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The Development of a Model to Ascertain Future Levels of Historic WEEE Arising (Historic WEEE)

Authors: Michael Johnson and Colin Fitzpatrick.

Comhshaol, Pobal agus Rialtas Áitiúil
Environment, Community and Local Government

weee ireland

European Recycling Platform

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ENVIRONMENTAL PROTECTION AGENCY

The Environmental Protection Agency (EPA) is responsible for protecting and improving the environment as a valuable asset for the people of Ireland. We are committed to protecting people and the environment from the harmful effects of radiation and pollution.

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- the contained use and controlled release of Genetically Modified Organisms *(GMOs)*;
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- Monitoring and reporting on Bathing Water Quality.

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- Office of Environmental Enforcement
- Office of Evidence and Assessment
- Office of Radiological Protection
- Office of Communications and Corporate Services

The EPA is assisted by an Advisory Committee of twelve members who meet regularly to discuss issues of concern and provide advice to the Board.

EPA Research Programme 2014–2020

The Development of a Model to Ascertain Future Levels of Historic WEEE Arising (Historic WEEE)

(2014-RE-DS-1)

EPA Research Report

Prepared for the Environmental Protection Agency

by

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The EPA Research Programme addresses the need for research in Ireland to inform policy and other stakeholders on a range of questions in relation to environmental protection. These reports are intended as contributions to the necessary debate on the protection of the environment.

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Executive Summary

The implementation of the Waste Electrical and Electronic Equipment (WEEE) Directive in Ireland in August 2005 facilitated, inter alia, the introduction of a formal system for the return and environmentally sound management of WEEE. Visible environmental management costs (vEMCs) were introduced to cover the cost of the environmentally sound management of “historic WEEE”, that is, all electrical and electronic equipment (EEE) that was placed on the Irish market before 15 August 2005. However, no information was available on how long it would take for this equipment to enter the newly created WEEE collection points and, therefore, very little was known about the levels of historic WEEE that would arise in the future. This created uncertainty with regard to how much money should be placed in reserve to fund the management of historic WEEE and for how long.

The research detailed in this report was carried out to address this problem by employing novel modelling techniques, in order to determine WEEE levels and the percentages of historic WEEE in Ireland over the period from 2000 to 2020, inclusive. The research focused on the three categories of EEE that contribute the largest amounts of WEEE each year by weight [fridges and freezers (“cold” WEEE), large household appliances and televisions) and were the main categories under discussion with regard to the continued use of vEMCs.

The model used was developed by the United Nations University and has been employed in other European countries to calculate total WEEE levels arising. It was tailored to calculate Irish historic WEEE levels using data gathered from a number of disparate sources, including trade statistics, Department of Environment, Community and Local Government data on housing stock and Central Statistics Office (CSO) data on the penetration rates of various appliances. The model outputs were processed to determine EEE sales and total WEEE figures, as well as the ratio of historic to non-historic WEEE in the market for each year of the 20-year period of interest.

The findings from the “WEEE Generated Model” indicate that, for the three categories of EEE considered in this project, historic WEEE comprises well over 50% of all material returning through official WEEE take-back channels in Ireland. Based on the model predictions for 2015, approximately 69% of all cold WEEE will be historic in nature, 59% of large household WEEE will be composed of historic WEEE and 77% of all television WEEE will be historic. According to the model predictions for 2020, these figures will reduce to 45% historic WEEE for the cold category, 38% historic WEEE for large household appliances and 54% historic WEEE for televisions.

These model results and associated predictions were validated using a statistically significant sampling of the three WEEE categories of interest in Ireland over the course of 1 year. Cold, household appliance and television WEEE were sampled at regular intervals at a number of different WEEE collection points, in order to determine the actual breakdown of historic versus non-historic WEEE arising at WEEE collection points. Furthermore, this sampling should be performed as an annual process of measurement and corroboration in the future, in order to inform national discussions on the continued use of vEMCs.

1 Introduction

The implementation of the Waste Electrical and Electronic Equipment (WEEE) Directive (2002/96/EC) in Ireland in August 2005 was a landmark event in the recycling of electrical and electronic equipment (EEE) in Ireland. Prior to this, end-of-life practices for such equipment were unstructured with no overarching framework, and landfilling and dumping were widespread. Under the new regulations, a take-back infrastructure at civic amenity sites and retailers was established, landfilling was banned and recycling was made mandatory with a collection target of 4 kg per person per year. Furthermore, according to this directive, the environmentally sound management (ESM) of any equipment placed on the market after 15 August 2005 must be financed by the producers, and for products already on the market, visible environmental management costs (vEMCs) were agreed. These vEMCs are implemented at the time of sale of certain new equipment in order to create a fund to finance the ESM of the historic WEEE arising from products already on the market. Two “not for profit” WEEE compliance schemes were established by producers to assist with the compliance with these new obligations.

These vEMCs associated with EEE sales have allowed the build-up of contingency funds for the ESM of historic WEEE; however, the question of how much money will actually be required was not fully resolved when the vEMCs were agreed as the necessary information to make such a judgement was simply not available. However, those involved in the collection of WEEE in Ireland have observed that historic WEEE continues to show up in significant quantities at all WEEE collection points across the country.

Although many of the vEMCs for large items of EEE have been discontinued, from 1 July 2014 they were re-introduced for certain categories of EEE: refrigerators have a vEMC of between EUR 5 and EUR 10, other large household appliances (LHAs) incur a vEMC of EUR 5 and large colour televisions (TVs) have a vEMC of EUR 5. More information on the WEEE Directive and the associated vEMC structures are given in Chapter 2 of this report. However, with no way of accurately measuring or predicting the return rates of historic WEEE, it is still unclear how much longer it will be before all of the historic WEEE has made its way back into the return stream from recycling.

This project was undertaken to address this and other related uncertainties, in order to provide an evidential basis for the continued use of vEMCs and predict the return rates of historic WEEE in Ireland in the future. It will also inform discussions on how much contingency will be required to fund historic WEEE in the future, the required lifetime for vEMCs and the ESM of historic WEEE in this regard. In this report, the specification, development and validation of a model for the prediction of historic WEEE return rates in the Irish market is detailed. The model was developed as a collaboration between the University of Limerick and the United Nations University (UNU), and models the Irish return stream figures for EEE, WEEE and historic WEEE for the years 2000 to 2020, inclusive.

Chapter 2 of this report contains a brief literature review, which provides information on the management of WEEE in Ireland, an introduction to statistical modelling and associated background information of direct relevance to this project. The specification and development of the model created through this body of work, herein referred to as the “WEEE Generated Model”, are described in Chapter 3. In collaboration with the UNU, inputs to the model and specifics on the workings of the model are also described in Chapter 3. Chapter 4 contains the results obtained from the model and details the predicted levels of EEE, WEEE and historic WEEE in Ireland up to 2020. These results are presented in graphical formats across the various categories of interest and are summarised in table and broader EEE category formats. The validation of the model and its findings are described in Chapter 5. This validation was performed by comparing the model results and predictions with sampled data collected from various Irish civic amenity sites, retailers and WEEE recycling facilities. Finally, the conclusions and recommendations from the project are presented in Chapter 6.

The model data are relevant to, for example, identifying whether existing contingency funds will be sufficient to cover future WEEE returns or whether vEMCs are needed for long-term future management considerations, and determining how large a contingency may be required. In particular, the EEE categories of refrigeration, LHAs and TVs/monitors [particularly cathode ray tube (CRT) TVs and monitors] are of direct relevance to this project, as these contribute most immediately to the ESM costs for WEEE in Ireland.

These findings are directly relevant to any future considerations of the continued use or re-introduction of vEMCs for WEEE, and the level of fees and costs that producers will need to make provisions for in the future. Under the WEEE Directive, recycling must be free of charge to the consumer. As a consequence, the re-introduction of vEMCs could be interpreted as non-compliance with this aspect of the directive and lead to issues in this regard.

2 Literature Review

2.1 Introduction

WEEE (also sometimes referred to as e-waste) is one of the fastest-growing solid waste streams across the globe. Dwivedy and Mittal (2010) attribute this rapid growth to factors such as continuous technological innovations, combined with increasing consumer demand, which has led to a rapid proliferation of electronic devices on the market. With this ever-increasing market for EEE, correspondingly large quantities of WEEE are being generated. Furthermore, this phenomenon is compounded at present by decreasing product lifespans and an increasing range of new and different product types, as highlighted in a recent article from the German Environment Agency (UBA).[1]

This review presents an overview of the WEEE Directive, the key shareholders in the Irish WEEE market and an overview of the WEEE financing structure in Ireland. In addition, some of the software tools and systems used in the development of the WEEE Generated Model are considered as well as a review of WEEE quantification studies worldwide.

2.2 The Waste Electrical and Electronic Equipment Directive

To improve the end-of-life handling of WEEE (which can cause major environmental and health problems if not properly managed), lessen the impact of such waste on the environment, contribute to a circular economy and enhance resource efficiency in this sector, the WEEE Directive was introduced in the European Union (EU). The first EU WEEE Directive (2002/96/EC), established in 2002, was a producer responsibility directive, which sought to improve the sustainable management of electronics at the end of their life by promoting the reuse, recycling and recovery of WEEE within the EU.

The main objective of this first WEEE Directive was to prevent the creation of WEEE and also promote reuse, recycling and recovery, in order to reduce the disposal of waste. This was to be achieved by minimising the disposal of WEEE as unsorted municipal waste, through achieving high levels of separate WEEE collection. In addition, the original directive aimed to improve the environmental performance of all operators, including producers, distributors, consumers and treatment facilities, in the EEE life cycle.

In Ireland, all producers and distributors (retailers) of EEE had to comply with the 2005 National WEEE Regulations [Statutory Instrument (S.I.) No. 340 of 2005]. These regulations catered for both commercial [i.e. “business to business” (B2B)] and domestic [i.e. “business to consumer” (B2C)] producers and distributors. Under these regulations, all producers and importers of EEE were required to fund the collection, treatment and ESM of WEEE from private households and businesses. From August 13 2005, members of the general public were also entitled to have WEEE taken back by retailers free of charge on a one-for-one basis.

The scope of the original WEEE Directive catered for the 10 categories of EEE/WEEE listed in Table 2.1.

The original WEEE Directive set an initial collection target of 4 kg, on average, per head of population per year of WEEE from private households (to be achieved by 31 December 2006). The recovery targets (by average weight per appliance) based on collected WEEE, as per the directive, are given in Table 2.2.

Table 2.1. Scope of the original WEEE Directive categories

Category	Type of EEE
1	LHAs
2	Small household appliances
3	Information technology (IT) and telecommunications equipment
4	Consumer equipment
5	Lighting equipment
6	Electrical and electronic tools
7	Toys, leisure and sports equipment
8	Medical devices
9	Monitoring and control equipment
10	Automatic dispensers

1 http://www.endseurope.com/article/45200/uba-calls-for-product-resource-efficiency-policies (accessed 1 January 2016).

Table 2.2. Recovery targets, as set out in the original WEEE Directive

Category	Rate of recovery	Rate of reuse/ recycling
1 and 10	80%	75%
3 and 4	75%	65%
2, 5, 6, 7 and 9	70%	50%

Member States were obliged to inform users about separate collection, the role of the consumer in recycling and the effects of hazardous substances. The new "crossed-out" wheelie bin symbol was also introduced under the original directive, and all new EEE on the market had to be marked with the logo shown in Figure 2.1.

Under the original directive, information for treatment facilities was also needed. To this end, Member States were required to take the necessary measures to ensure that producers provided reuse and treatment information for each type of new EEE on the market within 1 year of the equipment being put on the market. All EEE producers were required to be registered at a national level. A 3-year report from each Member State to the European Commission on the quantities and categories of EEE, and the implementation of the directive was also required.

In addition, through Article 4 (the Eco-Design Directive; 2009/125/EC), Member States were asked to "encourage" co-operation and measures for design and production that facilitated reuse, dismantling and recovery, unless environmental protection or safety demanded otherwise. The Waste Framework Directive

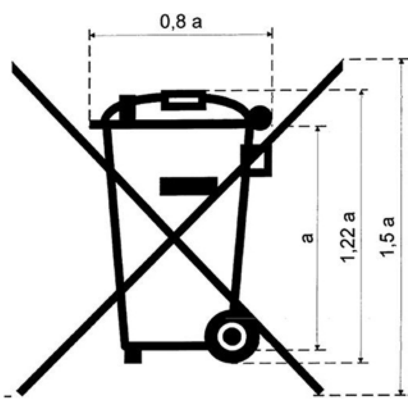

Figure 2.1. The crossed-out wheelie bin symbol introduced under the original WEEE Directive.

(2008/98/EC) provided a formal waste definition and stipulated the requirement for a permit for the treatment of WEEE.

In December 2008, the European Commission proposed that the original WEEE Directive be revised in order to address a number of shortfalls. These shortfalls were related to, for example, the unparalleled increase in the WEEE waste stream, which meant that original collection targets needed to be revised; the need to address illegal shipments of WEEE outside the EU by enforcing compliance with Waste Shipment Regulations more stringently; allowing reuse organisations access to WEEE material and the revision of the method for calculating collection rates in various member countries in the future.

The revised (recast) WEEE Directive (2012/19/EU) of the European Parliament and of the Council on waste electrical and electronic equipment (WEEE) was published on 4 July 2012 and came into effect on 13 August 2013. Member States had to transpose the revised WEEE Directive into national legislation by 14 February 2014. Key differences in the recast WEEE Directive include:

- More ambitious collection targets [a 45% take-back of what is placed on the market averaged across the previous 3 years' placed-on-the-market (POM) figures] to apply from 2016. This target will increase to 65% of EEE placed on the market or, alternatively, 85% based on WEEE generated after 2019. The existing collection target of at least 4 kg per person remained in place until the end of 2015.
- An increase in recovery targets: mandatory collection targets have increased to 65% of the average weight of EEE placed on the market over the previous 3 years in each Member State. The recycling and recovery targets increased by 5% on the basis of weight.
- The scope has been widened to include all EEE, except specific exemptions. In addition, the categories have been reorganisation into six types or "families". After 14 August 2018, all types of WEEE will be covered (i.e. there will be an "open scope").
- The free take-back of small household appliances (biggest external dimension no more than 25 cm) to retail stores (with a sales area of at least 400 m^2), regardless of whether the customer buys a new product or not.

Table 2.3. EEE classification categories under the new WEEE Directive

Temperature exchange equipment
Screens, monitors and equipment containing screens having a surface area greater than 100 cm^2.
Lamps
Large equipment (any external dimension more than 50 cm)
Small equipment (no external dimension more than 50 cm)
Small IT and telecommunication equipment (no external dimension more than 50 cm)

Under the new directive, from 15 August 2018, all EEE will be classified according to the (new) categories listed in Table 2.3.

Ireland's 2014 WEEE Regulations [European Union (Waste Electrical and Electronic Equipment) Regulations 2014 (S.I. No. 149 of 2014)] replaced the 2005 and 2011 regulations and amendments, and give effect to the provisions of the EU WEEE Directive 2012/19/EC in national legislation. In addition to the measures detailed in the revised WEEE Directive, as listed above, the 2014 WEEE Regulations include the following rules:

- Retailers must continue to take back WEEE from private households on a one-for-one basis. As previously mentioned, retailers with an EEE sales area of more than 400 m^2 must take back small WEEE (biggest external dimension less than 25 cm) without any obligation of consumers to purchase a new item.
- Retailers are no longer allowed to dispose of WEEE at their local civic amenity site.
- For certain categories of WEEE, vEMCs were re-introduced on 1 July 2014.
- Distance sellers now have to appoint an authorised representative (i.e. a locally based agent) to be responsible for ensuring that their WEEE obligations are met in full.
- Retailers have to keep records, for a period of no less than 2 years, of WEEE taken back and handed over to the compliance schemes.
- Article 30 of the regulations, entitled "Obligations of distributors to provide information to users of electrical and electronic equipment", sets out in detail the requirements for retailers with regard to signage and other information to be notified to users of EEE.

Following on from this, the term "WEEE arising", therefore, refers to the actual amounts of waste that are generated from any of the EEE categories listed in Table 2.3. Furthermore, the term "historic WEEE" specifically relates to waste from EEE products that were put on the market before 13 August 2005.

A standard of excellence, with respect to collection, logistics and the treatment of WEEE, known as the WEEE Label of Excellence (WEEELABEX), has been developed by numerous industry working groups within the WEEE Forum and funded under the EU LIFE programme.[2] This standard has been submitted for European standard approval [by the European Committee for Electrotechnical Standardization (CENELEC)] and will eventually be developed into an international standard [by the International Electrotechnical Commission (IEC)]. The 2014 WEEE Regulations stipulate that producers must ensure that all separately collected WEEE is treated in accordance with this standard.

2.3 International Waste Electrical and Electronic Equipment Legislation

Similar legislation exists in comparable forms around the world, such as the Japanese Specified Home Appliances Recycling (SHAR) Law and the Swiss Ordinance on the Return, Taking Back and Disposal of Electrical and Electronic Equipment (ORDEE).

In the USA, to date, 25 states have passed legislation mandating state-wide WEEE recycling and several more states are working on passing new or improved laws in this regard. All states, except California and Utah (which use an advanced recycling fee), use the "Producer Responsibility" approach, according to which the manufacturers must pay for recycling. This means that 65% of the population of the USA is now covered by a state WEEE recycling law. In China, the laws are primarily concerned with eliminating the import of WEEE. China has ratified the Basel Convention as well as the Basel Ban Amendment, officially banning the import of WEEE. In October 2008, The Chinese State Council also approved a "draft regulation on the management of electronic waste". This regulation is intended to promote

2 WEEE Forum Annual Report 2010. Available online: http://www.weee-forum.org/system/files/documents/2010_annual_report_final.pdf (accessed 11 July 2016).

the continued use of resources through recycling and to monitor the end-of-life treatment of electronics. Under the new regulations, the recycling of electronics by consumers is mandated. It also stipulates that unnecessary materials discarded during the manufacturing process must be recycled. The Extended Producer Responsibility (EPR) bill states that manufacturers are responsible for electronics collection and recycling in China, effectively making the producer more involved in the life cycle of a product. The Management Regulations for Recycling and Disposing of Consumer Electronics and Electronic Waste, effective from 1 January 2011 in China, bans the import of toxic WEEE, and stipulates that a licence is required for the treatment of WEEE and that treatment plants must tackle pollution.

In Australia, the National Waste Policy was agreed by governments across Australia and officially endorsed by the Council of Australian Governments in August 2010. The Product Stewardship Act 2011 introduced new legislation and provided a framework for developing legislatively backed product stewardship for Australia. Shortly after, the Product Stewardship Australia (PSA) and National Television and Computer Recycling Scheme (NTCRS) were introduced; these mandated the first targets for electronics recycling in Australia. The NTCRS has a strong focus on providing free access for the Australian public to WEEE recycling, with an initial focus on TVs, computers and computer peripherals.

2.4 Types of Waste Electrical and Electronic Equipment

At present, two main categories of WEEE are considered: commercial and consumer. Commercially generated WEEE is usually referred to as B2B WEEE, whereas consumer-generated (general-public-generated) WEEE is referred to as B2C WEEE. B2C WEEE recovery and recycling is usually handled by retailers in conjunction with a producer responsibility organisation (PRO)/compliance scheme (see section 2.5 of this report for more information in this regard). B2B WEEE producers must self-comply with all the regulations of the WEEE Directive and report to the Environmental Protection Agency (EPA); they do not have the option of using PRO services in this regard.

For the purposes of this report, an EEE producer is defined as any person who (irrespective of the selling technique used, including by means of distance communication) manufacturers, sells or resells EEE under their own brand or imports/exports EEE on a professional basis.[3] Producers of B2C EEE are obligated under law to finance the collection, ESM and treatment of historic and new WEEE generated from this waste stream, in accordance with the targets set out in legislation. They must also register with the national registration body Producer Register Limited[4] (PRL) and report, to the "Blackbox" (see section 2.5.1), the amount, in units, and weight (kg) of EEE placed onto the Irish market on a monthly basis to allow the calculation of market share and cost allocation.

With regard to B2B EEE that was placed on the market after 13 August 2005 (i.e. "new WEEE"), the producers must take back WEEE from the business end user and manage it, or make alternative financing arrangements with the business user (there must be a formal agreement between both parties on how and who will finance the management of WEEE). The WEEE must be managed by an authorised waste contractor with the relevant licence/permit.

With regard to B2B EEE that was placed on the market before 13 August 2005 (i.e. "historic WEEE"), the producer is obliged to take back any WEEE of a similar type and function (irrespective of brand) when a business user purchases new equipment. The producer is then responsible for the collection and environmental management of this WEEE. If the business user is simply discarding the WEEE and not replacing it, the responsibility for ensuring the ESM of WEEE remains with the business user. The WEEE must be managed by an authorised waste contractor with the relevant licence/permit and the business user must record the quantity delivered and treated at the authorised facility.

