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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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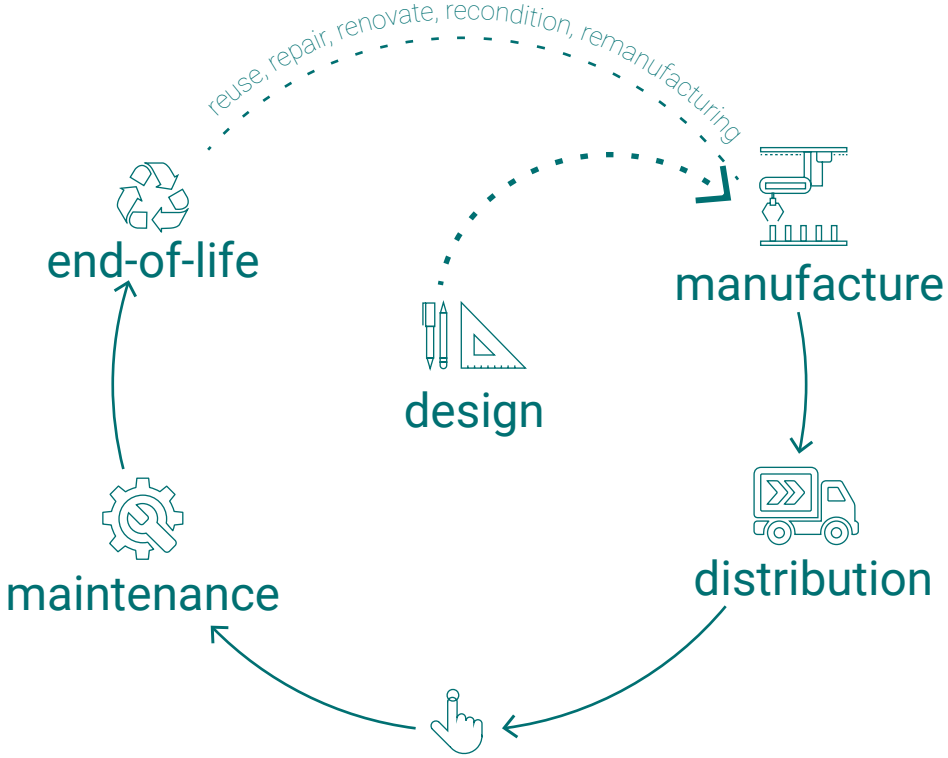
Towards a circular economy

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

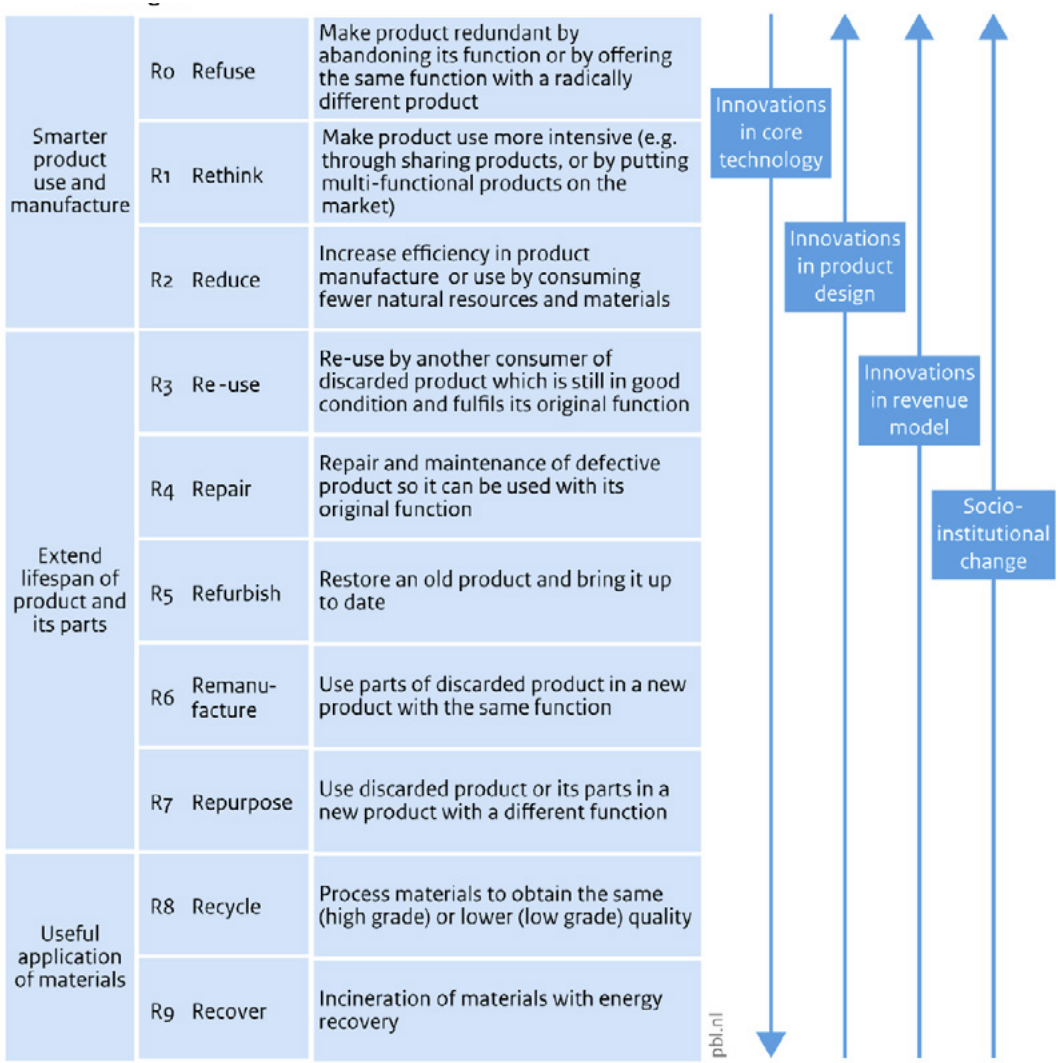
New strategies have been introduced to provide a renewed concept of development, including the creation new business models in the context of circular economy, a greater importance of intangible value, the merging of products and services *(de Arruda Torresa, 2017)*



