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Pro-circular behaviours and refrigerated display cabinets: supporting resource efficiency in the retail refrigeration sector

Zaneta Muranko[a]*, Deborah Andrews[a], Issa Chaer[b], Elizabeth J. Newton[c], Philip Proudman[d], Matt Longhurst[d]

[a]*School of Engineering, London South Bank University, 103 Borough Road, London, SE1 0AA, United Kingdom* [b]*School of the Built Environment and Architecture, London South Bank University, 103 Borough Road, London, SE1 0AA, United Kingdom* [c]*School of Applied Sciences, London South Bank University, 103 Borough Road, London, SE1 0AA, United Kingdom*

[d]*The Bond Group, Bond House, New Road, Sheerneess, ME12 1BB, United Kingdom*

Abstract

There is a need to change business and behaviour models from the linear to the circular in order to conserve energy and resources. This paper identifies what pro-circular behaviours can influence the development of a Circular Economy, with particular reference to the retail refrigeration industry.

Pro-circular behaviour is an action that is brought about due to the prioritisation of resource-efficiency with the aim of supporting the growth of a Circular Economy. A Circular Economy is an economic and industrial system where resources are kept in use for as long as possible. Greater uptake of alternative business models in the UK could help to create a more sustainable industry in retail refrigeration.

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* Corresponding author. Tel.: +44-2078-157172.
E-mail address: murankoz@lsbu.ac.uk

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1. Introduction

A Circular Economy can eliminate waste, provide resource security and lessen the environmental cost in the production and consumption of products. It is an alternative to the linear economy, which was established in the early days of the industrial revolution and is still prevalent in the majority of industries to date, including the retail refrigeration sector. The linear economy is based on the "take-make-use-dispose" path, where products are made, used and disposed of at the end of their life. This linear approach can lead to resource overuse, waste and is founded on the naive assumption of an infinite material supply. While this practice is common, governments [1, 2] and businesses are beginning to realise the "importance of moving to a more sustainable economy" [2].

Refrigerated Display Cabinets (RDCs) are used to stock and display chilled, frozen food and beverages in retail grocery stores. The manufacture of cabinets is typified by the extensive use of materials and energy, meaning that the development of a Circular Economy in this sector is particularly important. Businesses in the retail refrigeration sector can take a more circular approach to production and consumption through adopting alternative business models, such as repair, refurbishment and remanufacture of products [3].

Using Refrigerated Display Cabinets as an example, this paper illustrates the deficiencies of the linear production path and provides options for the implementation of pro-circular behaviours that can boost resource efficiency in the retail refrigeration sector. It also attempts to outline a number of environmental and economic benefits the alternative business models can bring.

2. Deficiencies of linear production in the retail refrigeration industry

The Centre for Remanufacturing and Reuse (CRR) forecasted that in 2015 around 81,000 *end-of-life* core Refrigerated Display Cabinets were available to be refurbished and remanufactured [4]. However only 15% of these cabinets were assumed to be re-engineered to a 'good-as-new' condition and bought by the UK retailers. The remaining 85% of cabinets were disposed of and replaced by new cabinets. This means that with an average cabinet weighing 750 kg [4], around 51,000 tonnes of long-life reusable components entered the waste steam in 2015 instead of being re-used. This amounts to an estimated 43,350 tonnes of metal, 1,530 tonnes glass, 4,590 tonnes of polymers. This level of disposal shows the scope for resource efficiency in the retail refrigeration sector, which in turn highlights the industries lack of pro-circular behaviours.

These disposal figures are even more remarkable when we take into account the amount of money UK retailers spent on importing new Refrigerated Display Cabinets from outside the UK, which in 2015 was £69.5 million [5]. This is equivalent to approximately 255,000 units. Cabinets imported from outside the UK and typically cheaper than those produced in the UK, though can often be lower in quality, energy-efficiency and life expectancy [4]. With scope for the UK to make approximately 81,000 units available through refurbishment and remanufacture in 2015, over a third of these imports could have been sourced within the UK market.

