

# New strategies for the refrigerator in the transition towards a circular economy

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## New strategies for the refrigerator in the transition towards a circular economy

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#### Towards a circular economy

In the last decades, the values of the traditional economy have been strongly challenged, considering the concept of development of the last century as the main cause of many environmental issues that we are facing today.



#### Towards a circular economy

New strategies have been introduced to provide a renewed concept of development, including the creation new business models in the context of circular economy, a greater importance of intangible value, the merging of products and services (de Arruda Torresa, 2017)



#### **Circular economy stragegies**

#### Circular economy strategies:

- Refuse
- Rethink
- Reduce
- Re-use
- Repair
- Refurbish
- Remanufacture
- Repurpose
- Recycle
- Recover

Source: RLI edited byPBL

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Smarter product use and manufacture	Ro	Refuse	Make product redundant by abandoning its function or by offering the same function with a radically different product	Innovations
	Rı	Rethink	Make product use more intensive (e.g. through sharing products, or by putting multi-functional products on the market)	in core technology
	R2	Reduce	Increase efficiency in product manufacture or use by consuming fewer natural resources and materials	Innovations in product design
	R3	Re-use	Re-use by another consumer of discarded product which is still in good condition and fulfils its original function	Innovations in revenue model
	R4	Repair	Repair and maintenance of defective product so it can be used with its original function	Socio- institutiona
Extend lifespan of product and its parts	R5	Refurbish	Restore an old product and bring it up to date	change
	R6	Remanu- facture	Use parts of discarded product in a new product with the same function	
	R7	Repurpose	Use discarded product or its parts in a new product with a different function	
Useful application of materials	R8	Recycle	Process materials to obtain the same (high grade) or lower (low grade) quality	
	R9	Recover	Incineration of materials with energy recovery	hbi.nl

**Circular economy combined** with other strategies

"What happens when we try to combine circular economy strategies with IoT data?"



#### The role of the IoT in design

IoT is growing importance also in the design field. As **design research by definition is intended to produce knowledge**, this knowledge can be acquired by merging different methods, e.g. qualitative and quantitative. The data collected and made available from IoT technologies quantifies aspects that were not measurable before.



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## Which product?

## The **refrigerator** is related to:

- food waste
- household energy consumption
- social implication, including the diffusion of supermarkets (h24) which modify eating habits
- impact of the materials used (mitigated by a long useful life - 14 years)



## Which product?

The **usage phase** impact more in products such as the refrigerator, which is characterised by a long lifespan and a continuous use (400-1100 KWh/y according to the related energy class).



## Which product?



### **Research questions**

"How can smart features of products/systems make refrigerators more circular/ sustainable?"

What circular strategy can we investigate?

#### **Circular economy stragegies**



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476 kilotons of household appliances (23 million units) were disposed of annually in the UK (Cooper and Mayers, 2000). With the human need for such appliances growing day by day, the natural resources needed to make them are shrinking (Wilson, 2016).

Material	Mt	Percentage
Aluminium	0,02	3,3
Copper	0,01	2,2
Glass	0,01	1,3
Plastics	0,08	15,5
Polyurethane foam	0,01	1,5
Steel	0,34	63,4
Other	0,01	1,2
Material to Energy Recovery	0,06	11,7

'Material Flows of the Home Appliance Industry' (Megalini et al., 2018) focus on the refrigerator Replacing and (eventually) disposing of products creates an environmental burden because it produces waste and uses up **scarce resources** to produce new consumer durables (Mugge et al., 2005). Proper recycling of refrigerators can allow to reuse metals, help **preserving this limited supply of materials**, as well as to help reduce the enormous amount of metal volume that enters landfills every year (Wilson, 2016).

Top: Compressor collection Source: Source Riaz and Sons

Bottom: recovery of appliances source: FEMA Photo Library Greg Henshall FEMA







Rethink the use of the components involved: 1) design the recovery of parts and materials through a complete disassembly 3) database of materials for recycling purposes 2) find more sustainable materials for performing tasks (eg. refrigerant)

#### **Rethink-refuse**



Refuse ownership in favor of other revenue strategies - sharing economy

- pay per use

are just two examples

#### Usage strategies



More than "repair"

- interact with the user (advice, provide aggregate data for users, visualization)
- facilitate predictive maintenance
- facilitate the upgrading, the replacement of parts, the improvement of the product
- allow the product to adapt to changed conditions (environmental, use, social)
- learn from user usage/ behaviour

#### **Before EoL strategies**



15.1% of cold appliances discarded were donated for free to family or friends, 0.8% were donated to charity and a further 6% were sold on (second hand shops, dealers) (Haines et al., 2010). Consumers prefer to think their product being reused rather than abandoned in landfills.

#### **Before EoL strategies**



- intercept the product to the suitable time in which it can be fully exploited, before it reaches its end of life
- avoid product disassembly by preserving its integrity
- monitor a test
  object to establish
  when the right time
  has come.

#### **Rethink - EoL strategies**



Reuse the whole product or part of it 1) for second use/ other targets (replacement of part, recondition, ...) 2) reuse parts of product as components for completely new products 3) design alternative lives

#### Usage strategies



Usage stategies are the most underestimated, to the point that there are no official circular strategies to satisfy this part of the chain

# Collecting data with instrumented products



#### **Field research: instrument a product**



Prototype: shield with sensors



Prototype: shield, smart plug and power supply

#### Field research: instrument a product

Instrumenting current refrigerators with **sensors** to detect **inside temperature**, humidity and noise, external coil heat dispersion.



#### Field research: instrument a product

We assume the **power consumption** as a reflection of the **refrigerator's activity** and the **light** as a reflection of **user interaction**. They are two standalone systems able to affect several other variables.



#### **Field research: Results**



NL - In Noise and Power Consumption











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#### **Field research: Results**















Remarks

From an in-depth analysis of data broader conclusions can be drawn, as well as reflections highlighting how the **situated knowledge** gained from the product can be leveraged in the design stage towards a circular economy

#### Remarks

#### **Discover patterns**

Possible implications arising from the user behaviour. Define **consumption patterns** that could be used to make specic changes in the refrigerator operation, such as affecting cooling cycles according to user routines. **Redesign processes** that may exploit user activity to enable product corrective actions.

#### **Predictive maintenance and alert** With the aid of **IoT learning system**, a future refrigerator should alert the user when they experience energy **anomalies**, preventing cooling **failure**, annoying noise and water leaking, up to prevent fridge failures by monitoring several parameters of the fridge itself.

#### Remarks

Adaptation and evolution the product should adapt and evolve with user changes, rather than forcing him to change. Build learning systems able to evolve and change with the user

#### Fluidity of design

Software updates are just an example of a product that evolves over time, changing and adapting to technological changes. We should start design products as systems, imaging components and functions that can be integrated, including modifying the starting object to respond to user needs. What if the product would change its behaviour according to contextual factors, usage information and the habits of those who use it? **Smart enabling technologies** could help us to do that.

#### A data-management platform

We need **more flexible tools** able to keep all the pieces of the holistic diagnosis at hand, **managing the information**, validating, testing allowing running changes, thus providing the **fluidity needed**.





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