2.5 Waste Electrical and Electronic Equipment in Ireland

2.5.1 Main contributors to management of WEEE in Ireland

Figure 2.2 shows an overview of the Irish WEEE Producer Responsibility Model for B2C with compliance

3 http://www.epa.ie/enforcement/weee/producers (accessed 1 January 2016).

4 The WEEE Register Society was established in 2005 as the national registration body for producers of EEE, but changed its name in January 2016 to the Producer Register Limited in order to better reflect its expanding remit.

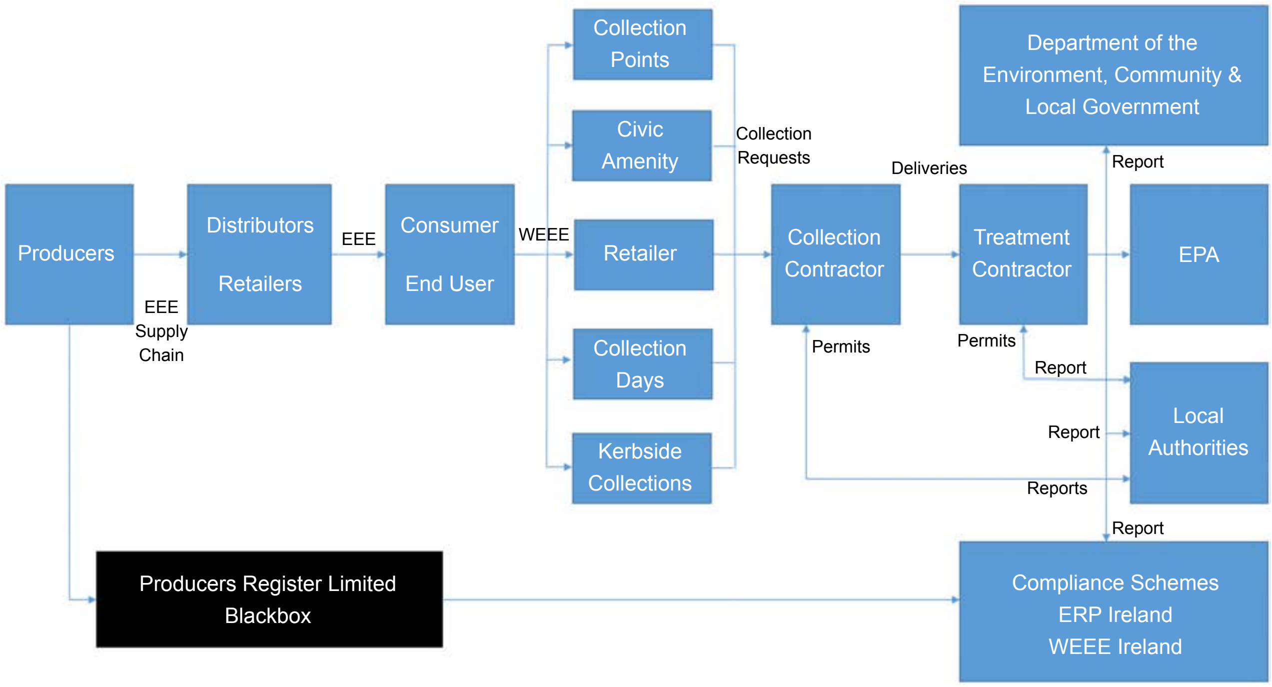

Figure 2.2. Irish WEEE Producer Responsibility Model. Adapted from PRI Report (DECLG, 2004).

schemes. It includes all of the major contributors to the supply chain and associated product life cycle. This does not include any leakages in the WEEE collection chain through informal or non-authorised channels.

The main contributors and actors in the Irish WEEE sphere are outlined in the following sections.

Environmental Protection Agency

The EPA was established in Ireland under section 19 of the Environmental Protection Agency Act 1992. The EPA's Office of Environmental Sustainability is responsible for leading the enforcement of WEEE regulations in Ireland (as part of the National Waste Prevention Programme). Under the WEEE and Battery Regulations, local authorities are responsible for the enforcement of many retailer obligations. The EPA engages with local authorities on an ongoing basis to ensure the effective enforcement of the regulations. The specific regulations are:

- the European Union (Waste Electrical and Electronic Equipment) Regulations 2014 (S.I. No. 149 of 2014);
- the European Union (Batteries and Accumulators) Regulations 2014 (S.I. No. 283 of 2014, as amended by S.I. No. 349 of 2014 and S.I. No. 347 of 2015).

Compliance schemes

Under the WEEE Directive, the compliance schemes are producer responsibility schemes operated by a PRO. The PRO (or, in legislative parlance, the approved body) is a non-profit organisation that takes on the obligations of its producer members for the collection, treatment and ESM of WEEE.

There are two approved WEEE PROs in Ireland: WEEE Ireland and the European Recycling Platform (ERP Ireland). These PROs have been approved by the Minister for the Environment, Community and Local Government and operate subject to conditions of approval as determined by this Minister. B2C producers of EEE can join either of these PROs or self-comply with the WEEE Regulations/Legislation. At present in Ireland, no B2C producers use this latter option, that is, all compliant producers are members of either WEEE Ireland or ERP Ireland. As mentioned previously, B2B producers of EEE do not have the option to join a PRO and so have to self-comply and report to the EPA.

Retailers

Retailers have certain responsibilities, under the WEEE Directive, if they sell EEE. These primarily include the responsibility to provide customers with a means to dispose of their old household EEE when they purchase newer versions of the same equipment and the responsibility to inform customers with regard to WEEE-related information, for example about vEMCs. WEEE regulations apply to retailers regardless of how they sell their products, and whether that be by direct or indirect means (e.g. using the internet, mail order or telephone).

Local authorities and civic amenity sites

In addition to the delivery of services, such as housing, planning, road maintenance and water treatment, local authorities also collaborate with the EPA on environmental protection issues, such as the enforcement of many retailer obligations under the WEEE Directive. Civic amenity sites (or facilities) are purpose-designed facilities, operated by, or on behalf of, a local authority, where the public can drop off materials free of charge for recycling. They provide facilities for the efficient reception and temporary storage of recyclable and non-recyclable waste materials, including segregated WEEE arising from private households.

Producer Register Limited

PRL was established as a registration body in Ireland and its functions include the following:

- to maintain a register of producers and authorised representatives;
- to determine the market share of individual producers through the Blackbox function (currently managed by Deloitte);
- to establish and maintain a register of approved organisations that perform “prepare for reuse” of WEEE activities;
- to obtain criteria from the minister with regard to the approval of organisations that perform “prepare for reuse” of WEEE activities, and approve such organisations;
- to track and report non-compliance and notify the relevant local authority or the EPA;
- to act as the registration body for preparing-for-reuse organisations;
- the verification that each producer has adequate financial guarantees in place;
- the verification of vEMCs.

PRL is a co-founding member of the wider European WEEE Registers Network (EWRN).

The TransFrontier Shipments Office

The TransFrontier Shipments (TFS) Office was established on 12 July 2007, and led to the designation of Dublin City Council as the national competent authority for the export, import and transit of waste shipments under S.I. No. 419 of 2007 Waste Management (Shipments of Waste) Regulations, 2007. The TFS Office is responsible for monitoring all trans-frontier shipments of waste, defining new notification procedures, waste listings and the implementation and enforcement of provisions for waste transportation into and out of the EU.

2.5.2 The financing of waste electrical and electronic equipment treatment in Ireland

Historic (B2C) WEEE is defined as (B2C) WEEE arising from EEE put on the market before 13 August 2005. Under the WEEE Directive, the ESM of historic WEEE must be financed by producers and have regard to the “polluter pays” principle.

The vEMCs are the costs of the ESM of WEEE from private households arising from EEE placed on the market before 13 August 2005. In this context, “environmentally sound management of waste electrical and electronic equipment” means the collection, storage, treatment and recovery (or, as appropriate, disposal) of WEEE in an environmentally sound manner.

Under the original WEEE Directive, producers were allowed to show vEMCs on new products (Categories 1, 2, 4, 5 and 6) placed on the market by unit for a limited period. For Categories 3, 7, 8, 9 and 10, vEMCs did not apply. The vEMCs were determined and approved by PRL in consultation with the producers/PROs, in adherence with Article 16 (11) of the WEEE Regulations, which stated that the vEMCs may not exceed the current substantiated costs of the ESM of WEEE. These vEMCs contributed to the Producer Recycling Fund (PRF). On 13 February 2011 (in accordance with the WEEE Regulations), vEMCs were discontinued for all WEEE, except for some Category 1 products (for which vEMCs were discontinued in February 2013).

As a result of stakeholder consultation during the transposition of the recast WEEE Directive, new vEMCs were agreed; these vEMCs took effect on 1 July 2014 and will apply until 1 July 2020 to a limited range of EEE; however, these vEMCs are significantly lower than the

Table 2.4. New vEMCs for EEE products as from 1 July 2014

Category	Description	vEMCs (EUR)
1.1	Refrigeration – all refrigeration, all side by side/American-style refrigeration	10
1.2	Refrigeration – all refrigeration, all larder and two-door (under–over configuration) appliances	5
1.2	Chest freezers – all chest freezers of more than 150 L	5
1.2a	All refrigeration – all under-counter/table-top refrigeration	5
1.2a	Chest freezers – all chest freezers of less than 150 L	
1.3	Large appliances	5
1.3	Washing machines – washer dryers, washing machines	5
1.3	Clothes dryers – clothes dryers	5
1.3	Dish washing machines – dish washing machines	5
1.3	Cooking appliances – combination ovens, ovens, gas cookers with electric/electronic elements, free-standing slot in and high backs	5
1.3	Electric stoves – electric stoves	5
1.3	Other large appliances used for cooking and other processing of food – rotisseries	5
1.3	Other large appliances – sun beds	5
4.1	Large colour TVs (visible screen size)	5
4.1	Large TVs (> 73 cm) – including plasma/LCD/CRT TVs, projection TVs	5
4.2	Medium-size colour TVs (52–72 cm) – including plasma/LCD/CRT TVs	0
4.3	Small colour TVs (visible screen size up to 51 cm) – including plasma/LCD/CRT TVs	0
5.1	All lamps – fluorescent lamps	0.15
5.1	All lamps – LED light sources	0.05

LCD, liquid-crystal display; LED, light-emitting diode.

costs introduced with the original WEEE Regulations in 2005. The new vEMCs (which must be shown on product price tickets) are shown in Table 2.4.

Calculating the quantity of historic WEEE that remains on the market is notoriously troublesome and fraught with difficulty, because of factors such as the lack of available data relating to EEE that was put on the market before the establishment of PRL, the lack of knowledge with regard to product residence times and the lack of data on historic WEEE arising. However, it is clear that, with time, historic WEEE will eventually phase out and all returned products will then have to be financed by producers as part of their WEEE Directive obligations. Since the implementation of the first WEEE Directive, the vEMCs have been reviewed on numerous occasions based on the best-available information at the time.

Finally, it is important to note that not all WEEE (historic or otherwise) will be recycled through official channels; in fact, a significant percentage of all WEEE is still not being recycled and treated through official channels. For example, as documented in a recent report by Huisman *et al.* (2015), the Countering WEEE Illegal Trade (CWIT) project found that, in 2012, only 35% (3.3 million tonnes) of European WEEE was reported through official collection and recycling channels, and the remaining 65% (6.15 million tonnes) was exported (16%), recycled under unofficial/non-compliant channels in Europe (33%), scavenged for valuable parts (8%) or thrown into municipal waste (8%).

2.6 Modelling Toolsets

An accurate estimation of the timing and quantity of disposed consumer durables is essential for the sustainable and efficient management of end-of-life consumer durables (Kang and Schoenung, 2006a). Models, as simplified representations of these real systems, can both reproduce or recreate ("portrait" models) and anticipate ("paragon" models) the system and are crucial for providing an understanding of the real system (Pérez Ríos, 2010).

There are many challenges associated with modelling the quantities of end-of-life consumer durables. The main challenges include:

- the insufficient, or at best fragmented, time-series data regarding sales, the existing products in use and the average product mass;

- the insufficient understanding of consumer disposal behaviour, especially with regard to how and when end-of-life durables are disposed of by the consumer.

Lending credence to these considerations, recent research by Ongondo *et al.* (2011), who conducted a global review of the management of electrical and electronic waste management, concluded that the reported global quantities of WEEE are grossly underestimated.

Traditionally, it has been quite difficult to model and distinguish between the quantities and flows of WEEE in a country. Because of the heterogeneous nature of the WEEE market and materials, coupled with the many and diverse constituent components involved, it has been difficult to determine how much EEE is placed on the market, how much of this eventually becomes WEEE (e.g. by direct reuse) and exactly what fraction is collected and treated at the national level by compliance schemes. To further complicate the WEEE modelling process, alternative (undocumented) processing streams for WEEE also exist, including complementary recycling, door-to-door trade, second-hand shops, residual waste from households (for small appliances, etc.) or businesses (B2B) and/or (illegally) exported EEE.

In addition, the accuracy of non-validated results can be compounded by low data quality, the insufficient validation of model parameters, unrealistic assumptions and the oversimplification of market conditions. The quality of data from diverse sources varies, and such data are often inconsistent with each other.

Nevertheless, several authors have proposed models to forecast the waste flow of durable goods. Some reports focus on the product, quantifying the number or weight of one (or many) consumer durable product(s) (e.g. Oguchi *et al.*, 2008; Yang *et al.*, 2008). An alternative approach involves studying the flows of materials from consumer durables and quantifying these flows at the material (e.g. lead, plastics, copper and glass) level. (For examples of this approach, please refer to Elshkaki *et al.*, 2005; Spatari *et al.*, 2005; Gregory *et al.*, 2009.)

In general, the different evaluation methods available for quantifying WEEE generation (including the methods of Walk, 2004; Yu *et al.*, 2010; Araújo *et al.*, 2012; Lau *et al.*, 2013) can be classified into four distinct groups:

1. **Disposal-related analysis** uses WEEE figures obtained from collection channels, treatment facilities and disposal sites. It usually requires empirical data from parallel disposal streams to estimate overall WEEE generation.

2. **Time-series analyses (projections)** extrapolate historical data into the future. This type of analysis can also be applied to fill in the gaps of past unknown years from available datasets.

3. **Factor models** tend to use determinant factors for correlation and are based on hypothesised causal relationships between exogenous factors, such as population size and income level versus WEEE generation (see Beigl *et al.*, 2004; Huisman *et al.*, 2008; Huisman, 2010). This is the least explored analysis method because of the associated complex anthropological effects, high uncertainty with regard to long-term patterns and the considerable requirement for advanced modelling techniques.

4. **Input–output analysis (IOA)** is the most frequently used method and there are multiple model variations. This analysis method has been applied to estimate WEEE generation in many regional and country studies, including by He *et al.* (2006), Kang and Schoenung (2006b), Peralta and Fontanos (2006), Yang *et al.* (2008), Robinson (2009), Dwivedy and Mittal (2010), Chung (2011), Zhang *et al.* (2011), Araújo *et al.* (2012) and Polák and Drápalová (2012). This method quantitatively evaluates the sources, pathways and final sinks of material flows, as illustrated by Walk (2004), Beigl *et al.* (2004) and Chung *et al.* (2011).

2.6.1 Regression analysis

Regression analysis (also called the "regression method" or the "regression technique") is a statistical tool used to investigate the relationships among variables. It is usually used to ascertain the causal effect of one variable upon another in order to forecast the change in a "dependent variable" based on the change in one or more "independent variables". Generally, this involves assembling data on the underlying variable(s) of interest and employing regression to estimate the quantitative effect of the causal variables upon the variable that they influence. Typically, a regression analysis is performed for one of two purposes: either to predict the value of a dependent variable or to estimate the effect of some explanatory variable on such a dependent variable.

Regression analysis is also known as “curve fitting” or “line fitting” because the corresponding equation can be used to fit a curve or line to data points, so that the differences in the distances of data points from the curve or line are minimised. The relationships depicted by a regression analysis are, generally, only associative, which means that any cause–effect (causal) inference is purely subjective.

2.6.2 The Weibull function

The majority of WEEE models described in the literature utilise the Weibull function to describe the lifetime of EEE, from being placed on the market through retention phases to product end-of-life/WEEE. Weibull models and analyses can be used to model datasets (containing values greater than zero), such as failure data or EEE life-cycle data.

Figure 2.3 shows a typical Weibull function, used to model the WEEE lifetime for Category 1 (fridges) under the Irish PRL category listings, based on residence times established for Belgian households.

In addition to modelling WEEE return rates, Weibull analysis can also be used for diverse applications, such as making predictions about a product’s lifespan, comparing the reliability of competing product designs, statistically establishing warranty policies and proactively managing spare parts inventories. In academia, Weibull analysis has been used to model diverse phenomena, such as the length of labour strikes, AIDS (acquired immune deficiency syndrome) mortality rates and earthquake probabilities (Weibull, 1951; Yunbao and Baohe, 2011; Tezerjani *et al.*, 2015).

The Weibull distribution has the probability density function (PDF) described by Equation 2.1 for $x \geq 0$:

$$f(x) = \frac{\beta}{\alpha}\left(\frac{x}{\alpha}\right)^{\beta-1} e^{-\left(\frac{x}{\alpha}\right)^{\beta}} \qquad \text{(Equation 2.1)}$$

In Equation 2.1, $\beta > 0$ is the shape parameter and $a > 0$ is the scale parameter.

The corresponding cumulative distribution function (CDF) is given by Equation 2.2:

$$F(x) = 1 - e^{-\left(\frac{x}{\alpha}\right)^{\beta}} \qquad \text{(Equation 2.2)}$$

In Equation 2.2, $1/a$ can be viewed as the failure rate. If “x” represents “time to failure”, then the Weibull distribution is characterised by the fact that the failure rate is proportional to a power of time, namely $\beta - 1$. Thus, β can be interpreted as follows:

- A value of $\beta < 1$ indicates that the failure rate decreases over time. This happens if there is significant “infant mortality” or if defective items fail early and the failure rate decreases over time as the defective items are weeded out of the population.
- A value of $\beta = 1$ indicates that the failure rate is constant over time. This might suggest random external events are causing mortality or failure.
- A value of $\beta > 1$ indicates that the failure rate increases with time. This happens if there is an “ageing” process, for example if parts are more likely to wear out and/or fail as time goes on.

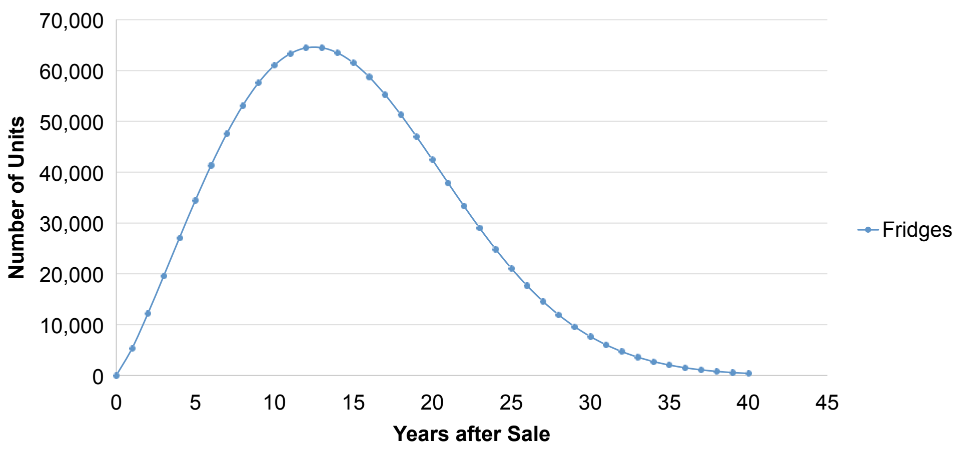

Figure 2.3. Weibull function used to model return rates for WEEE Category 1.

2.7 Data Sources

For this project, a number of important datasets and resources have been identified, specific to the Irish economy and WEEE market, which will aid in the derivation of the WEEE model for Ireland and associated historic WEEE projections.

In addition to the databases and datasets listed in section 2.7.1 of this report (ProdCom, ComEXT, etc.), the *Review of the Producer Responsibility Initiative Model in Ireland* has also gathered a lot of useful data about products placed on the market (Gorecki, 2013).