The creation of a new refurbishment and remanufacture market in the UK retail refrigeration sector is a job creation opportunity. Latest figures show there is an estimated 1.6 million people unemployed in the UK [6]. Therefore, there is scope for manufacturers to train (e.g., apprentices) and hire more staff (temporary and permanent) should the retail refrigeration industry become more pro-circular and there be a demand for refurbished and remanufactured cabinets.

3. Pro-circular behaviours of the retail refrigeration sector

Literature on the Circular Economy frequently discusses need for behavioural change. To date, behaviour has not been identified and defined in Circular Economy literature. To distinguish specific behaviours that support the development of a Circular Economy, authors of this paper propose to define pro-circular behaviour as: a*n action which is brought about due to prioritising resource-efficiency. This behaviour benefits or at least reduces damage to the environment, economy and society.* Examples of pro-circular behaviours specific to the retail refrigeration

industry and their potential outcomes are shown in Table 1. These behaviours align with alternative business models, such as repair, refurbishment and remanufacture of Refrigerated Display Cabinets (RDCs).

Table 1. Examples of pro-circular behaviours in the retail refrigeration industry and their environmental and socio-economic outcomes.

Supplier / producer behaviour	Customer behaviour	Outcomes
Repairing and maintaining RDCs	Requesting repair and maintenance service	Reduction of waste, air, water and soil pollution; more education, training and job opportunities; innovation and growth of local businesses
On-site refurbishing RDCs	Requesting on-site refurbishment service	
Factory-remanufacturing RDCs	Buying remanufactured RDCs	

4. Circular Economy of Refrigerated Display Cabinets (RDCs)

Refrigerated Display Cabinets have the capability to meet the principles of the Circular Economy through their remanufacture and refurbishment. A cabinet's life can be prolonged with an appropriate approach to their design, use and *end-of-life* stage. On average over 90% of a cabinet body is made from reusable and long life materials. This accounts for 85% metals (steel, aluminium, brass, copper), 3% polymers and 3% glass [4]. In line with the rules for design for longevity (namely use of durable parts) and easy disassembly at the *end-of-life* (simplified structure), the best quality units can continue to cycle in service for longer than their typical lifespan which is on average 5 years. A cabinet can be renewed 3 times before their absolute *end-of-life* [7], as opposed to being disposed of after 5 years from purchase. To increase the resource efficiency of cabinets, businesses can adopt a circular approach to products by accommodating alternative business models, such as: repair, refurbishment, remanufacture and recycling as shown in Figure 1. Recycling, which is listed as the last step to achieving the Circular Economy of Refrigerated Display Cabinets is distinguished from the models. This is due it focusing on material reproduction, not direct reuse.

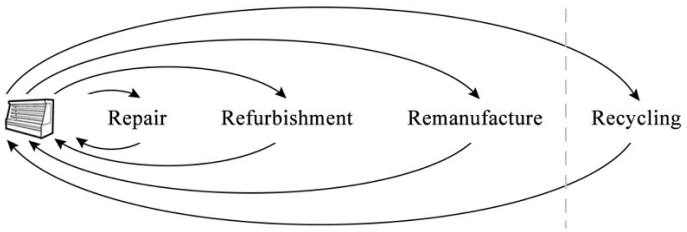

Fig. 1. Refrigerated Display Cabinets (RDCs) and achievable steps of Circular Economy.

RDCs in grocery stores are regularly serviced by specialist refrigeration engineers who undertake regular maintenance. This service usually involves refrigeration system repair, body repair and part refit. In a typical RDCs lifecycle, on average a maximum of 10% of its body is replaced during maintenance. This service has the potential to prolong the life of products and subsequently support the growth of the Circular Economy in the retail refrigeration sector.

On-site refurbishment of Refrigerated Display Cabinets is a cosmetic modification, which is commonly performed due its financial benefits and convenience. It occurs when manufacturers or specialised refurbishment companies are commissioned by retail businesses to recondition their existing refrigeration equipment. Refurbishment of cabinets involves reconditioning between 10% to 50% of their total mass [8] by replacing old or damaged components with new or remanufactured parts (e.g. fan, lighting, shelves, door, panels). The refurbishment usually takes place on premise, normally overnight and during the closing hours to avoid store disruption. As a result, refurbished cabinets can usually stay in use for an additional 5 years. This model is commonly practiced by the industry.