Circular economy stragegies

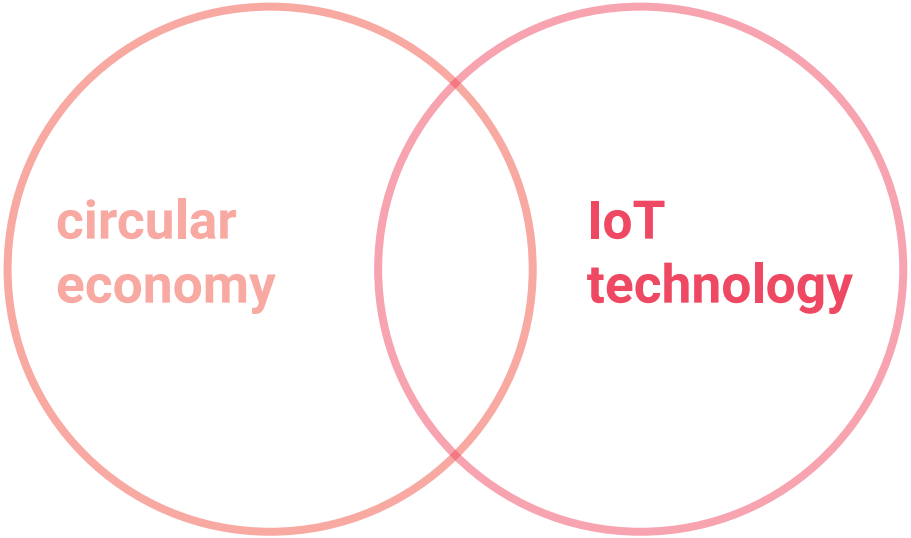
Circular economy strategies:
- Refuse
- Rethink
- Reduce
- Re-use
- Repair
- Refurbish
- Remanufacture
- Repurpose
- Recycle
- Recover