2.7.1 Available datasets

POM data are also available for Ireland for various periods from sources, such as those described below:

1. ProdCom: ProdCom[5] provides statistics on the production of manufactured goods for all European countries, including Ireland. Annual domestic production and import/export volume data for specific products are registered under ProdCom Commodity Codes (PCCs; the EU's statistical classifications of the national production of commodities) and Combined Nomenclature (CN) Codes (the EU's statistics of the national import and export of commodities), respectively. Data ranging from 1995 to 2013 are presently available for access and download.
2. ComEXT: ComEXT[6] is a database of statistical information on the trade of goods (in Europe) managed by Eurostat, which is the Statistical Office of the European Commission. Again, the EU CN codes are correlated with the United Nations UNU 58 – WEEE Classification codes mentioned in the next list point.
3. The UNU 58 – WEEE Classification: the UNU-KEYS classification system has been used since 2012 in EU countries such as the Netherlands, Italy and Belgium. The UNU-KEYS comprise an EEE product classification system comprising 58 products. The codes, with the associated classification system and framework, allow detailed assessments of future WEEE arising and the future potential to collect and recycle WEEE; this classification system formed one of the key datasets for this project.
4. The UNU code designations are constructed in such a way that supports two viewpoints: a product (functionality) perspective and a legal and recycling perspective. The list of UNU codes categorises various products in such a way that both high-level (per collection category) and detailed analyses (per appliance type) are compatible. This links and divides all possible EEE and WEEE products (about 900 products) into B2B or B2C, in the 5 to 7 collection categories, which are often used in practice, the 10 WEEE Directive product categories and the 17 UNU sub-categories.
5. The UNU-KEYS are also linked with all the EEE-related PCCs and CN codes used for national statistics and customs; this will allow future international comparisons and, thus, comparable POM and WEEE assessments.
6. PRL POM data: PRL (through their appointed agent, namely Deloitte) manages the WEEE Blackbox, which is responsible for the receipt and processing of data on the market share of registered producers and the determination of market share based on product type, producer, etc. In addition, the data may be used to evaluate the vEMCs, advise on the adequacy of financial guarantees and provide management reports and year-end reports for each producer and/or compliance scheme. The Blackbox data may also be used to garner EEE POM data for 2006 to 2014 across the 10 different WEEE categories currently recognised under the scheme.
7. Compliance scheme sampling results: in addition to reported data from the compliance schemes, monitoring organisations, etc., individual sampling of the WEEE return systems for one or both of the Irish compliance schemes may also be utilised as a means to gather additional data on the return rate of WEEE, augment the datasets available and validate the findings of the WEEE Generated Model.
8. Irish databases: with regard to the original stock of material (EEE) *in situ* in Ireland, the Central Statistics Office (CSO) Household Budget Surveys of 1987, 1994/1995, 1999/2000 and 2004/2005 (which provide data on penetration rates of

5 http://ec.europa.eu/eurostat/web/prodcom (accessed 1 January 2016).

6 http://epp.eurostat.ec.europa.eu/newxtweb/ (accessed 1 January 2016).

electrical appliances in households), combined with regression analysis methods, are very important. Likewise, other CSO datasets on the quantities of housing stock, Department of the Environment, Community and Local Government (DECLG) publications, Sustainable Energy Authority of Ireland (SEAI) data, etc., are useful in this regard.

9. EPA waste characterisation: this[7] ongoing project by the EPA aims to characterise the household and non-household municipal waste arising in Ireland and build on a number of different projects, including the municipal waste characterisation methodology developed by the EPA in 1996 and miscellaneous associated surveys conducted since in various sectors across Ireland.

2.8 Review of Waste Electrical and Electronic Equipment Studies

This section of the report considers WEEE-related studies and research carried out in other countries, both within the EU and also worldwide, that are comparable to the Irish context.

7 http://testweb.epa.ie/waste/municipal/ (accessed 1 January 2016).

2.8.1 *Studies by the United Nations University Institute for the Advanced Study of Sustainability*

In 2007, the UNU WEEE review by Huisman *et al.* (2008) made a major contribution to the scientific basis for the recasting of the WEEE Directive (EC, 2003). This extended study led to a fundamentally altered recast WEEE Directive proposal (Council of the European Union, 2011).

The Dutch WEEE flows study by Huisman *et al.* (2012) provided a factual basis for the recast WEEE Directive collection target definition in the Netherlands at the time and provided a more detailed and complete quantitative assessment of the WEEE flows. The study focused on all WEEE types (but did not distinguish between WEEE and historic WEEE), developing methods to estimate quantities of WEEE based on historic sales data, average residence times and stocks in households and businesses. A lot of effort was also made to examine complementary WEEE flows, including exports, other than the formal compliance schemes. The model, as shown in Figure 2.4, employed both Weibull and normal distributions to calculate the residence times of discarded products, based on comprehensive audits of products in the Netherlands and elsewhere returned in 2007.

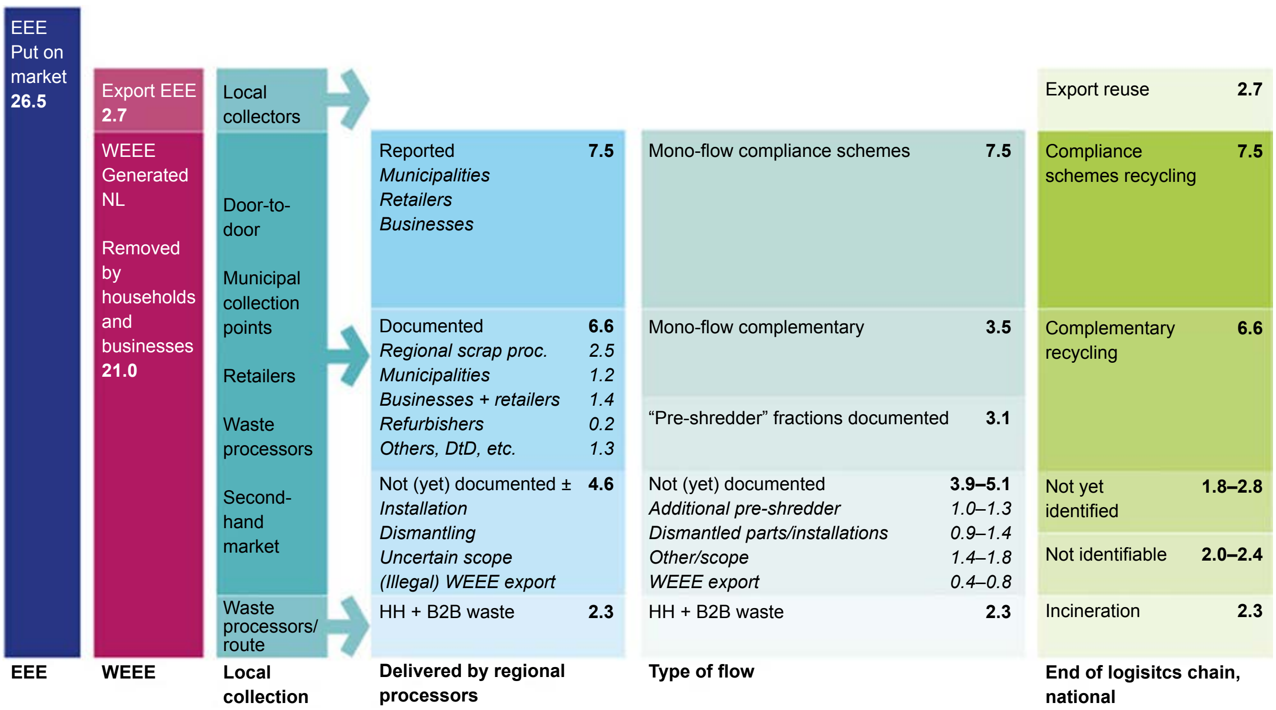

Figure 2.4. Dutch WEEE Generated Model, 2010. HH, household. Figure courtesy of J. Huisman, UNU.

This study (and associated work) resulted in the development of a new and unprecedentedly accurate WEEE Generated Model by the UNU, which calculates WEEE amounts based on interrelated historic sales data, average residence times and stocks in households and businesses. For example, the "residence times" used in the WEEE Generated Model in the Netherlands were obtained from the 2007 household and 2010 B2B market surveys conducted by the market research institute GfK. These data are highly detailed and comprise two "residence time" datasets:

1. the number of appliances as well as their age (including the second-hand loop) at the time of being discarded;
2. the age composition of the stock of appliances not yet discarded.

The latter dataset, in particular, helps to fine-tune lifespan data, independent of increasing or decreasing past sales. The age distribution of the GfK data was used as a basis for the associated statistical model. In addition, a "first-year-failure rate" was added, as, for many electronic products, there is a small peak in the number discarded in the first year because they are "dead-on-arrival" or consumers dislike what they bought.

This UNU WEEE Generated Model is therefore based on combining national statistics for the countries being considered, and may act as an independent source to check completeness of register and sales data from the various industry associations in that country.

2.8.2 e-Waste monitor report

In 2014, the UNU Institute for the Advanced Study of Sustainability (UNU-IAS) also published the first global e-Waste (or WEEE) monitor report (Baldé *et al.*, 2015). In this document, the authors describe the emergence of e-waste, or WEEE, as one of the fastest-growing waste streams worldwide, with complex characteristics and an aggressive growth history, facilitated by the shorter times-to-market of modern technology and ever-shortening product lifespans.

The authors of the report estimated that the amount of WEEE generated globally in 2014 was approximately 41.8 million tonnes. Of this, approximately 6.5 million tonnes was reported as being formally treated by national take-back and recycling/reuse schemes. In the EU alone, 700,000 tonnes of WEEE ends up in rubbish/waste bins annually. The amount of WEEE is expected to grow to 49.8 million tonnes by 2018, with an annual growth rate of 4% to 5%.

Most of the WEEE surveyed in the report was generated in Asia: 16 million tonnes in 2014. The highest per inhabitant WEEE quantity (15.6 kg per inhabitant) was generated in Europe, with a total WEEE generation total (including Russia) of 11.6 million tonnes. Oceania generated the lowest quantity of WEEE, 0.6 million tonnes. However, on a per-inhabitant scale, the amount was nearly as high as in Europe (15.2 kg per inhabitant).

Africa generated the lowest amount of WEEE per inhabitant: only 1.7 kg per inhabitant was generated in 2014. This equates to 1.9 million tonnes of WEEE for the whole continent. The Americas generated 11.7 million tonnes of WEEE in 2014 (North America generated 7.9 million tonnes, Central America generated 1.1 million tonnes and South America generated 2.7 million tonnes), which represented 12.2 kg per inhabitant.

In the EU, approximately 40% of the WEEE generated annually is treated through approved recycling and reuse channels at present; in the USA and Canada, the level is around 12%; for China and Japan, it is around 24–30%; and in Australia, it is around 1%.

2.8.3 Scandinavia

The TemaNord project was initiated by the Nordic WEEE Group after the introduction of the EU WEEE Directive in 2003. It comprised members from Denmark, Finland, Iceland, Sweden and Norway. In the group's report to the Nordic Council's subgroup on EEE waste (Nordic Council of Ministers, 2009), a method to calculate or measure the amount of WEEE generated in the Nordic states was presented. The main purpose of the project was to establish a method to measure WEEE generated. Although the method described in the report was originally developed for use in the Scandinavian countries, it can readily be expanded to cater for other countries and regions. This WEEE-measurement approach also allows for comparison and exchanges of experiences amongst the members. Furthermore, the approach is adaptable and can be updated as new information and datasets become available.

For the approach adopted here, an initial literature review (mainly of Nordic literature) and screening were carried out first, in order to define the scope and method for the project. This also included a review of the existing statistics on the consumption and collection of electric and electronic products. Relevant information on various factors, such as economical capacity, consumer behaviour, trends, technology development and the technical function and lifetime of associated products, featured heavily in this stage of the process.

From this, the requirements for the proposed measurement method were formulated. Some requirements had been specified in advance by the steering committee, while others were defined as a result of the project's progression with regard to the level of ambition and the establishment of a feasible/practical method.

This collected knowledge led to the development of the measurement method and the associated guidelines. At this stage, mathematical functions for estimating continuing lifetime profiles on the basis of lifetime data were adopted, adjusted for the specifics of the project and stored in a worksheet. Specifically, two different categories of input were identified for the model, namely the volumes of products supplied to the market (both historical and future) and the lifetime distributions for individual products of interest.

With the required data identified, the next stage of the project was to collect empirical data for the project. This included the collection of data on EEE POM data, etc., for the specified timeframes. In addition, an expert panel was established in order to contribute estimated lifetime data (via the Delphi method) for further selected products of interest in this study. This yielded the set of operational data for the project, which could be encapsulated in the final stage, namely the WEEE measurement method test.

For this, an Excel-based modelling and calculation tool, based on these findings and results, was also developed for use as both a test/illustration of the method and a modelling/planning tool for future calculations.

In addition, Pannuzzo (2014) presented a treatise on WEEE in Finland. In this publication, EEE devices characterised by a high content of precious metals were considered. Temporal connections between POM products and WEEE collection/recycling in Finland were investigated, taking into account factors such as product lifespan and consumer behaviour.

Statistical (historical) data for the report were gathered from official statistics and miscellaneous literature sources. The WEEE generated was calculated using a Weibull distribution/function for each product of interest. These official statistics, literature data and surveys, which were carried out in the Helsinki metropolitan area, were used (and implemented in the STAN[8] software) to perform a material flow analysis by means of mass balances. These results were then evaluated from an economic point view.

2.8.4 Asia

In South Korea, traditionally there have been no official statistics for annual WEEE generation or collection. Kim *et al.* (2013) addressed this by estimating the annual amount of WEEE generated in South Korea between 2000 and 2020 for eight different products, as well as estimating the annual percentage of WEEE collected through the EPR bill (for more information, see Wen *et al.*, 2009) recycling programme between 2003 and 2009.

They did this by estimating the amount of WEEE generated using a population balance model (PBM) in conjunction with a lifespan distribution analysis. Different WEEE generation methods have different advantages and disadvantages, depending on the estimation model used (Wen *et al.*, 2009). In the study by Kim *et al.* (2013), the PBM, which has been used in many academic studies (e.g. Oguchi *et al.*, 2006; Yamasue *et al.*, 2009; Yoshida *et al.*, 2009), was applied. The authors claim that the main advantage of the PBM approach is that over- or underestimation of WEEE generation is less likely than with other approaches because the model utilises the mass balance principle of inflow (shipment volume), outflow (waste volume) and stock (ownership volume). In addition, it is a time-series material flow analysis model, which allows for the estimation of past and future WEEE generation. However, PBM estimations are severely limited if estimating the amount of WEEE generated for products that have a fast growth phase or are declining on the market, as the parameters of lifespan distribution vary quite significantly under these conditions.

This is one of the first studies to apply the PBM estimation model to WEEE generation in South Korea. For this study, the lifespan distribution analysis of EEE was based on the results of a questionnaire survey of 1000 households, which were analysed using the Weibull distribution. From this, the domestic service lifespan

8 STAN is a probabilistic programming language and software for describing data and model for Bayesian inference.

and lifespan distribution shape parameter could be estimated. This yielded WEEE generation information for the corresponding households across the eight selected product types. Additional information, such as the shipment volume and the number of products owned by households, were used in this stage of the analysis.

Other studies of interest include those by the Korea Society of Waste Management (KSWM, 1998) and Lee *et al.* (2007). In both of these studies, WEEE generation was estimated in South Korea from sales data and product lifespan information. Both studies employed the use of the estimation "delay model" (see van der Voet *et al.*, 2002), which has been widely used in the field of WEEE generation estimation. In the KSWM (1998) study, the authors used the model to estimate the number of waste desktop personal computers (PCs) that would be generated between 1998 and 2030 using an assumed lifespan. In the second study, Lee *et al.* (2007) used the same model to estimate the amount of WEEE generated for four end-of-life household electronic appliances between 2000 and 2005 on the assumption that the average lifespan of the four items was about 10 years. In fact, in both of these papers, the lifespans of the products were assumed, not derived from empirical data.

Also in South Korea, the Association of Electronics Environment (AEE, 2005) used the discard rate and number of households to estimate the quantity of WEEE generated from a questionnaire survey of approximately 1800 respondents. In the 1998 KSWM study, the authors calculated the amount of WEEE generated for four items by aggregating the amount collected through questionnaire surveys of WEEE collectors. Meanwhile, Jang and Kim (2010) estimated the number of end-of-life mobile phones generated between 2000 and 2007 using data on the number of new subscribers, in conjunction with data on the number of phones purchased domestically in each of the years between 2000 and 2007. The Korea Environment Institute (KEI, 2009) calculated the amount of WEEE generated for six items between 2000 and 2015.

In Japan, Oguchi *et al.* (2006) carried out a questionnaire-based survey related to the equipment owned by households and enterprises and, specifically, the WEEE lifetime of such items. In particular, the study estimated the life-cycle profiles for 23 different types of EEE. Using these lifetime distributions, the quantity of waste equipment was estimated for 2003 to 2008. The analysis found that, in Japan, the average lifetimes of relatively expensive equipment tend to be longer than the lifetimes of less expensive items, whereas small to medium-sized equipment tend to have relatively short lifetimes. Calculations for the associated Weibull function parameter(s) were also carried out in this study. The total WEEE arising numbers for the 23 types of equipment considered was estimated to be 130 million units, of which waste cellular phones accounted for 45 million units.

Also in Japan, Oguchi *et al.* (2008) conducted a product flow analysis (PFA) for 94 consumer durables in Japan to obtain a complete picture of the domestic flow. Data on domestic shipment, average weight and average lifespan of each product were surveyed and estimated based on statistics and product catalogues from manufacturers. Using these data, the quantity of domestic shipment and waste from households and enterprises was estimated as inflow and outflow to the system.

This study was the first to report on the complete picture of domestic product flow of consumer durables in Japan. On the basis of the results, the target items for Japan's recycling laws can be validated in terms of market share, landfill waste reduction (because the total waste weight of 9 target items accounts for 68% of the total 94 items) and overall return on investment. The number of waste products was relatively large for items such as cellular phones, video cassette recorders (VCRs) and notebook PCs (which contain numerous hazardous and/or valuable substances), but, as expected, their combined waste weight was small. The proportion of waste products to totals collected for the nine selected target items, ranged from 2% to 56% on a weight basis (and from 4% to 59% on a number basis), because some waste products are taken to industrial waste treatment facilities and exported. In addition, at the post-consumer stage, approximately 46–68% of the waste products are still unidentified in the flow diagram for the 94 items. These products might have been treated as municipal or industrial waste, exported or illegally dumped; therefore, their flow is still to be clarified through further research.

2.8.5 United Kingdom

The UK organisation WRAP (Waste and Resources Action Programme) have also conducted work on the flows of electronic products, and have produced estimates for the amount of material that will reach the end of its useful life in each year until 2020 (Haig *et al.*, 2011). In the UK, approximately 1.5 million tonnes of EEE is purchased each year by consumers and businesses. Of this, approximately 30% is collected for recycling through the official WEEE system.

The WRAP study estimated the current and future flows of EEE and WEEE in and out of the UK. The key goals of the report were to forecast the likely volumes of used electrical and electronic equipment (UEEE) arising in the UK at the time and in future; to identify the main routes for the disposal and reprocessing of WEEE, both within and outside the formal WEEE processing infrastructure; and to quantify the likely flows of material separately for each WEEE category through each of the main disposal and reprocessing routes.

The study used a normal distribution method to estimate lifespan distributions of products, in conjunction with sales data, to predict the quantities of WEEE arising in the UK and estimate material flows through the different parts of the treatment system after the decision is made by the user to dispose of a product.

Similar to the report by the Nordic Council of Ministers (2009) mentioned previously, an Excel-based WEEE flows mass balance model was developed as part of the work documented in the UK WRAP Report (Haig *et al.*, 2011). This model is flexible and may be used to evaluate the effect of changing the model input parameters in terms of where and how WEEE is treated. In addition, it allows the user to consider the likely impact of future changes in the composition of the WEEE stream as customer-purchasing and disposal habits change.

The study uses a combination of data and estimates to forecast the main flows of EEE sales and UEEE arising in and across the borders of the UK. These estimates were used to develop the associated, Excel-based WEEE flows mass balance model in order to build an understanding of the products entering the UK, the end-of-life products entering the waste stream and the resulting flows of materials. This WEEE flows mass balance model calculates flows separately for B2C and B2B WEEE.

Figure 2.5 (from Haig *et al.*, 2011) shows the development of a flowsheet that describes the various disposal routes of WEEE in the UK model. The figure is split into three main sections: disposal options, processing stages and the final disposal options.

2.8.6 Others

In the study by Araújo *et al.* (2012), the authors considered the generation of WEEE in Brazil. In developing countries, such as Brazil, the sales of EEE are increasing dramatically. Usually, there is no reliable data about the quantities of such WEEE generated. A new law for solid waste management was brought into force in Brazil in 2010. This has meant that the necessary infrastructure to ensure the ESM of WEEE has been designed, developed and implemented in the country. This paper considers some of the models used for WEEE estimation and calculation as part of this infrastructure in Brazil.

