontrolled treatment and illegal shipment to developing countries. Only organizations operating to sufficiently high standards should be considered eligible to undertake refurbishment and reuse activities. Furthermore a survey conducted by the European commission showed the main reasons for consumers not buying second-hand products were concerns of the quality/usability of the product (58%), with Health and safety also being a serious concerns (50%) [38]. A recently published standard (31st March 2011) for reuse of WEEE has being developed by British Standards Institution (bsi) called PAS 141 [47]. PAS 141 differentiates between untested WEEE/ Used WEEE(UEEE) and Reused WEEE (RWEEE) assuring and protecting customers of the quality and electrical safety of the RWEEE. It also provides a tool for which certified refurbishers can identify REEE and constituent components that have been subject to the tests set out in PAS 141 from untested WEEE and UEEE.

Energy rating of reused appliances

The energy rating of refurbished appliances is a third significant factor in the context of reuse activities for white goods, for insuring the TCO for the consumer is not increased. There could be a requirement for legislation setting minimum standards on what grade of energy rated appliance can be refurbished, but this pre-emptive measure may be excessive and unnecessary .In general consumers are aware of the TCO specifically with regard to energy labels and the market has responded in kind with a significant penetration of ‘A’ rated appliances. A simple recommendation for refurbishers would be to refurbish machines with energy rating the same or higher than the cheapest newest appliance on the market, therefore ensuring a similar or reduced TCO and environmental impact.

6 Conclusion

A green economy is one that results in improved human well-being and social equity, while significantly reducing environmental risks and ecological scarcities (United Nations Environment Programme (UNEP) 2010). The development of the green economy can make a significant contribution to economic growth by creating employment, ensuring real sustainable economic growth, and minimizing environmental pollution. Waste represents an under-utilized resource of considerable value. This article has provided evidence that a reuse policy for white goods adheres to the three pillars of sustainability: social, environmental and economical. In times of economic instability in Ireland, job creation initiatives require strong governmental support. It is necessary to ensure the net environmental gain associated with reuse of the appliance is not offset by the efficiency improvements associated with the use of a new system. This obviously minimizes the overall TCO for the consumer as well, which is important. The strongest indication from data presented supports reuse of white goods as a sustainable strategy. At a minimum legislation needs to change to incentivize compliance schemes and social enterprises to enter this arena.

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