Off-site factory-remanufacture is usually performed on units that are around 10 years old that require cosmetic and technical modifications in order to be brought to a 'good-as-new' condition. It always takes place in an industrial set up and is performed by manufacturers who specialise in remanufacturing. The remanufacturing of Refrigerated Display Cabinets utilises at least 50% of the components sourced from the old cabinets in production of new cabinets [9]. It is assumed that this model is known to the industry, but retailers and manufacturers frequently perceive this process as complex, and choose the 'hassle-free' option of purchasing or producing a new product. As a result remanufacturing is rarely practised and therefore a missed opportunity for businesses in the UK.

Recycling is a process of converting waste into usable materials for manufacture. Typically a material created through recycling consumes less energy than if the material was manufactured from new. Despite this recycling is a very energy-consuming process, as illustrating in the recycling of Refrigerated Display Cabinets, where materials are subject to transportation, shredding, separation and reproduction. For example 70% of cabinets body is made with steel. An average amount of energy required to melt a tonne of scrap steel is 500 kWh [10]. Majority of steel components contained in a cabinet can be reused without melting. Reuse is significantly more environmentally friendly than recycling and it can prevent the environmental impacts, such as greenhouse gas emissions related to energy consumption in the recycling.

Recycling solely focuses on the reproduction of materials contained within products. It doesn't focus on the potential to expand a products lifecycle which is a key element of the Circular Economy. It therefore should be viewed as stepping stone to achieving resource efficiency. Where Refrigerated Display cabinets show limited damage or component parts are still functional, every effort should be made for them to be remanufactured or refurbished. Recycling should be a final resort, only practised on *end-of-life c*abinets, where their reproduction (repair, refurbishment or remanufacture) is not economically viable. This can be due to cabinets showing extensive damage or the majority of components are no longer functioning.

5. Circular Economy practice – industry example

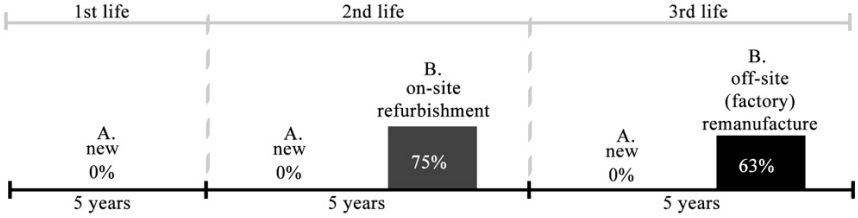

Fig. 2. Proportion of original components typically reused in the reproduction of Refrigerated Display Cabinets (RDCs).

The life-span of single new 1.25m remote open fronted Refrigerated Display Cabinet can be as long as 15 years. Figure 2 illustrates an example of how this is achieved using the processes of refurbishment and remanufacture, and highlights the average resource savings across 3 different lifecycle scenarios where in:

1st life: retailer buys a new cabinet and uses it for a period of 5 years.

2nd life:

A. the retailer disposes the cabinet after 5 years of use and buys a new one.
B. the retailer refurbishes the previously bought cabinet on-site. The refurbishment reuses 75% of the cabinet original components and extends its lifecycle for another 5 years. The remaining 25% of the original components are disposed of and replaced with newly manufactured parts.

3rd life:

A. the retailer purchases a new cabinet to replace the disposed one.
B. the retailer remanufactures the previously bought cabinet off-site, in a factory. The remanufacture reuses 63% of the cabinet's original components and extends its lifecycle for another 5 years. The remaining 37% of the original components are disposed of and replaced with newly manufactured parts. This is uncommon behaviour amongst retailers.