A review of the literature regarding the estimation of WEEE generated is presented in the paper. This focuses on developing countries, particularly in Latin America. It briefly describes the current WEEE system in Brazil and presents an updated estimate/model for the generation of WEEE there. Considering the limited EEE data available in Brazil, the model for WEEE generation estimation proposed uses different/hybrid methods for mature and non-mature market products.

The results presented by the authors show that, in the Brazilian market, the most important variable is equipment lifetime; a thorough understanding of consumer behaviour is required to estimate this variable. As it is a rapidly expanding market, the anticipated increase in WEEE arising is still ahead for Brazil. In the near future, better data will provide more reliable estimates of waste generation and a clearer interpretation of the lifetime variable.

2.9 Waste Electrical and Electronic Equipment Literature – In Review

The following summarises the major topics considered in this chapter of the report:

- Globally, WEEE is one of the fastest-growing solid waste streams, compounded, at present, by decreasing lifespans and an increasing range of new and different product types.
- The EU WEEE Directive was introduced in 2002 to improve the end-of-life handling of WEEE, lessen its impact on the environment, contribute to a circular economy and enhance WEEE resource efficiency.

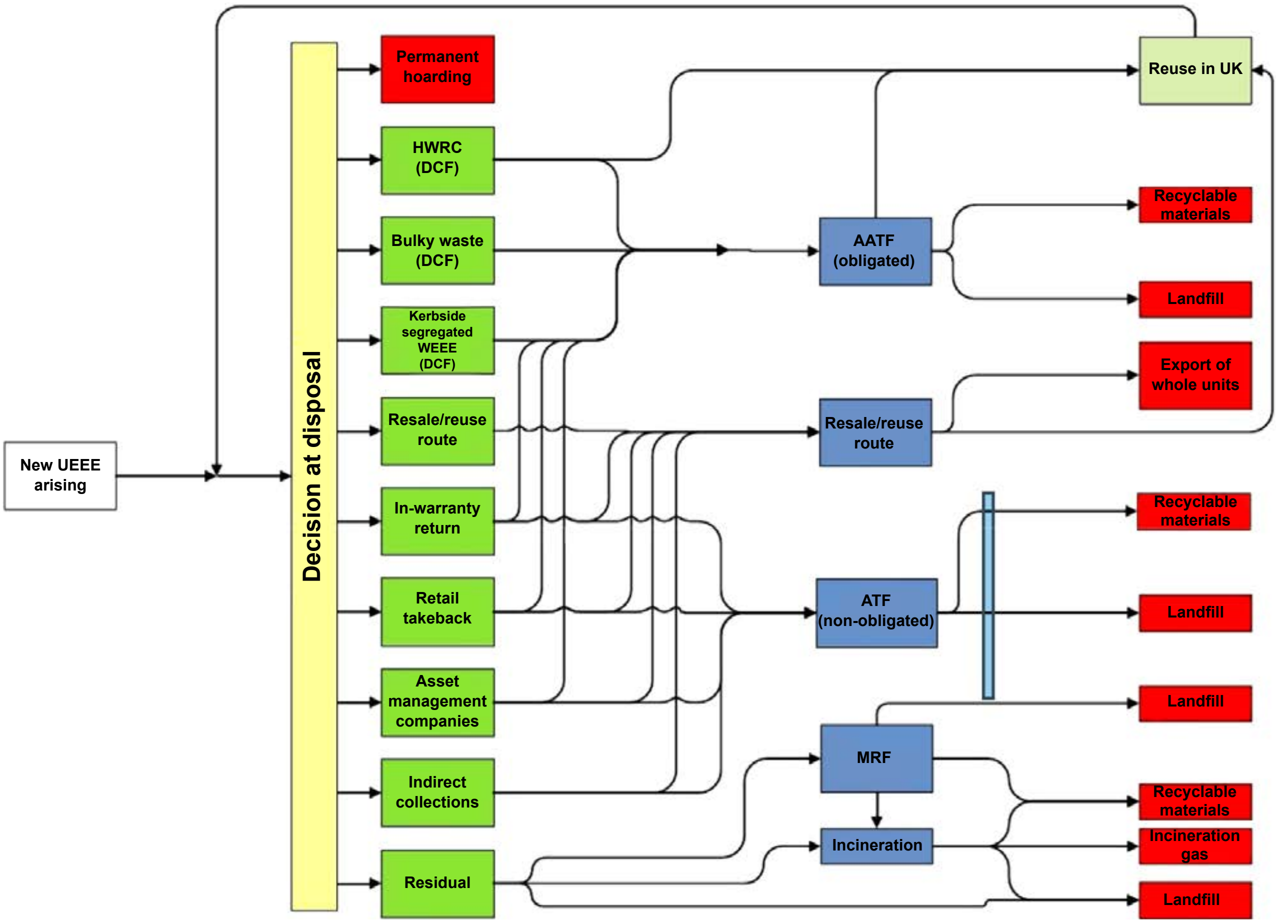

Figure 2.5. Flowsheet showing WEEE Disposal Channels in UK. Disposal options are shown in green, processing stages are presented in blue and the final disposal options are highlighted in red. Figure courtesy of WRAP and Axion Consulting Ltd, UK.

- The WEEE Directive was revised in 2012 to address a number of key issues, including widened scope, increased recovery and collection targets, and a revised classification structure.
- WEEE legislation comparable to the EU WEEE Directive exists in various forms throughout the world, highlighting the global nature of the WEEE problem. These include the Japanese SHAR Law, the Swiss ORDEE, the National Waste Policy in Australia and the EPR bill in China.
- Key contributors and actors in the Irish WEEE market include the EPA, PROs/Compliance Schemes, local authorities, civic amenity sites and PRL.
- Under both WEEE Directives, vEMCs have been used to fund the Producer Recycling Fund, which was responsible for funding the recycling of historic WEEE in Ireland. However, as no reliable data existed on EEE or WEEE levels, the calculation of such vEMCs has, historically, been a time-consuming, troublesome and difficult task.
- IOA methods are the most commonly used means of calculating WEEE generation in a market, rather than disposal-related analysis, time-series analysis or factor models.
- The mathematical Weibull function is commonly used in conjunction with such WEEE generation measurement methods to model the future WEEE stream.
- Available data sources, such as ProdCom, ComEXT, PRL Blackbox data and Irish databases, can be included as inputs to such a modelling and calculation scenario.

Comparable and ground-breaking WEEE studies in the literature include the Dutch WEEE flows study (Huisman *et al.*, 2012), the global e-waste monitor report (Baldé *et al.*, 2015), the Nordic WEEE Group report (Nordic Council of Ministers, 2009) and the WEEE estimation report for South Korea (Kim *et al.*, 2013).

3 Project Implementation

3.1 Introduction

The following sections detail the architecture, implementation of the return stream modelling and prediction of historic WEEE return rates for the project in the Irish Market. In this chapter, the project implementation and how the historic WEEE project was realised are described in section 3.2. The collaboration between the University of Limerick and the UNU in the adaptation of the UNU WEEE Generated Model for Irish return streams is discussed in section 3.3. A description and overview of the actual model is given in section 3.4. Finally, some of the datasets and sources used to provide information for the adapted Irish WEEE Generated Model are briefly described in section 3.5.

3.2 Project Implementation

The “Historic WEEE Project” description can be encapsulated in the following statement: “Using a range of data sources including census data, historic WEEE audits and comprehensive sampling this project will employ material flow analysis and statistical methods to estimate future return rates of historic WEEE”.

Therefore, the aim of the project is to provide reliable estimations of the rates of generation of historic WEEE for the future Irish market. Such information will be used to inform policy on WEEE financing, and to support logistic and treatment-requirement planning into the future.

The overarching task was to model how the stock of EEE material that has accumulated in households over a 20-year period has and will be returned in the future. Initial implementation work defined the exact parameters of the model needed and established the time base for the operating model (which was dependent on the resolution of the available data and the accuracy of model predictions). This provides the basis for associated sampling methodologies and informs the review of comparable models elsewhere in Europe and further afield.

Once the full range of available data is known, the final system will be modelled, all assumptions will be declared and the primary data collection requirements will be known. The development of this model forms the second section of the project implementation and focuses on the realisation of a mathematical model describing the cumulative return rates of the EEE product groups of interest for the project.

Using such model outputs and associated information, the project will be able to determine return rates and parameters associated with life-cycle functions (e.g. upper- and lower-bound Weibull probability density functions) for each EEE product category in the range of interest.

In order to create such a model, which can estimate the return rate of historic WEEE, the original stock in place for each category of EEE in Ireland will need to be known. Therefore, this forms the core of the next stage of project implementation. Using a combination of national statistics (e.g. CSO household budget surveys, housing stocks and sales figures), estimates will be developed at specific intervals over the specified timeframe for the total stock of equipment in place.

The penultimate stage of the project involved integrating the outputs of each of the three previous sections to produce the overall findings of the project. This produced an estimate for the future generation of historic WEEE in each category of interest. These estimates were validated by sampling the WEEE return stream in order to corroborate the projected historic WEEE figures. In addition, recommendations and suggestions for sampling methodologies and future updates have been provided, in order to facilitate updates to the projections on an annual basis.

3.3 United Nations University Collaboration

Upon consideration of the implementation options for the historic WEEE modelling project (in particular the modelling and determination of life-cycle parameters for the associated WEEE categories), and following on from a comprehensive review of the current state of research in the field, it was decided that a collaboration between the University of Limerick and the United Nations University Institute for Sustainability and Peace (UNU-ISP) for the modelling of product residence times using Irish input parameters would be the best and most advantageous way to implement the project modelling task.

There are a number of associated benefits to such a collaboration, including:

- the leverage of a decade of experience that the UNU-ISP has of working in the field of WEEE modelling and sampling;
- access to the support tools and experiences that UNU can offer in the area of WEEE sampling and modelling;
- the use of UNU-KEYS as well as Irish PRL categories, which will ensure that the resultant data are harmonised with international standards and enable direct comparisons with data from other countries;
- the collaborative work could serve as preparatory work for other potential studies on the quantification of other aspects of WEEE flows (e.g. landfill, export and scrap metal merchants);
- the international collaboration will ensure a much wider audience for communication and dissemination activities.

The UNU has been heavily involved in WEEE sampling, modelling and legislation advice since 2006. In 2007, the UNU WEEE review study (Huisman *et al*., 2008) formed the scientific basis of the European Commission's own impact assessment and a selection of policy options in the field of WEEE. The landmark *The Dutch WEEE Flows* report (Huisman *et al.*, 2012) was based on 2010 POM and WEEE generated amounts for the Netherlands and provided the first complete and detailed analysis of the WEEE flows in this country. As a result, the project has led to a significant improvement in the understanding of the generation and destinations of WEEE, not only in the Netherlands, but also across the rest of the EU. This study has since been successfully followed up, between 2012 and 2015, by similar country studies in Belgium (Wielenga and Huisman, 2013), Italy (Magalini *et al*., 2012), France (ADEME, 2013), Portugal and Romania (Magalini *et al*., 2015). As a consequence, the UNU-applied methodology proposed for use in this project has now become more streamlined and suitable for implementation and adoption in other countries, such as Ireland.

3.4 The WEEE Generated Model

The UNU "WEEE Generated Model" that was used in this project for the analysis of WEEE return rates and the prediction of future return streams was derived from the application of IOA methods, in order to improve the evaluation methods currently employed for quantifying WEEE generation. Products typically enter such a system at the point of sales (EEE sales in this case). These products then accumulate in the built environment (in which they have become EEE stock). When these EEE products reach their end of their life after a certain period (i.e. lifespan), they leave the system as WEEE (van der Voet *et al.*, 2002). IOA models attempt to quantitatively describe the dynamics and magnitude of, and the interconnection between, the product sales, stocks and lifespans of such a system (Brunner and Rechberger, 2004; Walk, 2004; Gregory *et al.*, 2009; Lau *et al.* 2013).

In the WEEE Generated Model, IOA techniques are employed to quantitatively evaluate the sources, pathways and final sinks of the EEE material flows (Wang *et al.*, 2013). With data collected for all three IOA areas (sales, stock and lifespan of the product), the WEEE Generated Model applies a multivariate IOA called the "Sales–Stock–Lifespan Model" to determine the generation and associated WEEE parameters for that market.

Figure 3.1 shows the typical contributors to and relationship between these IOA variables and the available datasets. In this figure, the life cycle of EEE in society is modelled as the inflow, stock and outflow of a funnel. Information can be extracted from each dataset for any historical year, that is, for sales, stock size and age composition, lifespan profiles or disposal age distribution of the resulting WEEE. The relationship between these data points is also shown in Figure 3.1. The mathematical and logical functions applied in the model for the conservation of mass, IOA rules and algorithms are instrumental for filling in the data gaps and validating data quality in the model. For more detail on the laws, rules and algorithms employed in the implementation of this model, please refer to Wang *et al.* (2013).

Within the EEE market, product lifespan varies among countries, owners and individuals, and usually takes the form of a probability distribution for a given population (Oguchi *et al*., 2010). Because of factors such as

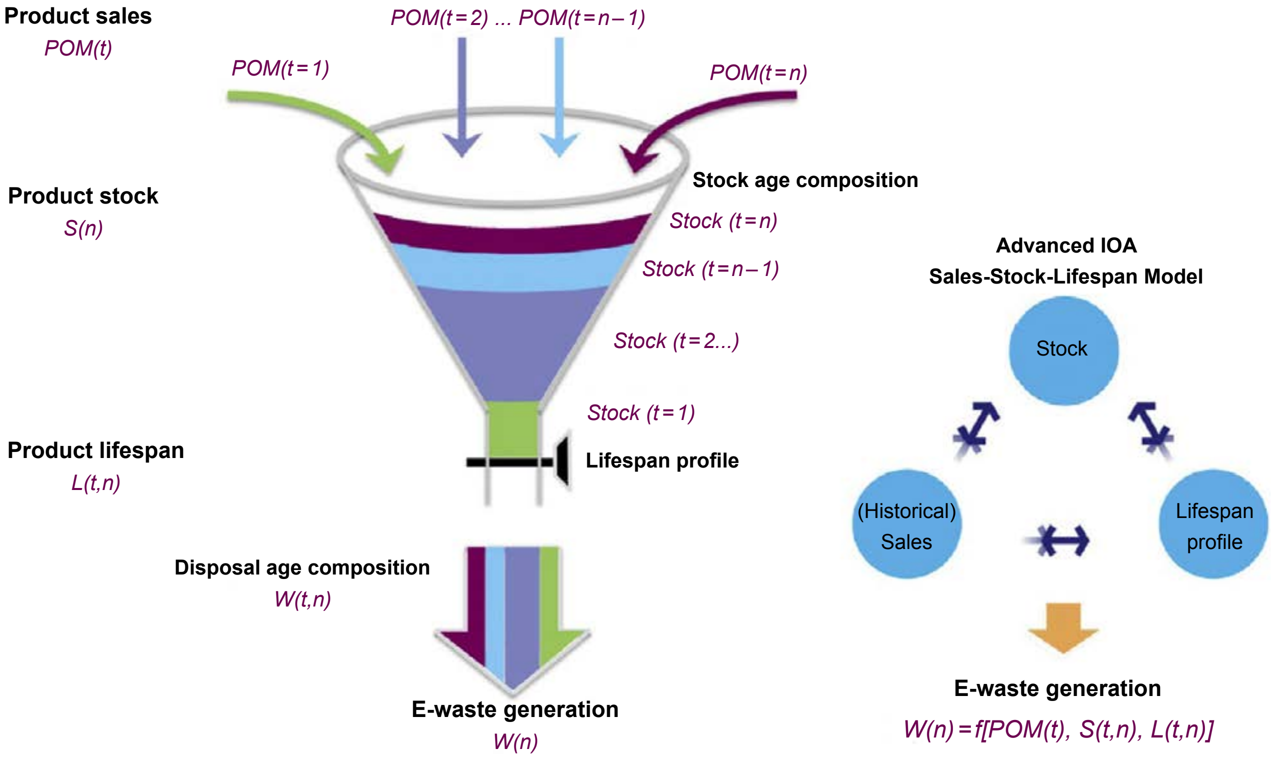

Figure 3.1. WEEE Generated Model using the Sales–Stock–Lifespan Model to enhance WEEE estimates. Figure courtesy of Huisman *et al.* (2012).

social and technical development, product lifespan is a time-dependent model input, so parameters of lifespan distributions corresponding to each historical sales year are modelled. For the WEEE Generated Model and the underlying Sales–Stock–Lifespan Model, the Weibull distribution function was applied to model the lifespan profile of EEE. As opposed to other statistical distributions (e.g. normal, lognormal or beta distributions), it has been shown that the Weibull function is the best fit for the EEE market: it has higher analytical tractability than other models and produces the best fit curves for the lifespans of most EEE products (Melo, 1999; Walk, 2004; Nordic Council of Ministers, 2009).

Within the WEEE Generated Model, each data point contains not only information about its own representing variable, but also potential indications with regard to other variables. By applying all the formulas in the model, additional modelling data can be extracted from known data. This enables the maximum capture of all available data, which improves the estimation without losing the potential implications. Thus, the WEEE Generated Model/Sales–Stock–Lifespan Model adopts multivariate analysis by involving all three variables in IOAs and multiple data points to estimate WEEE generation. Section 3.5 of this chapter provides more detailed information on the sources and types of datasets used to tailor the WEEE Generated Model to the Irish economic market.

Once the datasets have been identified and gathered, the WEEE Generated Model (Sales–Stock–Lifespan Model) may then be applied to a multivariate analysis based on available Irish data points. This is done to ensure reliable and continuous datasets for model calculation, either by filling in the data gaps or finding the most reliable available data source(s). Variables and datasets are used in conjunction here, as the variable(s) associated with the highest data quality are used to validate and consolidate any variables in the dataset that have a lower data quality. Empirical and logical constraints (such as market saturation figures) are also used to consolidate the available datasets at this point.

Once reliable sales and stock data have been garnered for the Irish market and validated/consolidated as described, the WEEE Generated Model can then be applied directly to calculate the WEEE generation figures for the period in question. Implementing the model in this fashion guarantees greater data consolidation and multivariate analysis, thereby improving the accuracy and generated results for the WEEE Generated Model, compared with other traditional or bespoke approaches. The results of the WEEE Generated Model for the Irish Market are presented in Chapter 4 of this report.

3.5 Irish Datasets for the WEEE Generated Model

For the Irish EEE market and the associated datasets used by the WEEE Generated Model, the datasets are divided into three broad categories. For the WEEE Generated Model, input datasets are broadly categorised into "sales", "stock" and "lifespan" datasets, as per the model overview presented in the section 3.4. Data from diverse sources, such as the Dutch WEEE Flows Survey (Huisman *et al.*, 2012); the Irish CSO[9] (i.e. housing Information); the SEAI for EEE penetration rates in Ireland (SEAI, 2013); and the DECLG[10] were utilised as inputs for the various sections of the WEEE Generated Model for Ireland.

For Irish EEE product sales, data were obtained from national statistics on domestic commodity production (e.g. PRL Blackbox data) and also from import/export figures, such as those available from Eurostat and ProdCom. In this regard, the average weight of the individual EEE products is an important variable with regard to linking product quantities (in units or pieces) to their weight (in metric tonnes).

9 http://www.cso.ie/en/statistics/housingandhouseholds/ (accessed 11 July 2016).

10 http://www.environ.ie/search/archived/current/type/publications (accessed 11 July 2016).

The Irish stock dataset for the WEEE Generated Model includes all EEE products for the given year(s), that is, stock that is in use as well as "secondary" EEE (e.g. products classed as "end of life", "in hibernation" or "in dead storage"). This is accomplished using stock quantity information, housing information, EEE penetration rates for Ireland and comparable data from other EU countries on return stream sampling, consumer and business surveys. All of this information allows the calculation of the number of EEE products on the Irish market. In addition, the stock age distribution for Irish EEE products was used to augment these results, providing extra and very useful information on both sales and lifespan profiles for EEE products over the specific historical year(s) of interest.

For EEE products on the Irish market, "lifespan" is defined as the time between the initial shipment of the new EEE product and the ensuing end point at which it was discarded from a household or enterprise and accepted through the WEEE return stream. Census figures and household completions have been used, in conjunction with the generic Weibull parameters for the various EEE classes, in order to ascertain the product lifespans of the various EEE categories being considered in this report.

As with all multivariable analysis and modelling, the data used for the Irish Market in this model were verified and acquired via statistically robust sampling methods. These data were also pre-checked for errors, and corrected if necessary. The use of incorrect units, unrealistic average product weights and the mixing of B2C/B2B components are common errors (Troschinetz and Mihelcic, 2009). For more information on these and other sources of data for the model, please refer to section 2.7 of this report.

4 WEEE Generated Model Results

4.1 Introduction

This chapter details the outputs/findings of the project. Specifically, the historic WEEE figures and predictions for the Irish EEE market are presented for the period from 2000 to 2020, inclusive. These figures were generated using the UNU WEEE Generated Model, in conjunction with the appropriate Irish datasets, as described in Chapter 3. The sections of the UNU-KEYS and Irish PRL categories that are directly relevant to the results presented in this report are described in section 4.2. The historic WEEE, total EEE and total WEEE figures generated from the model using the UNU-KEYS, over the aforementioned timeframe, are presented in section 4.3. Finally, the same historic WEEE figures transposed back to the Irish PRL categories of interest are presented in section 4.4.

4.2 Mapping UNU-KEYS to Product Register Limited Categories

For modelling the Irish WEEE return stream using the UNU WEEE Generated Model, the Irish PRL data, from sources such as the PRL Blackbox, had to be mapped to the corresponding UNU-KEYS for use as inputs to the model. The PRL category listing[13] comprises 10 distinct categories for the classification of WEEE, of which this project was interested in items from Categories 1 and 4, as detailed in Table 4.1.

As previously described, the UNU-KEYS are the UNU classification for WEEE product categories and are used to classify the input data for the WEEE Generated Model.[14] The 58 categories used for the UNU-KEYS are grouped into 10 primary categories, according to the original EU WEEE Directive. Of these 58 categories, eight are directly relevant to the EEE product types considered in this research. Table 4.2 lists the UNU-KEYS categories used as inputs for the WEEE Generated Model.

The PRL categories and UNU-KEYS align as shown in Table 4.3.

For this conversion, the split/conversion factors shown here were used to map the PRL categories to the corresponding UNU-KEYS for the WEEE Generated Model. These split factors were obtained by mapping equivalent Dutch and/or Article 7 UNU-KEY figures to the Irish market, in order to generate the corresponding proportions for the three categories of interest (see Tables 4.4, 4.5 and 4.6). In each case, the figures given represent the "splits" of the various categories

13 http://www.producerregister.ie/uploads/news/The_ProducerRegisterCategoryListings5.7.pdf (accessed 2 August 2016).

14 http://i.unu.edu/media/ias.unu.edu-en/project/2238/UNU-KEYS-to-HS-Codes.xls (accessed 1 January 2016).

Table 4.1. Irish PRL Categories

PRL category	Description	Recycling cost (EUR)
1.1	Refrigeration – all refrigeration – all side by side/American-style refrigeration	10.00
1.2	Refrigeration – all larder and two-door (under/over configuration) appliances Chest Freezers – all chest freezers above 150 L	5.00
1.2a	Refrigeration – all under-counter/table-top refrigeration Chest Freezers – all chest freezers below 150 L	5.00
1.3	LHAs – washing machines, clothes dryers, dish washing machines, cooking appliances, electric stoves, other large appliances	5.00
4.1	Large colour TVs (visible screen size) Large TVs (> 73 cm), including plasma/LCD/CRT TVs, projection TV	5.00
4.2	Medium-sized colour TVs (visible screen size) Medium-sized TVs (52–72 cm), including plasma/LCD/CRT TVs	0.00
4.3	Small colour TVs (visible screen size) Small TVs (0–51 cm), including plasma/LCD/CRT TVs	0.00

Table 4.2. UNU-KEY categories used in the WEEE Generated Model

UNU-KEY category	UNU-KEY description
0102	Dishwashers
0103	Kitchen (e.g. large furnaces, ovens, cooking equipment)
0104	Washing machines (including combined dryers)
0105	Dryers (wash dryers, centrifuges)
0108	Fridges (including combi-fridges)
0109	Freezers
0407	Cathode ray tube TVs
0408	Flat display panel TVs (LCD, LED, plasma)

Table 4.3. Mapping of PRL categories to UNU-KEYS

UNU-KEYS		PRL WEEE Categories	
Category	**Description**	**Category**	**Description**
108	Fridges (including combi-fridges)	1.1	Refrigeration – all refrigeration – all side by side/American-style refrigeration
		1.2	Refrigeration – all refrigeration – all larder and two door (under/over configuration) appliances Chest freezers – all chest freezers above 150 L
109	Freezers	1.2a	All refrigeration – all under-counter/table-top refrigeration Chest freezers – all chest freezers below 150 L
102	Dishwashers	1.3	LHAs Washing machines – washer dryers, washing machines Clothes dryers – clothes dryers Dish washing machines – dish washing machines Cooking appliances – combination oven, oven, gas cooker Electric stoves – electric stoves
103	Kitchen (e.g. large furnaces, ovens, cooking equipment)		
104	Washing machines (including combined dryers)		
105	Dryers (wash dryers, centrifuges)		
407	Cathode ray tube TVs	4.1	Large colour TVs (visible screen size) Large TVs (> 73 cm), including plasma/LCD/CRT TVs and projection TVs
408	Flat display panel TVs (LCD, LED, plasma)	4.2	Medium-sized colour TVs (52–72 cm), including plasma/LCD/CRT TVs
		4.3	Small TVs (0–51 cm), including plasma/LCD/CRT TVs

Table 4.4. Distribution of cold EEE for UNU-KEY Mapping

Cold category	Year								
	2006	2007	2008	2009	2010	2011	2012	2013	2014
UNU-KEY 0108	82%	83%	86%	79%	82%	81%	83%	83%	83%
UNU-KEY 0109	18%	17%	14%	21%	18%	19%	17%	17%	17%

Table 4.5. Distribution of LHA EEE for UNU-KEY Mapping

LHA category	Year								
	2006	2007	2008	2009	2010	2011	2012	2013	2014
UNU-KEY 0102	22%	21%	22%	21%	24%	21%	21%	22%	21%
UNU-KEY 0103	20%	20%	20%	23%	23%	26%	27%	22%	23%
UNU-KEY 0104	40%	39%	39%	39%	36%	34%	33%	36%	38%
UNU-KEY 0105	19%	19%	19%	18%	17%	19%	19%	19%	17%

Table 4.6. Distribution of TV EEE for UNU-KEY Mapping

TV category	Year								
	2006	2007	2008	2009	2010	2011	2012	2013	2014
UNU-KEY 0407	64%	56%	38%	36%	20%	0%	0%	0%	0%
UNU-KEY 0408	36%	44%	62%	64%	80%	100%	100%	100%	100%

into their relevant sub-categories; for example, the "cold" WEEE category comprises two sub-categories: fridges (UNU-KEY 0108) and freezers (UNU-KEY 0109) (Table 4.4).

4.3 WEEE Generated Model Results – UNU-KEY Formats

With the Irish EEE sales, life-cycle and model data used in conjunction with the UNU WEEE Generated Model, a set of predictions for the historic WEEE return rates were generated for the eight UNU-KEY categories of interest in this project. Table 4.7 gives the historic WEEE prediction figures for all eight categories for the Irish market from 2000 to 2020, inclusive.

The following figures (Figures 4.1–4.8) show the historic WEEE return rate(s), graphed as a function of the same timescale as in Table 4.7, plotted against EEE POM and WEEE figures for each of the corresponding UNU-KEY categories. For each data point, EEE sales (POM) data, WEEE (collected material) and historic WEEE as a percentage of this overall total for the corresponding categories are shown. These figures are presented in ascending order of UNU-KEY, as per Table 4.7.

4.4 WEEE Generated Model Results – PRL formats

The eight UNU-KEYS presented as the outputs of the WEEE Generated Model may be mapped to their equivalent Irish counterparts as follows: cold EEE (PRL Categories 1.1 and 1.2) comprises UNU-KEYS 0108 (Fridges) and 0109 (Freezers); LHA (PRL Category 1.3) is mapped to the sum of UNU-KEYS 0102 (Dishwashers), 0103 (Ovens), 0104 (Washing Machines) and 0105 (Dryers); while TV (PRL Category 4) is equivalent to the total of UNU-KEYS 0407 (CRT TVs) and 0408 (Flat-Panel TVs). This mapping is summarised in Table 4.8.

With these conversions, Table 4.9 summarises the WEEE Generated Model outputs for these three categories: cold, LHA and TV. Both the WEEE (in tonnes) and historic WEEE (as percentages) are given for 2000 to 2020 for these categories. In addition, Figure 4.9 shows the WEEE and the per cent historic WEEE figures for all "cold" EEE (PRL Categories 1.1 and 1.2) in Ireland; Figure 4.10 presents the comparable situation for all LHA EEE (PRL Category 1.3) in Ireland; and Figure 4.11 gives the WEEE and per cent historic WEEE data for all TVs (PRL Category 4) in Ireland.

Table 4.7. Irish historic WEEE figures (%) for 2000 to 2020, inclusive, using the WEEE Generated Model

Year	Dish washers UNU-KEY 0102	Ovens UNU-KEY 0103	Washing machines UNU-KEY 0104	Dryers UNU-KEY 0105	Fridges UNU-KEY 0108	Freezers UNU-KEY 0109	CRT TVs UNU-KEY 0407	Flat-panel TVs UNU-KEY 0408
2000	100.00	100.00	100.00	100.00	100.00	100.00	100.00	
2001	100.00	100.00	100.00	100.00	100.00	100.00	100.00	
2002	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
2003	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
2004	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
2005	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
2006	97.46	99.85	98.32	99.84	99.61	99.98	100.00	84.84
2007	92.45	99.03	94.61	98.90	98.18	99.82	100.00	59.62
2008	86.52	97.38	89.76	96.92	95.72	99.45	99.99	38.97
2009	80.75	94.95	84.41	93.96	92.47	98.84	99.99	26.31
2010	75.37	91.89	78.87	90.27	88.68	97.95	99.99	18.41
2011	70.45	88.39	73.29	86.08	84.50	96.77	99.99	12.80
2012	66.02	84.57	67.77	81.55	79.99	95.28	99.98	8.99
2013	62.00	80.57	62.35	76.84	75.21	93.47	99.98	6.57
2014	58.26	76.52	57.00	72.06	70.32	91.36	99.98	4.96
2015	54.57	72.45	51.68	67.28	65.32	88.93	99.98	3.81
2016	50.85	68.40	46.44	62.50	60.23	86.18	99.97	2.95
2017	47.13	64.39	41.36	57.74	55.13	83.10	99.97	2.30
2018	43.44	60.40	36.52	53.01	50.09	79.69	99.97	1.80
2019	39.80	56.44	31.97	48.32	45.14	75.98	99.97	1.40
2020	36.24	52.49	27.75	43.68	40.35	71.99	99.97	1.10

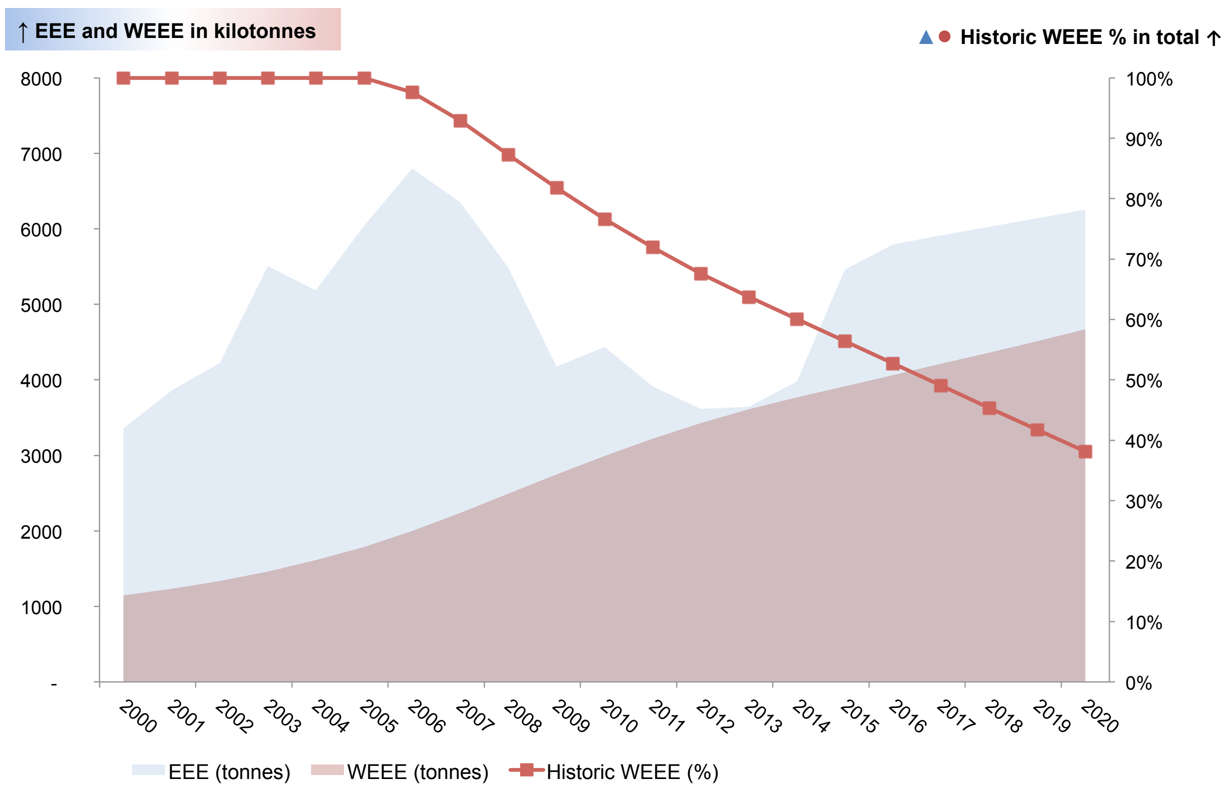

Figure 4.1. EEE, WEEE and historic WEEE for Category 0102 – dishwashers.

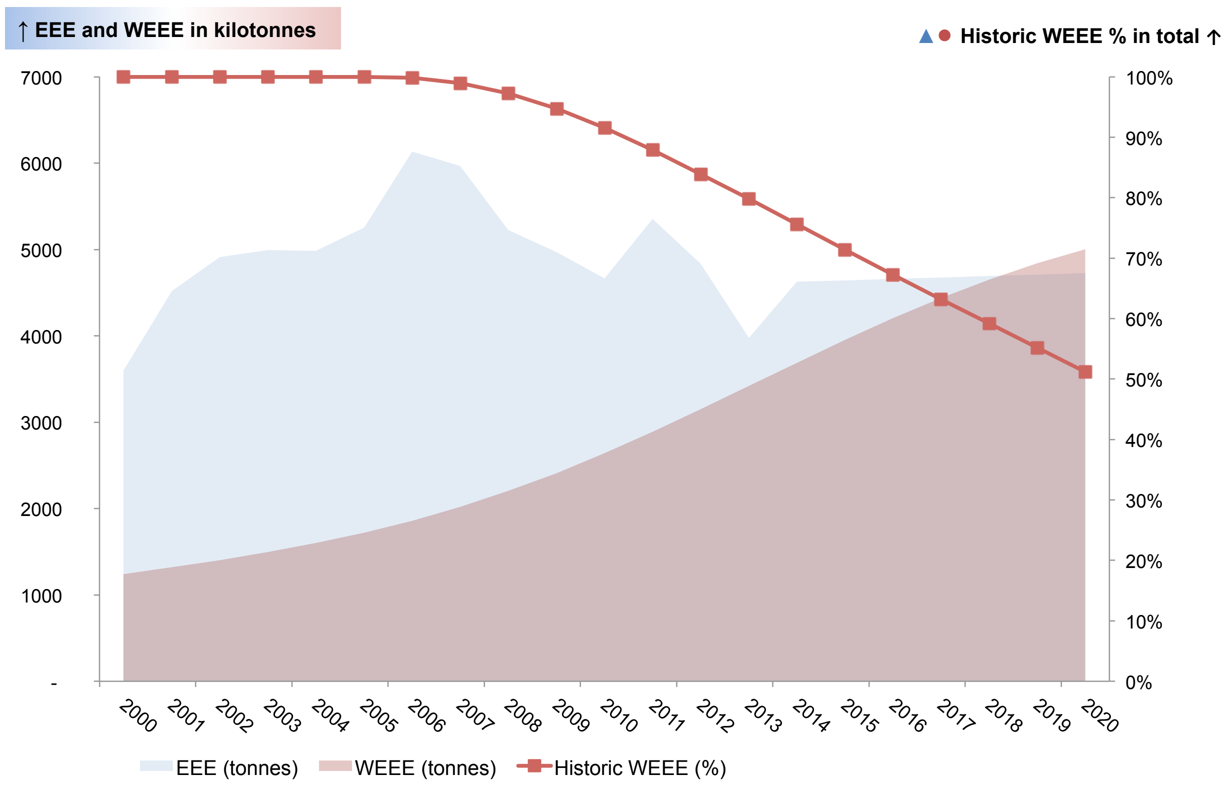

Figure 4.2. EEE, WEEE and historic WEEE for Category 0103 – ovens.

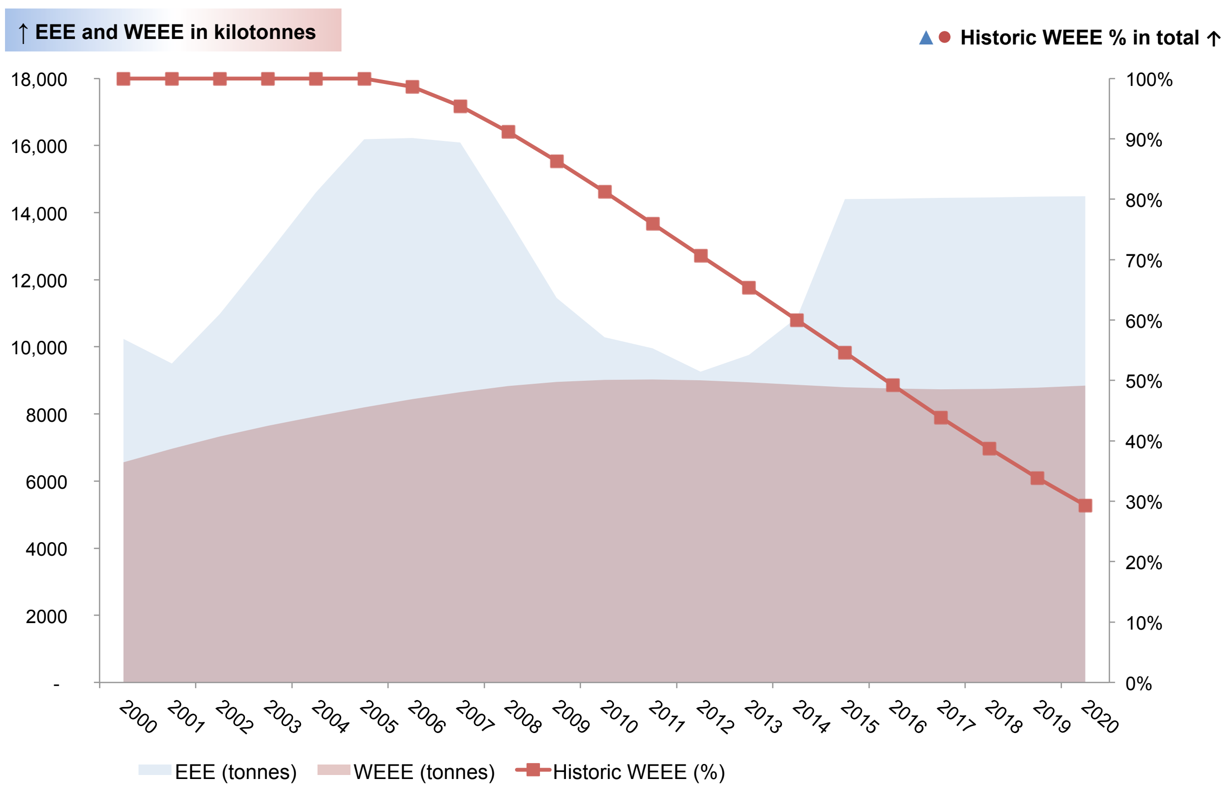

Figure 4.3. EEE, WEEE and historic WEEE for Category 0104 – washing machines.