5.1. Results

The weight of components in a 1.25m long remote open fronted Refrigerated Display Cabinet used in this study is 500kg. If this cabinet was refurbished after 5 years, up to 375kg (75%) of the original components could be reused. After 10 years the same cabinet could be remanufactured, resulting in 315kg (63%) of original components being reused. Graph 3 illustrates the proportion of new materials (galvanised steel, stainless steel, glass, polyurethane foam, MDF, copper and aluminium) required in the production of 50 Refrigerated Display Cabinets across 3 different life cycles scenarios, occurring over a 15 year period when a retailer buys:

1. 50 new cabinets every 5 years (in all 3 life-cycles)
2. 50 new (1st life), refurbishes cabinets on-site (2nd life), buys new 50 cabinets again (3rd life)
3. 50 new (1st life), refurbishes cabinets on-site (2nd life), remanufactures all 50 (3rd life)

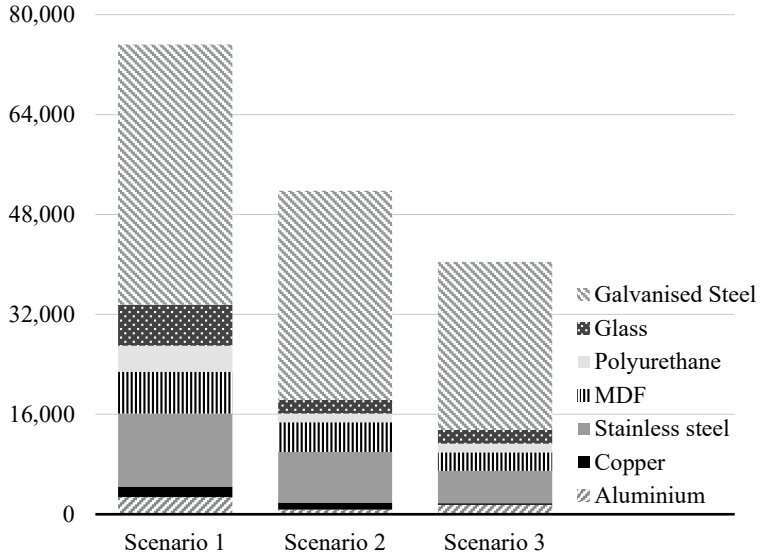

Fig. 3. Weight of new materials required in production of 50 RDCs across 3 different lifecycles.

In scenario 1 over 75 tonnes of material is needed to manufacture 150 new Refrigerated Display Cabinets. This results in 50 tonnes of material entering the waste-stream. Scenario 1 is the least resource efficient. Scenario 3 shows the most resource-efficient lifecycle of cabinets purchase. This is based on the purchase and reproduction of 50 cabinets over the period of 3 lifecycles. Scenario 3 results in a substantial resource saving. It is estimated that almost 35 tonnes of materials, including 27 tonnes of galvanised steel, 5.2 tones of stainless steel and 2.2 tonnes of glass, could be reused over a period of 15 years, preventing them from entering the waste stream.

6. Discussion

There is evidence that pro-circular behaviours are slowly becoming more prevalent in the industry. For example the Corporate Social Responsibility reports of many UK retailers publicise their socio-economic and environmental achievements. These range from investment in local businesses (e.g. farmers), waste prevention (e.g. food, carrier bags) and sustainable operations (e.g. water efficiency). This suggests that goals regarding the resource-efficiency of refrigeration equipment could soon be on the agenda for many retailers in the industry.

A conduct of a behaviour is usually driven by an intention, however this can also depend on the ability to perform it. To encourage the P-CBs amongst retailers, business models such as refurbishment and remanufacture of Refrigerated Display Cabinets, need to be widely adopted. As it is based on principle of supply and demand, it is unlikely that manufacturers will make these services available, should retailers continue to demonstrate anti-

circular behaviours. This indicates that the development of the Circular Economy in the retail refrigeration sector requires inputs from both, producer and consumer.

7. Conclusions

The environmental benefits of the P-CBs emphasise the need for development of a Circular Economy in the UK retail refrigeration industry. This will require a wider adoption of alternative business models. Despite the technical capabilities to comply with these models, industry continues to decline refurbishment and remanufacture of Refrigerated Display Cabinets. The implementation of these models relies on collaboration between manufacturers and purchasers of retail refrigeration equipment.

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