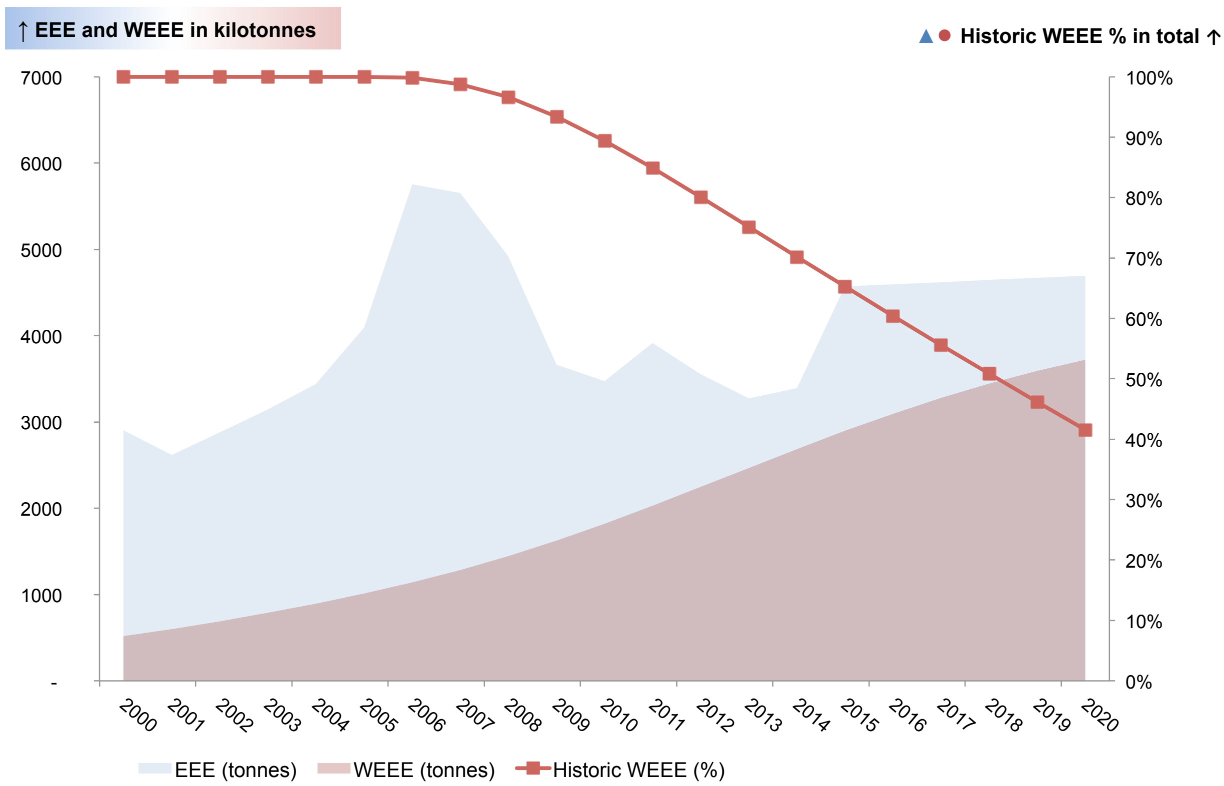

Figure 4.4. EEE, WEEE and historic WEEE for Category 0105 – dryers.

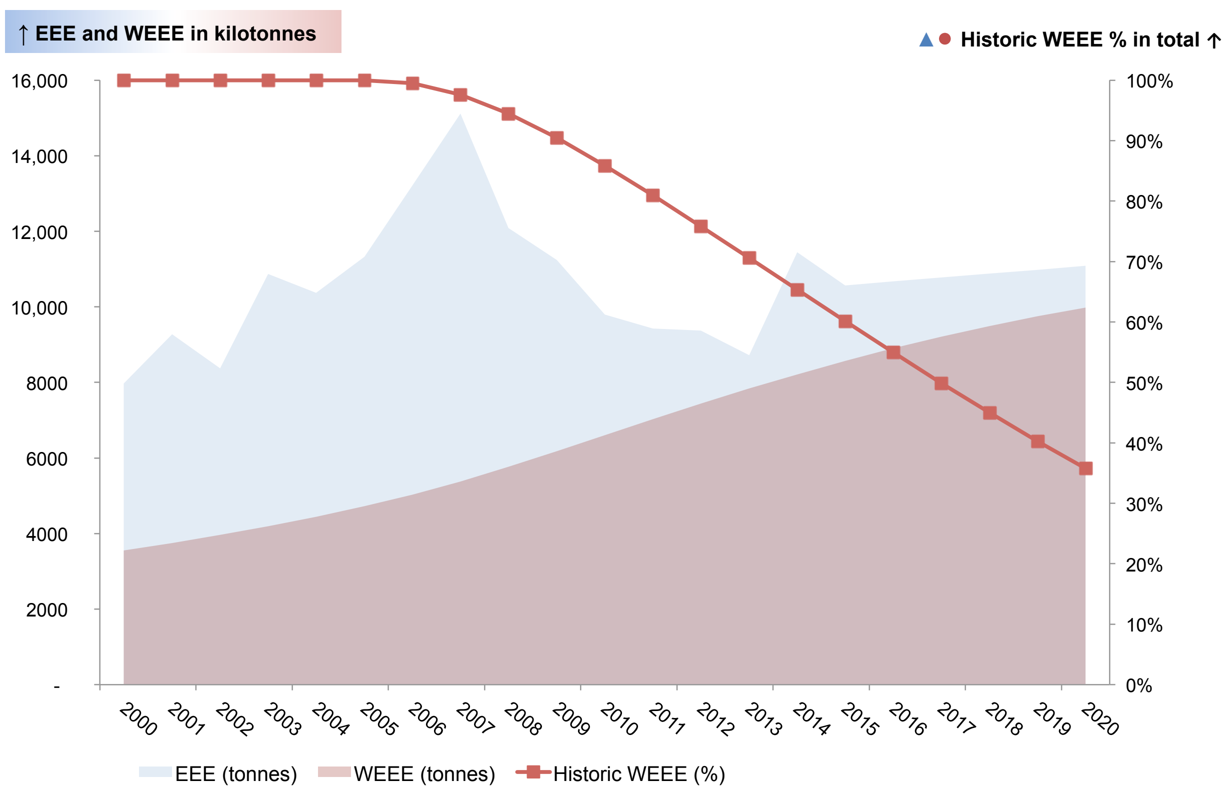

Figure 4.5. EEE, WEEE and historic WEEE for Category 0108 – fridges.

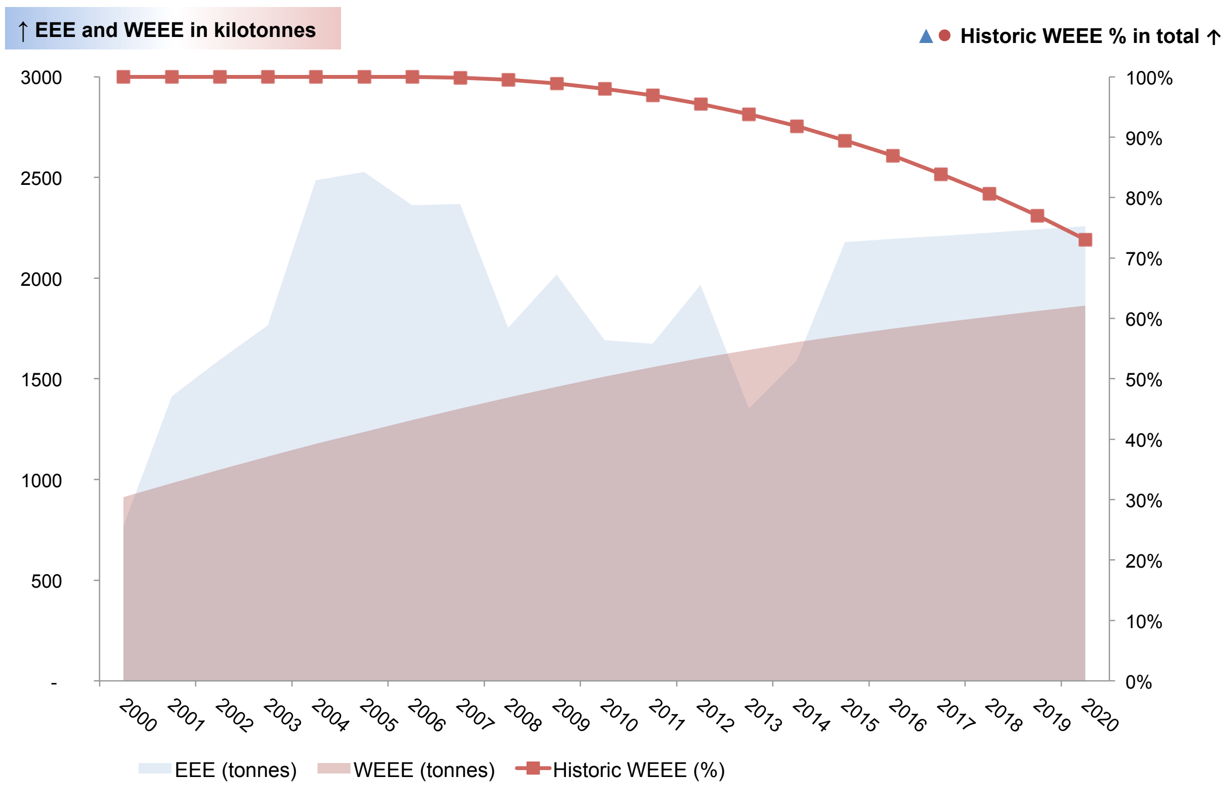

Figure 4.6. EEE, WEEE and historic WEEE for Category 0109 – freezers.

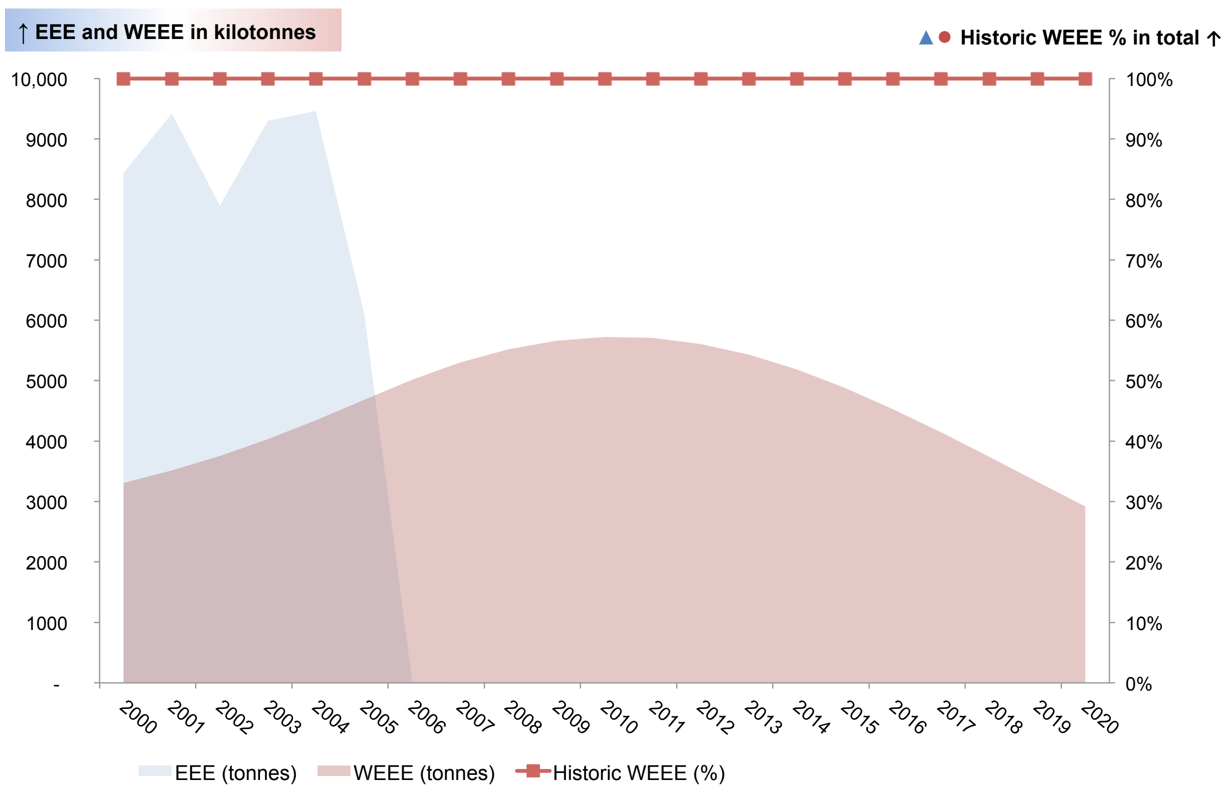

Figure 4.7. EEE, WEEE and historic WEEE for Category 0407 – CRT TVs.

Table 4.8. Mapping the Irish WEEE Groups/Categories to UNU-KEYS

WEEE Group	Irish (PRL) WEEE Categories	Equivalent EU (UNU-KEY) Categories
Cold	Category 1.1, Category 1.2	0108, 0109
LHA	Category 1.3	0102, 0103, 0104, 0105
TV	Category 4	0407, 0408

Table 4.9. WEEE and historic WEEE figures for cold, LHA and TV EEE categories in Ireland

Year	Cold WEEE (tonnes)	Cold historic WEEE (%)	LHA WEEE (tonnes)	LHA historic WEEE (%)	TV WEEE (tonnes)	TV historic WEEE (%)
2000	4461	100	9463	100	3306	100
2001	4728	100	10,120	100	3516	100
2002	5008	100	10,757	100	3759	100
2003	5304	100	11,394	100	4034	100
2004	5622	100	12,041	100	4350	100
2005	5960	100	12,719	100	4703	100
2006	6328	100	13,438	99	5054	100
2007	6733	99	14,195	95	5372	99
2008	7175	96	14,973	91	5653	99
2009	7638	94	15,738	86	5892	97
2010	8112	90	16,472	82	6088	95
2011	8583	87	17,172	77	6253	92
2012	9042	83	17,829	72	6388	89
2013	9480	78	18,439	68	6471	85
2014	9895	74	19,007	63	6488	81
2015	10,288	69	19,564	59	6441	77
2016	10,654	64	20,118	54	6339	72
2017	10,994	60	20,666	50	6186	68
2018	11,305	55	21,202	46	5991	63
2019	11,585	50	21,725	42	5766	58
2020	11,840	45	22,234	38	5508	54

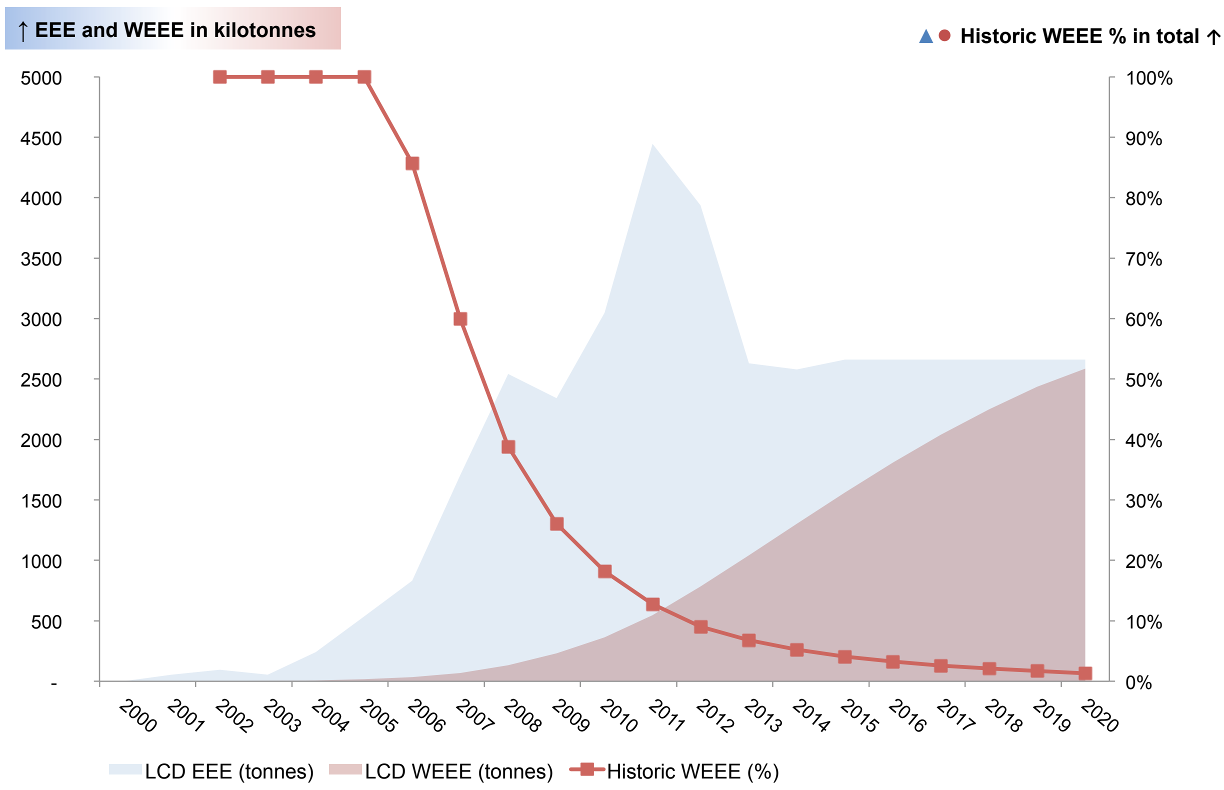

Figure 4.8. EEE, WEEE and historic WEEE for Category 0408 – LCD TVs. LCD, liquid-crystal display.

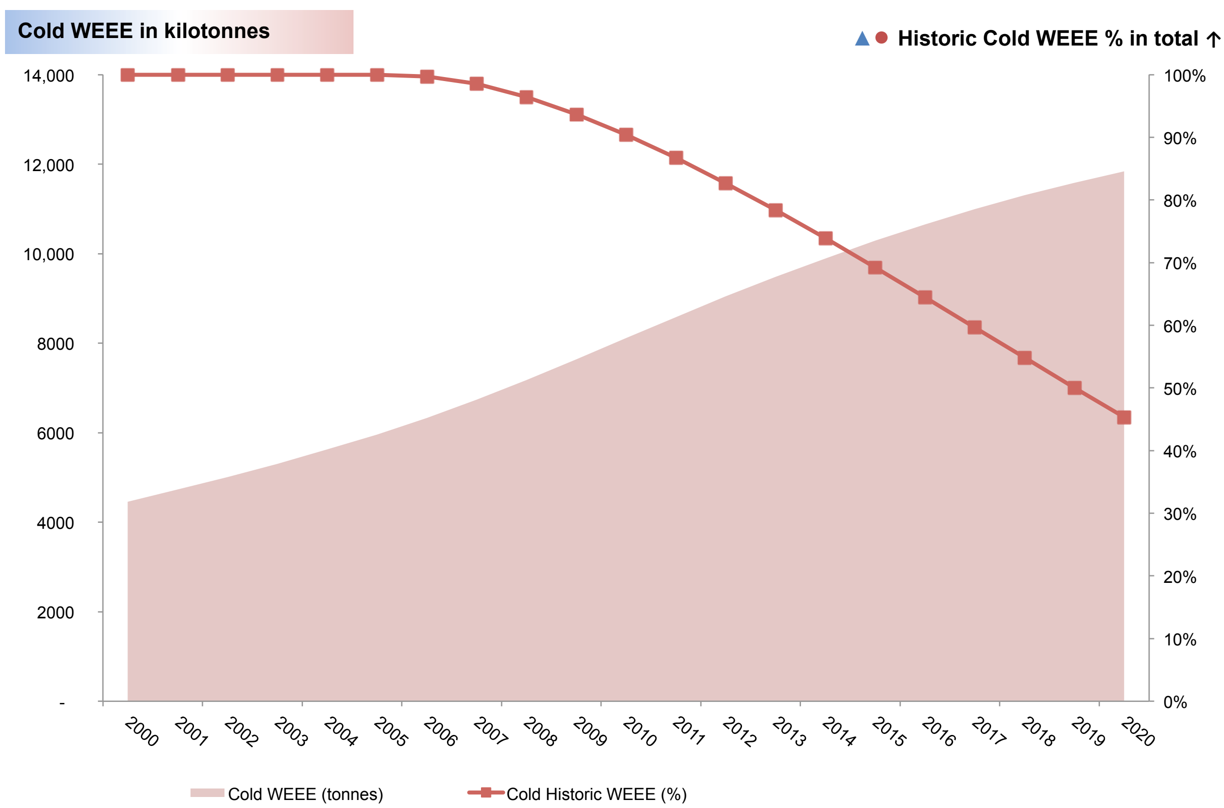

Figure 4.9. WEEE and historic WEEE for cold EEE in Ireland.

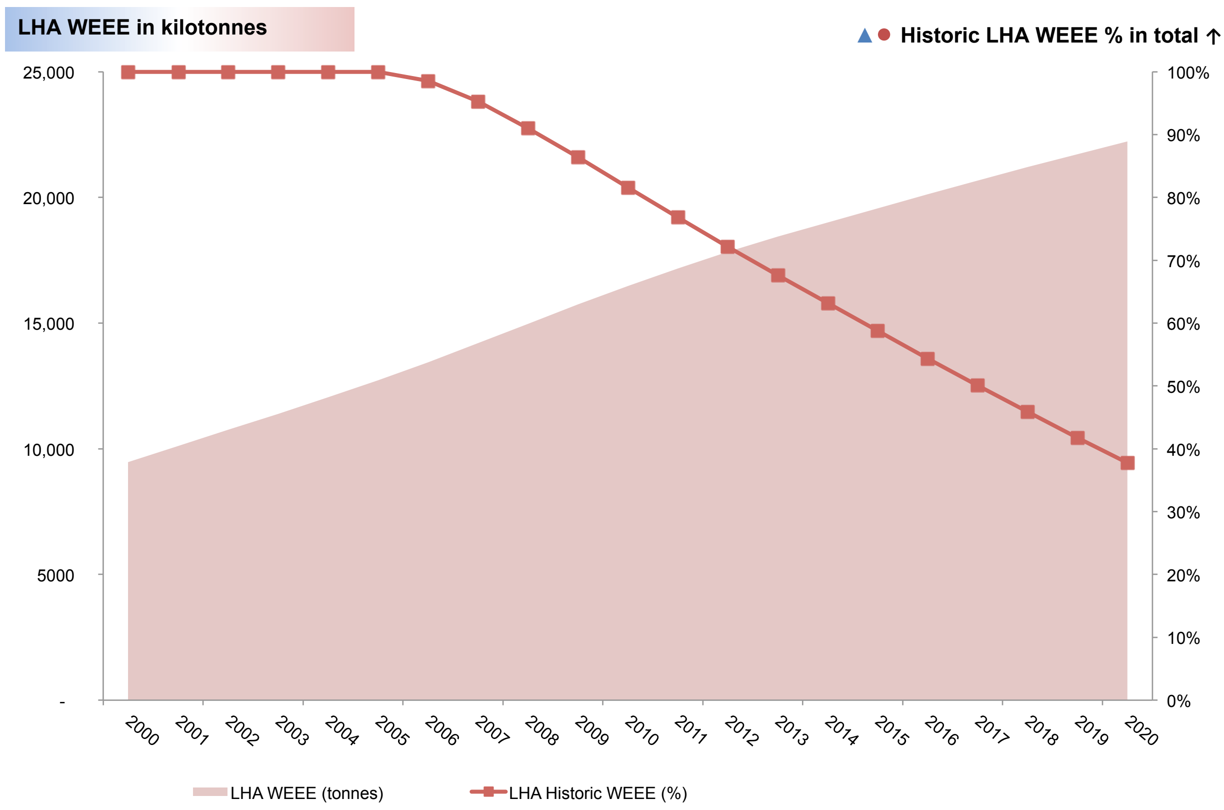

Figure 4.10. WEEE and historic WEEE for LHA EEE in Ireland.

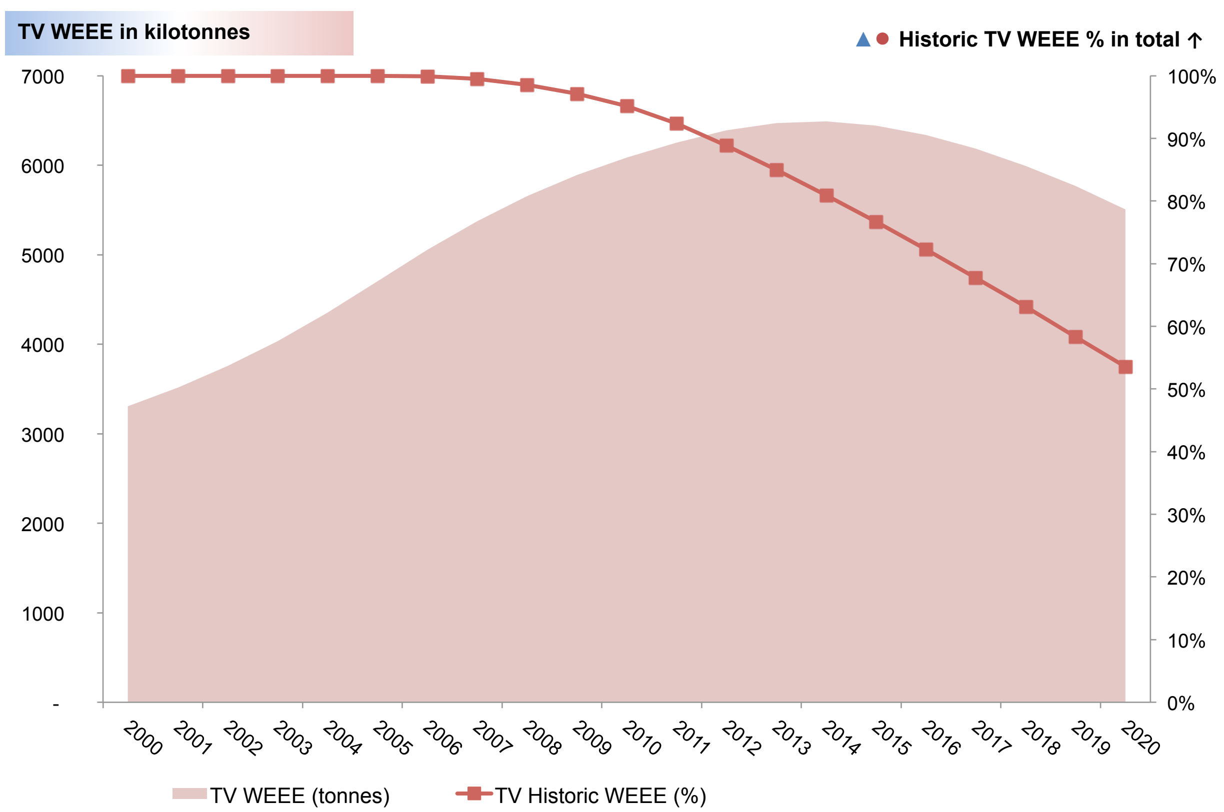

Figure 4.11. WEEE and historic WEEE for TV EEE in Ireland.

5 Validation with Irish WEEE Sampling

5.1 Introduction

This chapter of the report considers the validation of the WEEE Generated Model outputs through physical sampling of the Irish WEEE return stream. Specifically, three categories of WEEE were considered, as outlined in section 5.2. The logistics of the physical sampling locations, quantities, etc., carried out over the course of this project are detailed in section 5.3. Finally, section 5.4 computes the sampled data results for the three different WEEE categories and correlates these with the expected outputs, as predicted using the WEEE Generated Model detailed in Chapter 4.

5.2 WEEE Return Stream Sampling Methodology

The Irish WEEE return stream was sampled across a number of different categories and at a number of different locations around the country. This was then used as a means of validation for the outputs of the WEEE Generated Model described in Chapter 4. There were three main EEE categories sampled during the course of this work, namely:

- Category 1 ("cold"): this category consisted of sampling fridges and freezers in the return stream;
- Category 1 ("LHA"): dishwashers, washing machines, dryers and ovens were sampled in this return stream;
- Category 4 ("TVs"): both CRT and flat-panel TVs were considered in this category.

For each category sampled, the main goal of the sampling exercise was to determine whether the individual WEEE was historic or non-historic in nature. To accomplish this, the WEEE was examined for the presence or absence of the crossed-out wheelie bin symbol. This symbol has been in use since the WEEE Directive came into force as a special logo [in addition to the CE (*Conformité Européene*) logo] to show that the equipment should not be disposed of in the normal waste stream. In this way, it is a clear indication of the nature of the WEEE, that is, whether it is historic or non-historic. There are two variations of the crossed-out wheelie bin symbol, as shown in Figures 5.1 and 5.2.

Figure 5.1. Crossed-out wheelie bin logo version 1.

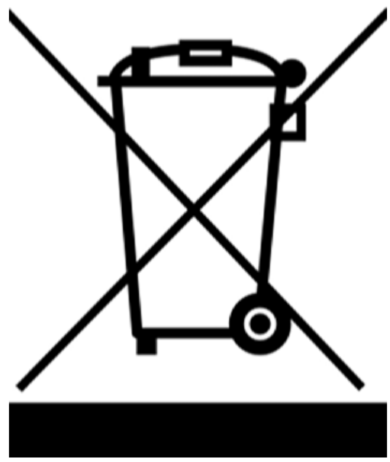

Figure 5.2. Crossed-out wheelie bin logo version 2.

Both symbols denote equipment that is to be disposed of in the WEEE return stream. However, the horizontal bar below the second version signifies that the piece of electrical equipment was manufactured after 13 August 2005 and therefore shows that the equipment was manufactured after the WEEE Directive came into force. Only the symbol in Figure 5.2 was considered in this study to determine whether a product was historic or not.

Sampling was carried out in accordance with the safety requirements and regulations of the University of Limerick and the relevant WEEE return stream locations. Appropriate safety gear (steel-toed boots, high-visibility jackets, etc.) was used, in accordance with the requirements of each site visited.

For each of the return steam categories that were sampled, the specific procedures and sampling methodologies outlined in the following sections were adopted.

5.2.1 "Cold" category sampling

As fridges/freezers are bulky appliances, they were examined as part of the standard processing stream in each location, in order to avoid unnecessary handling. The approach adopted for the sampling of cold WEEE equipment (fridges and/or freezers) in the return stream is described below:

- For each appliance being processed as part of this return stream, the device was examined for the presence or absence of the historic WEEE crossed-out wheelie bin symbol (Figure 5.2) and its condition noted (historic WEEE symbol present or absent).
- For each device, it was determined if CFC (chlorofluorocarbon) or pentane gases were utilised in the cooling/refrigeration system.

The sampling results were presented in the format shown in Table 5.1.

5.2.2 Large household appliance category sampling

Again, as LHAs are relatively bulky, they were examined as part of the standard processing stream to avoid unnecessary handling. The following approach for the sampling of LHA from the WEEE return stream was adopted by the University of Limerick personnel conducting the sampling:

- For each appliance processed in this return stream, the device was examined for the presence or absence of the historic WEEE crossed-out wheelie bin symbol.
- The appliance type (washing machine, dishwasher, dryer or oven) was noted.

For LHA goods, the sampled data were presented in the format shown in Table 5.2.

5.2.3 Television category sampling

For the sampling of TVs from the WEEE return stream, the following approach was adopted by the University of Limerick personnel conducting the sampling:

- a display from the cage of collected displays to be sampled was removed;
- the TV was examined for the presence or absence of the historic WEEE crossed-out wheelie bin symbol;
- whether the display was a TV or a computer monitor was noted; if it was a TV, whether it was a flat-panel or CRT TV was noted;
- the weight was logged if it is to be recorded as part of compliance scheme sampling;
- the display was moved to the cage of sampled devices.

Table 5.3 shows the typical data logging format used for this sampling operation.

Table 5.1. WEEE cold return stream sampling results format

Sample number	Cooling technology	WEEE symbol	UNU code

Table 5.2. LHA return stream sampling layout

Sample number	Appliance type	WEEE symbol	UNU code

Table 5.3. TV return stream sampling layout

Sample number	TV or monitor	CRT/flat panel	WEEE symbol	Weight	UNU code

5.3 Irish Return Stream Sampling

As well as sampling across the different categories, the WEEE return stream was sampled at a number of different locations around the country. These sampling locations and the categories sampled are listed in Table 5.4.

The required sample size for each WEEE category was determined on the basis of the population size and required statistical confidence intervals (CIs)/levels.[15] As a general rule, the higher the desired confidence level and the lower the desired CI (margin of error), the greater the number of items that must be sampled. For this project, a confidence level of 95% was chosen with associated CIs of 5% (for LHA and TV) or 6% (for cold). A 95% confidence level corresponds to a statistical *Z*-score of 1.96.[16] The required sample size for a given population can then be calculated using the equation:

$$\text{Required sample size} = z_{\text{score}} \times \frac{\text{SD} \times (1 - \text{SD})}{\text{confidence interval}} \qquad \text{(Equation 5.1)}$$

15 http://www.surveysystem.com/sscalc.htm (accessed 1 January 2016).

16 http://www.sjsu.edu/faculty/gerstman/StatPrimer/z-two-tails.pdf (accessed 1 January 2016).

In Equation 5.1, SD refers to the standard deviation for the entire population and can be calculated using the formula:

$$\text{SD} = \sqrt{\frac{\sum (X - M)^2}{n - 1}} \qquad \text{(Equation 5.2)}$$

In Equation 5.2, "X" refers to the individual samples and "M" is the mean of the set. These calculations were used to determine the required number of samples for the cold, LHA and TV WEEE categories and yield the sampling requirements for this project, as shown in Table 5.5.

Table 5.6 summarises the quantity of EEE stock sampled over the course of the project for all of the sampled sites, according to the three sample categories of interest (cold, LHA and TV).

5.4 Sampling and WEEE Generated Model Validations

For all of the goods sampled during the course of this project, Table 5.7 summarises the breakdown of historic versus non-historic WEEE for the three main product categories in 2015.

The comparison of these results with the WEEE Generated Model output(s) described in Chapter 4 of this report is best achieved by displaying the historic

Table 5.4. Return stream sampling locations

WEEE return stream location	Types of WEEE sampled
Rehab Recycle, Ballymount, County Dublin	Cold, LHA and TVs
KMK Metals, Tullamore, County Offaly	LHA
Mungret Civic Amenity Site, County Limerick	Cold, LHA
Television Recycling Village, Duleek, County Meath	TVs

Table 5.5. Sampling requirements for Irish historic WEEE categories

Sampling category	Population size	CI	Confidence level	Number of samples required
Cold	26,633	6%	95%	265
LHA	70,000	5%	95%	382
TV	95,000	5%	95%	383

Table 5.6. Summary of sampled WEEE types and quantities

Sampling type	WEEE sampled	Sample totals
Cold	Fridges, freezers	268
LHA	Washing machines, dishwashers, dryers, ovens	472
TV	CRT, flat-panel	486

Table 5.7. WEEE sample results for the Irish return stream in 2015

Type of EEE	Total sampled	Historic WEEE	Non-historic WEEE	Historic WEEE (%)	Non-historic WEEE (%)
Cold	268	180	88	67.2	32.8
LHA	472	256	216	54.2	45.8
TV	486	353	133	72.6	27.4

Table 5.8. Results of the WEEE sampling for the Irish return stream in 2015

Year/dataset	Cold historic WEEE (%)	LHA historic WEEE (%)	TV historic WEEE (%)
2015 sampled data	72	54	73
2015 model predictions	69	59	77

WEEE predictions from the WEEE Generated Model versus the percentage historic WEEE figures from the sampling activities above as graphs. Table 5.8 shows the results of the WEEE sampled data after they had been processed and the percentage of historic WEEE extracted for the three different WEEE categories, contrasted with the WEEE Generated Model predictions for the same categories and timeframe.

The following graphs are presented in this section of the report: Figure 5.3 shows the cold WEEE model predictions versus the 2015 sampled cold WEEE data; Figure 5.4 shows the same parameters, but for the LHA category; and Figure 5.5 presents the percentage historic WEEE prediction(s) versus the sampled values for the TV category.

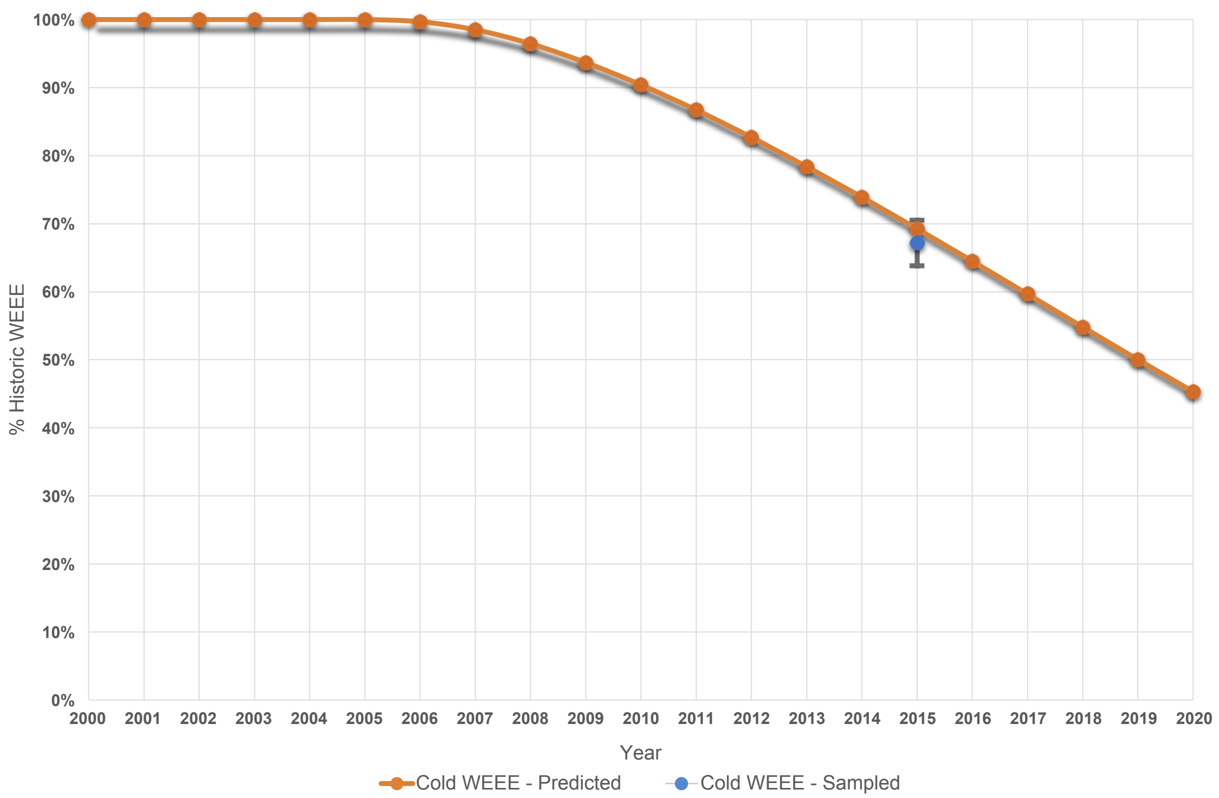

Figure 5.3. Percentage historic WEEE for the cold category – predicted vs sampled data.

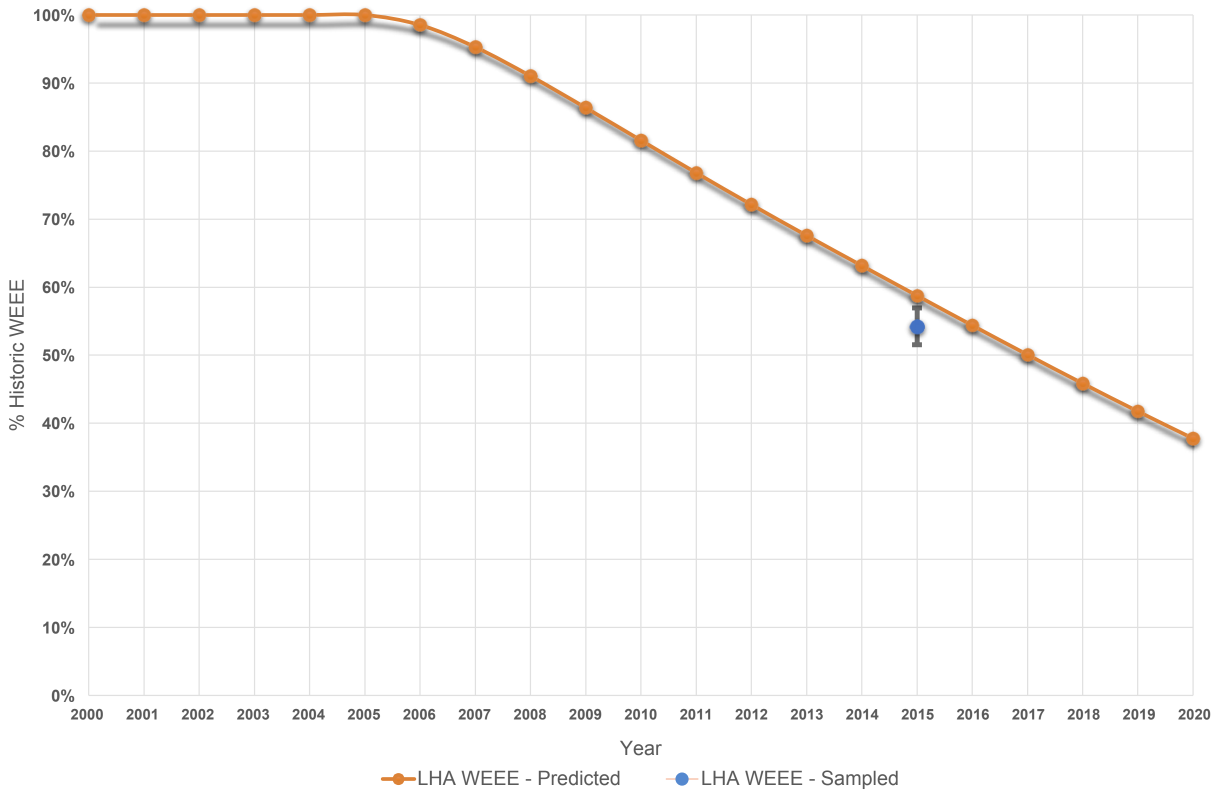

Figure 5.4. Percentage historic WEEE for the LHA category – predicted vs sampled data.

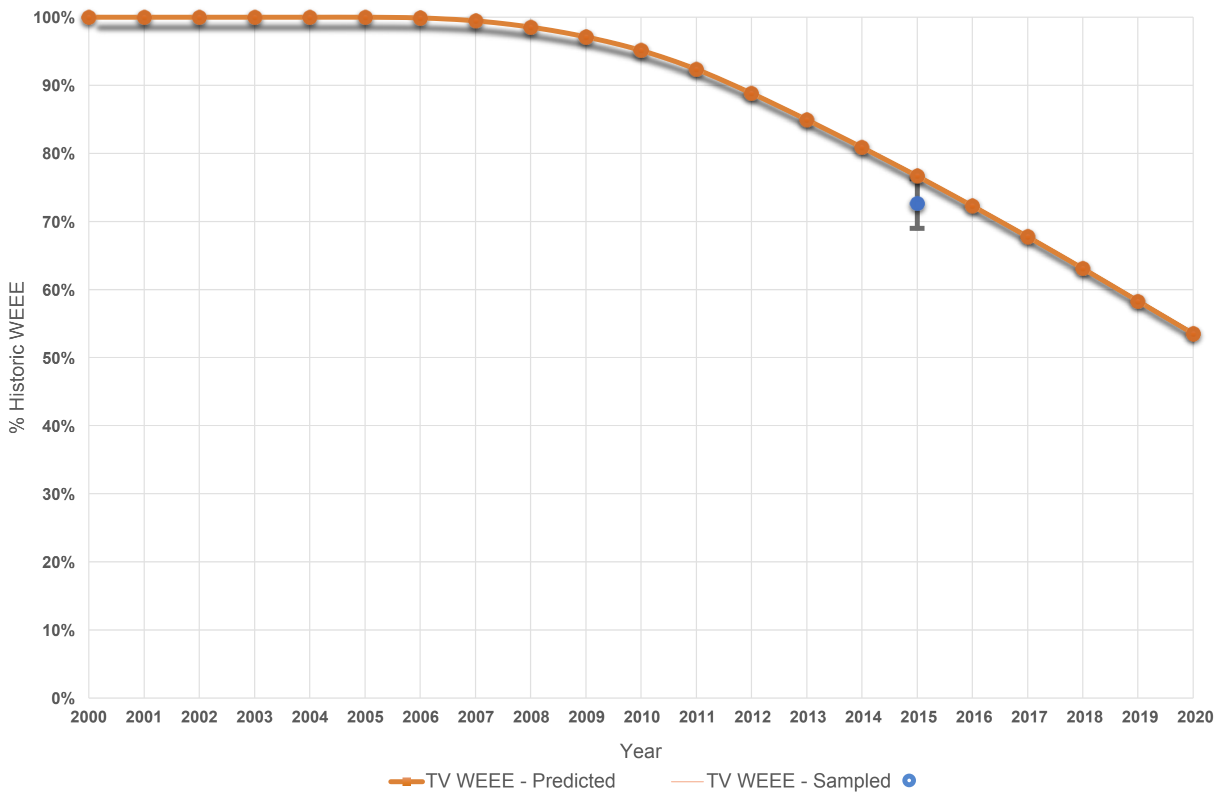

Figure 5.5. Percentage historic WEEE for the TV category – predicted vs sampled data.

A statistical analysis of the sampled data gives an estimate of the percentage of historic WEEE present in the return stream for the period of interest (2015, in this case). The larger the sample size (i.e. the more WEEE sampled), the more accurate the result, with the mean of the sampled results (M) tending to get closer and closer to the true mean [i.e. the mean of the whole WEEE population (μ)]. For the WEEE sample data presented in this report, standard error (SE) bars and CIs were used to make inferences from the comparison of the predicted WEEE Generated Model data with the data from the WEEE return stream sampling. M, with SE bars or CIs, gives an indication of the region in which μ would be expected to lie (which should correspond to the WEEE Generated Model predictions for that period). The CIs define the values that are most plausible for μ.

As shown in Figures 5.3, 5.4 and 5.5, the sampled data from the various WEEE categories are presented with SE and 95% CIs. These data points and associated error bars correlate very well with the expected (predicted) values for the cold, LHA and TV EEE categories.

For each of the WEEE categories, there is a strong correlation between the model predicted data for 2015 and the sample data. Therefore, the sampled data corroborate the model predictions very well across the cold, LHA and TV WEEE classes considered, especially given the constraints of the sampling process, etc. Further sampling is recommended on an annual basis to corroborate these findings and allow continuous improvement and refinement of the model predictions as newer data become available.

6 Conclusion and Recommendations

6.1 Conclusions

This report has documented the development and validation of a model for the prediction of historic WEEE for Ireland and the results of this model have been applied to the Irish WEEE sector. The model in question was developed as a collaboration between the University of Limerick and the UNU. It considers the specifics of the Irish EEE and WEEE sectors and utilises a model that had been validated across other EU countries to obtain specific EEE, WEEE and historic WEEE figures and projections for Ireland for the 20-year period from 2000 to 2020, inclusive. The model has been empirically validated for Irish WEEE using first-hand sampled recycling data across the distinct categories of interest in this project, namely cold WEEE, LHA WEEE and displays/TV WEEE.

According to the model, historic WEEE as a percentage of total WEEE across the three categories of interest are currently 69% for the cold category, 59% for the LHA category and 77% for the TV category. Therefore, there are still substantial quantities of historic WEEE in the return stream, even 10 years after the implementation of the WEEE Directive in Ireland. Over the course of the next 5 years, the model predicts that these levels will reduce to 45%, 38% and 54%, respectively, by 2020. While this is a noticeable reduction in historic WEEE levels, the model predictions would seem to suggest that historic WEEE will still arise in Ireland in the cold, LHA and TV return streams for the next 10 or more years.

6.2 Recommendations

Some of the recommendations arising from the research and modelling carried out during this project are listed below:

- It is recommended that certain categories of WEEE that arise at collection points in Ireland are sampled annually and with sufficient coverage to provide a sampled estimate for the percentage of historic WEEE in the cold, LHA and TV WEEE categories (to allow a 95% confidence level and 5% CIs). This sampled estimate should then be used to validate the results of the WEEE Generated Model in order to continue to measure the accuracy of the model predictions into the future. This work should be co-ordinated through PRL, financed by compliance schemes and carried out by an independent third party.
- The modelling should be revisited before 2020, at which time the current model predictions will expire. Updated model predictions and results should be re-evaluated and updated for Ireland after 2020. Such data would inform policy decisions.
- Going forward, a more detailed and in-depth set of statistical data should be gathered, from sources such as household surveys, on EEE product penetration across Irish homes, in order to facilitate a better understanding of WEEE retention rates across the country. Regional disparities in the level of historic WEEE arising could also be considered based on this more detailed dataset.
- Consideration should be given to mapping the existing Irish WEEE categories to the UNU-KEY system for better compatibility with other EU countries. This might involve restructuring the WEEE categories in use, or may comprise an accepted set of Irish split factors, in order to allow the easy translation from one standard to another.

6.3 Recommended Procedure for Historic WEEE Sampling

As part of the Historic WEEE Project, it is recommended that the WEEE return stream is sampled annually for the cold (fridge/freezer), LHA (washing machines/dryers/dishwashers/ovens) and TV (CRT/flat) categories, in order to validate the predictions of the WEEE Generated Model for the years and categories of interest. To that end, the following paragraphs outline the steps recommended for this sampling process.

To determine the amount of WEEE that should be sampled in each of the three categories of interest (cold, LHA and TV), and ascertain the sample size required to achieve specific confidence levels and intervals in the sampled dataset, various online calculators (e.g. http://www.surveysystem.com/sscalc.htm) can be used. To use such a calculator, both the population and desired CI are needed to determine the required sample size.

As a general rule, the higher the confidence level and the lower the CI desired, the greater the sample size required. In this report, a confidence level of 95% was chosen with a CI of 5%. This means that if the sampling exercise is repeated, there is a 95% chance that the result will be within 5% of the original result.

As the total amount of WEEE generated in a given year cannot be known until the end of that year, the WEEE generated figure must be estimated. In this project, the data from the previous year were used (e.g. the amount of WEEE generated in 2014 was used as the population size for the calculation of 2015 sample sizes). By inputting both of these pieces of information and the desired confidence level into a sample size calculator, the necessary sample size for that WEEE category and year can be determined.

Once the sample size has been determined, the WEEE return stream(s) for that category should be sampled throughout the year. It is recommended that sampling is conducted across multiple sites and on multiple visits if possible, in order to obtain a better sample distribution. For each item of WEEE sampled, the age can be estimated based on the presence or absence of the crossed-out wheelie bin logo, as shown in Figure 2.1, whereby, if the logo is present, the WEEE should be categorised as non-historic, and, if the logo is absent, the WEEE should be categorised as historic.

When sufficient samples have been taken across all categories to satisfy the sampling requirements, the results can be collated using Excel (or equivalent) to determine the actual amount of historic WEEE in the sampled return stream using the formula:

$$\text{\% historic WEEE} = (\text{No. of historic WEEE samples}/\text{total No. of WEEE samples}) \times 100\% \quad \text{(Equation 6.1)}$$

This figure can then be plotted on the output chart of the model, along with error bars, to evaluate the level of agreement between the model and sampled value.

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Abbreviations

μ	Mean of the whole population
AATF	Approved authorised treatment facility
ATF	Authorised treatment facility
B2B	Business to business
B2C	Business to consumer
CI	Confidence interval
CN	Combined Nomenclature
CRT	Cathode ray tube
CSO	Central Statistics Office
DCF	Designated collection facility
DECLG	Department of the Environment, Community and Local Government
EEE	Electrical and electronic equipment
EPA	Environmental Protection Agency
ERP	European Recycling Platform
ESM	Environmentally sound management
EU	European Union
HWRC	Household waste recycling centre
IOA	Input–output analysis
IT	Information technology
KSWM	Korea Society of Waste Management
LCD	Liquid-crystal display
LED	Light-emitting diode
LHA	Large household appliance
M	Mean of the sampled results
MRF	Materials recovery facility
NTCRS	National Television and Computer Recycling Scheme
ORDEE	Ordinance on the Return, Taking Back and Disposal of Electrical and Electronic Equipment
PBM	Population balance model
PC	Personal computer
PCC	ProdCom Commodity Code
POM	Placed-on-the-market
PRL	Producer Register Limited
PRO	Producer responsibility organisation
SE	Standard error
SEAI	Sustainable Energy Authority of Ireland
SHAR	Specified Home Appliances Recycling
TFS	TransFrontier Shipments
TV	Television
UEEE	Used electrical and electronic equipment
UNU	United Nations University
UNU-ISP	United Nations University Institute for Sustainability and Peace
vEMC	Visible environmental management cost
WEEE	Waste electrical and electronic equipment

AN GHNÍOMHAIREACHT UM CHAOMHNÚ COMHSHAOIL
Tá an Ghníomhaireacht um Chaomhnú Comhshaoil (GCC) freagrach as an gcomhshaol a chaomhnú agus a fheabhsú mar shócmhainn luachmhar do mhuintir na hÉireann. Táimid tiomanta do dhaoine agus don chomhshaol a chosaint ó éifeachtaí díobhálacha na radaíochta agus an truaillithe.

Is féidir obair na Gníomhaireachta a roinnt ina trí phríomhréimse:

Rialú: *Déanaimid córais éifeachtacha rialaithe agus comhlíonta comhshaoil a chur i bhfeidhm chun torthaí maithe comhshaoil a sholáthar agus chun díriú orthu siúd nach gcloíonn leis na córais sin.*

Eolas: *Soláthraímid sonraí, faisnéis agus measúnú comhshaoil atá ar ardchaighdeán, spriocdhírithe agus tráthúil chun bonn eolais a chur faoin gcinnteoireacht ar gach leibhéal.*

Tacaíocht: *Bímid ag saothrú i gcomhar le grúpaí eile chun tacú le comhshaol atá glan, táirgiúil agus cosanta go maith, agus le hiompar a chuirfidh le comhshaol inbhuanaithe.*

Ár bhFreagrachtaí

Ceadúnú
Déanaimid na gníomhaíochtaí seo a leanas a rialú ionas nach ndéanann siad dochar do shláinte an phobail ná don chomhshaol:
- saoráidí dramhaíola *(m.sh. láithreáin líonta talún, loisceoirí, stáisiúin aistrithe dramhaíola)*;
- gníomhaíochtaí tionsclaíocha ar scála mór *(m.sh. déantúsaíocht cógaisíochta, déantúsaíocht stroighne, stáisiúin chumhachta)*;
- an diantalmhaíocht *(m.sh. muca, éanlaith)*;
- úsáid shrianta agus scaoileadh rialaithe Orgánach Géinmhodhnaithe *(OGM)*;
- foinsí radaíochta ianúcháin *(m.sh. trealamh x-gha agus radaiteiripe, foinsí tionsclaíocha)*;
- áiseanna móra stórála peitril;
- scardadh dramhuisce;
- gníomhaíochtaí dumpála ar farraige.

Forfheidhmiú Náisiúnta i leith Cúrsaí Comhshaoil
- Clár náisiúnta iniúchtaí agus cigireachtaí a dhéanamh gach bliain ar shaoráidí a bhfuil ceadúnas ón nGníomhaireacht acu.
- Maoirseacht a dhéanamh ar fhreagrachtaí cosanta comhshaoil na n-údarás áitiúil.
- Caighdeán an uisce óil, arna sholáthar ag soláthraithe uisce phoiblí, a mhaoirsiú.
- Obair le húdaráis áitiúla agus le gníomhaireachtaí eile chun dul i ngleic le coireanna comhshaoil trí chomhordú a dhéanamh ar líonra forfheidhmiúcháin náisiúnta, trí dhíriú ar chiontóirí, agus trí mhaoirsiú a dhéanamh ar leasúchán.
- Cur i bhfeidhm rialachán ar nós na Rialachán um Dhramhthrealamh Leictreach agus Leictreonach (DTLL), um Shrian ar Shubstaintí Guaiseacha agus na Rialachán um rialú ar shubstaintí a ídíonn an ciseal ózóin.
- An dlí a chur orthu siúd a bhriseann dlí an chomhshaoil agus a dhéanann dochar don chomhshaol.

Bainistíocht Uisce
- Monatóireacht agus tuairisciú a dhéanamh ar cháilíocht aibhneacha, lochanna, uiscí idirchriosacha agus cósta na hÉireann, agus screamhuiscí; leibhéil uisce agus sruthanna aibhneacha a thomhas.
- Comhordú náisiúnta agus maoirsiú a dhéanamh ar an gCreat-Treoir Uisce.
- Monatóireacht agus tuairisciú a dhéanamh ar Cháilíocht an Uisce Snámha.

Monatóireacht, Anailís agus Tuairisciú ar an gComhshaol
- Monatóireacht a dhéanamh ar cháilíocht an aeir agus Treoir an AE maidir le hAer Glan don Eoraip (CAFÉ) a chur chun feidhme.
- Tuairisciú neamhspleách le cabhrú le cinnteoireacht an rialtais náisiúnta agus na n-údarás áitiúil *(m.sh. tuairisciú tréimhsiúil ar staid Chomhshaol na hÉireann agus Tuarascálacha ar Tháscairí)*.

Rialú Astaíochtaí na nGás Ceaptha Teasa in Éirinn
- Fardail agus réamh-mheastacháin na hÉireann maidir le gáis cheaptha teasa a ullmhú.
- An Treoir maidir le Trádáil Astaíochtaí a chur chun feidhme i gcomhair breis agus 100 de na táirgeoirí dé-ocsaíde carbóin is mó in Éirinn.

Taighde agus Forbairt Comhshaoil
- Taighde comhshaoil a chistiú chun brúnna a shainaithint, bonn eolais a chur faoi bheartais, agus réitigh a sholáthar i réimsí na haeráide, an uisce agus na hinbhuanaitheachta.

Measúnacht Straitéiseach Timpeallachta
- Measúnacht a dhéanamh ar thionchar pleananna agus clár beartaithe ar an gcomhshaol in Éirinn *(m.sh. mórphleananna forbartha)*.

Cosaint Raideolaíoch
- Monatóireacht a dhéanamh ar leibhéil radaíochta, measúnacht a dhéanamh ar nochtadh mhuintir na hÉireann don radaíocht ianúcháin.
- Cabhrú le pleananna náisiúnta a fhorbairt le haghaidh éigeandálaí ag eascairt as taismí núicléacha.
- Monatóireacht a dhéanamh ar fhorbairtí thar lear a bhaineann le saoráidí núicléacha agus leis an tsábháilteacht raideolaíochta.
- Sainseirbhísí cosanta ar an radaíocht a sholáthar, nó maoirsiú a dhéanamh ar sholáthar na seirbhísí sin.

Treoir, Faisnéis Inrochtana agus Oideachas
- Comhairle agus treoir a chur ar fáil d'earnáil na tionsclaíochta agus don phobal maidir le hábhair a bhaineann le caomhnú an chomhshaoil agus leis an gcosaint raideolaíoch.
- Faisnéis thráthúil ar an gcomhshaol ar a bhfuil fáil éasca a chur ar fáil chun rannpháirtíocht an phobail a spreagadh sa chinnteoireacht i ndáil leis an gcomhshaol *(m.sh. Timpeall an Tí, léarscáileanna radóin)*.
- Comhairle a chur ar fáil don Rialtas maidir le hábhair a bhaineann leis an tsábháilteacht raideolaíoch agus le cúrsaí práinnfhreagartha.
- Plean Náisiúnta Bainistíochta Dramhaíola Guaisí a fhorbairt chun dramhaíl ghuaiseach a chosc agus a bhainistiú.

Múscailt Feasachta agus Athrú Iompraíochta
- Feasacht chomhshaoil níos fearr a ghiniúint agus dul i bhfeidhm ar athrú iompraíochta dearfach trí thacú le gnóthais, le pobail agus le teaghlaigh a bheith níos éifeachtúla ar acmhainní.
- Tástáil le haghaidh radóin a chur chun cinn i dtithe agus in ionaid oibre, agus gníomhartha leasúcháin a spreagadh nuair is gá.

Bainistíocht agus struchtúr na Gníomhaireachta um Chaomhnú Comhshaoil
Tá an ghníomhaíocht á bainistiú ag Bord lánaimseartha, ar a bhfuil Ard-Stiúrthóir agus cúigear Stiúrthóirí. Déantar an obair ar fud cúig cinn d'Oifigí:
- An Oifig um Inmharthanacht Comhshaoil
- An Oifig Forfheidhmithe i leith cúrsaí Comhshaoil
- An Oifig um Fianaise is Measúnú
- An Oifig um Cosaint Raideolaíoch
- An Oifig Cumarsáide agus Seirbhísí Corparáideacha

Tá Coiste Comhairleach ag an nGníomhaireacht le cabhrú léi. Tá dáréag comhaltaí air agus tagann siad le chéile go rialta le plé a dhéanamh ar ábhair imní agus le comhairle a chur ar an mBord.

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The Development of a Model to Ascertain Future Levels of Historic WEEE Arising (Historic WEEE)

epaResearch
Climate - Water - Sustainability
Identifying pressures • Informing policy • Developing solutions

Authors: Michael Johnson and Colin Fitzpatrick.

This project has developed and validated a model to ascertain the current and future levels of historic WEEE which is arising at collection and treatment facilities in Ireland. It provides reliable estimations on the rates of generation of Irish historical WEEE from the period 2000 to 2020. The model predictions were validated using WEEE Return Stream sampled data for the year 2015 and recommendations made for further sampling processes going forward.

Identify Pressures

Based on modelled outcomes, this project has identified pressures in the WEEE recycling system based on the historic WEEE versus non-historic WEEE splits as well as the predicted volumes of historic WEEE arising entering return streams up to 2020

Informing Policy

The outputs of this project may be used to inform policy on WEEE financing and to support logistics and treatment requirements planning into the future. These include, but are not limited to, the financing of WEEE Recycling in Ireland, compliance with the WEEE Directive, planning recycling requirements and improving resource efficiency.

Developing Solutions

This project has produced a range of estimates for the future generation of historic WEEE in Ireland across the range of consumer EEE considered in the scope of the project. Quantifiable, empirical figures and predictions are now available for the Irish WEEE market, reflecting the idiosyncrasies of the market. A detailed sampling methodology has also been provided, enabling the model projections to be updated on an annual basis.

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