Source: RLI edited byPBL



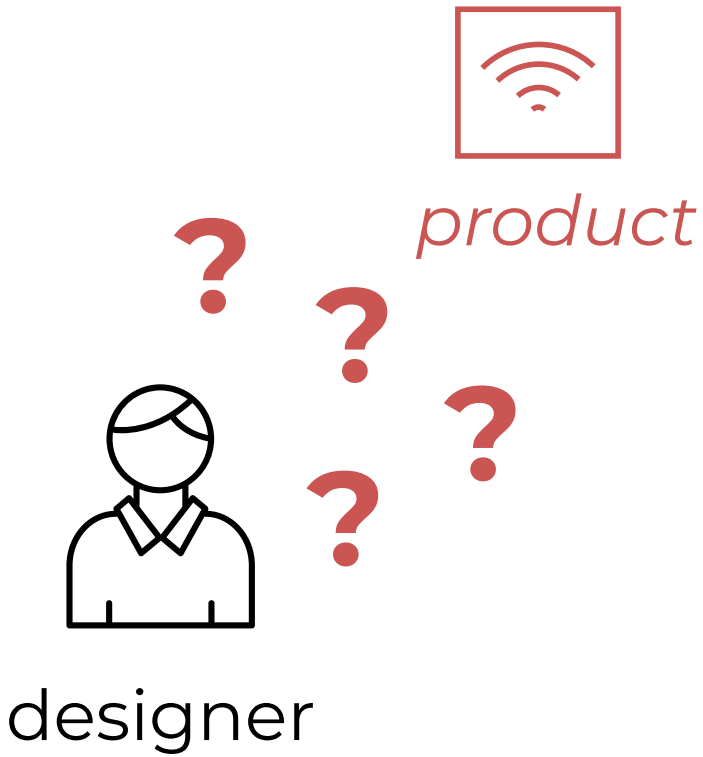
Circular economy combined with other strategies

"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.



Which product?

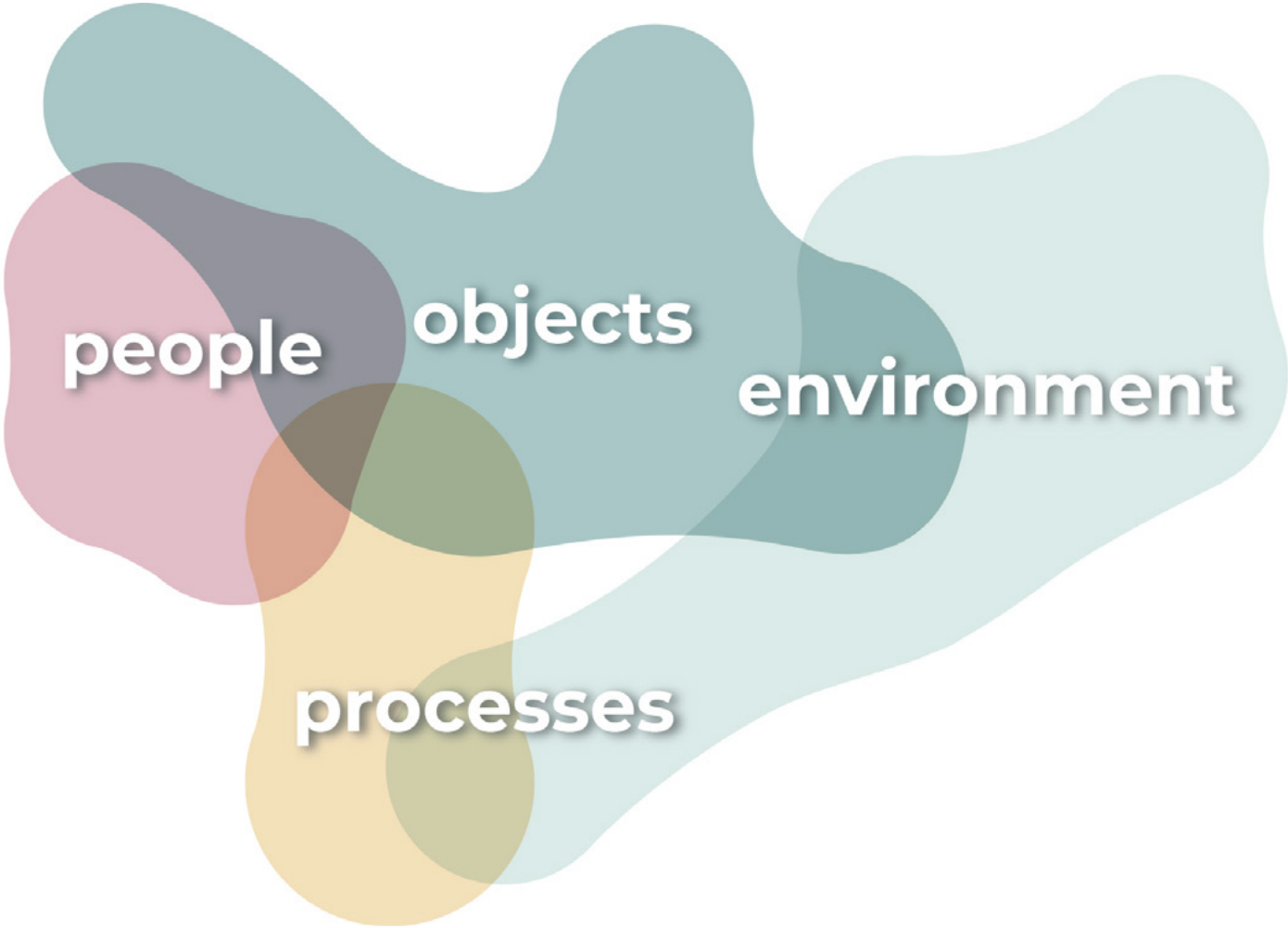
The **refrigerator** is related to:

- 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?

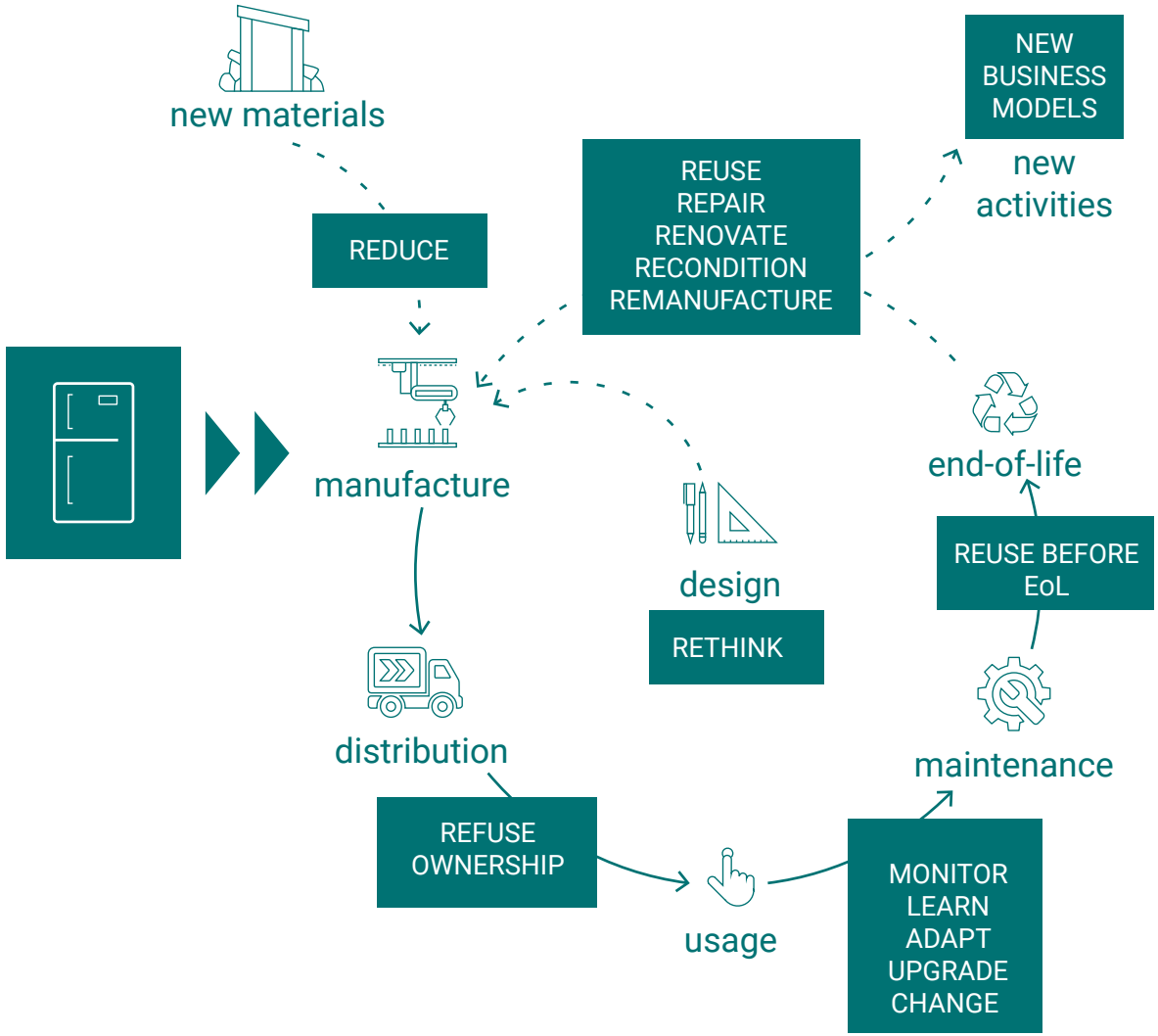


Research questions

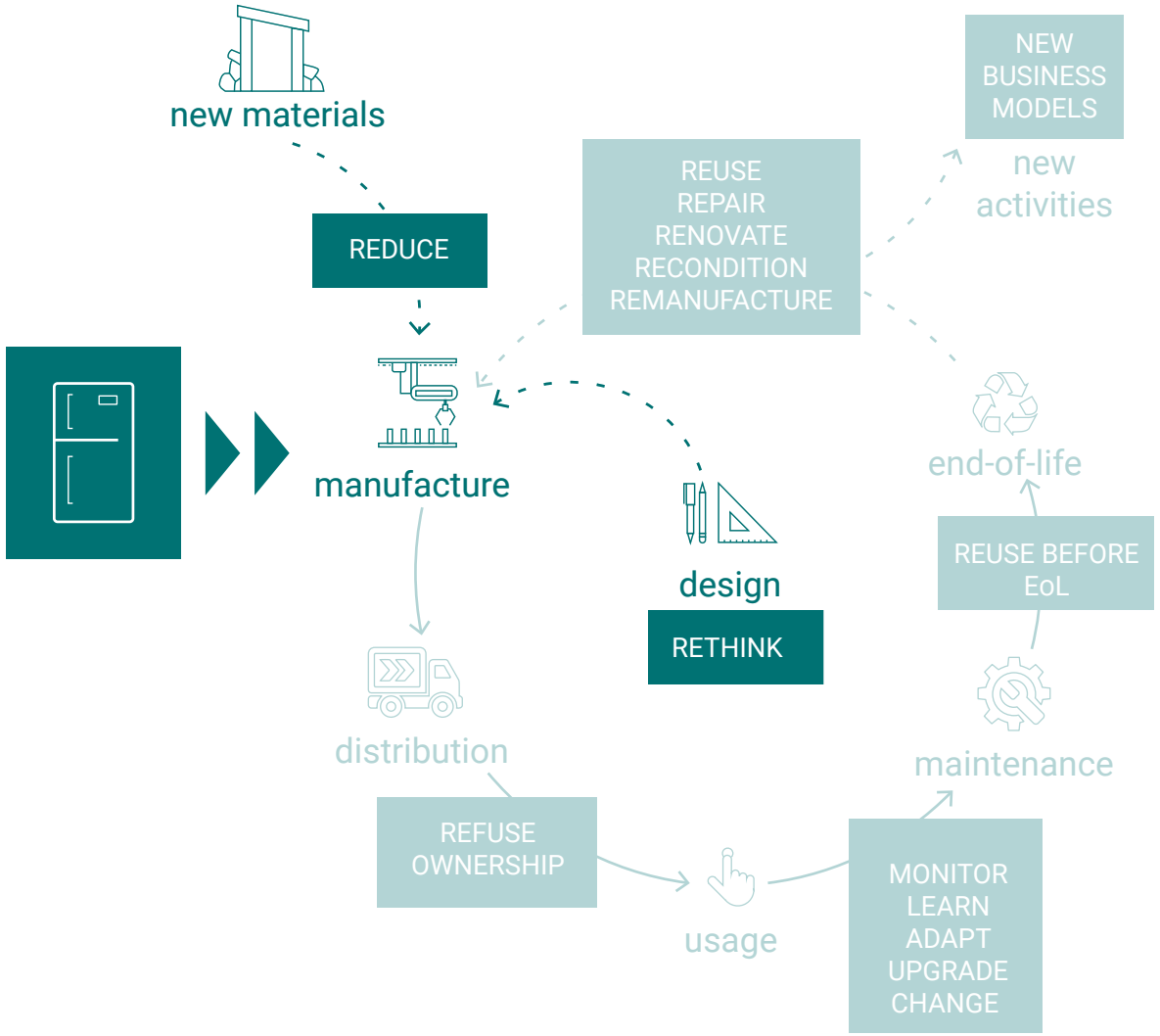
"How can smart features of products/systems make refrigerators more circular/ sustainable?"

"What circular strategy can we investigate?"

Circular economy stragegies



Rethink-reduce



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).

Rethink-reduce

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

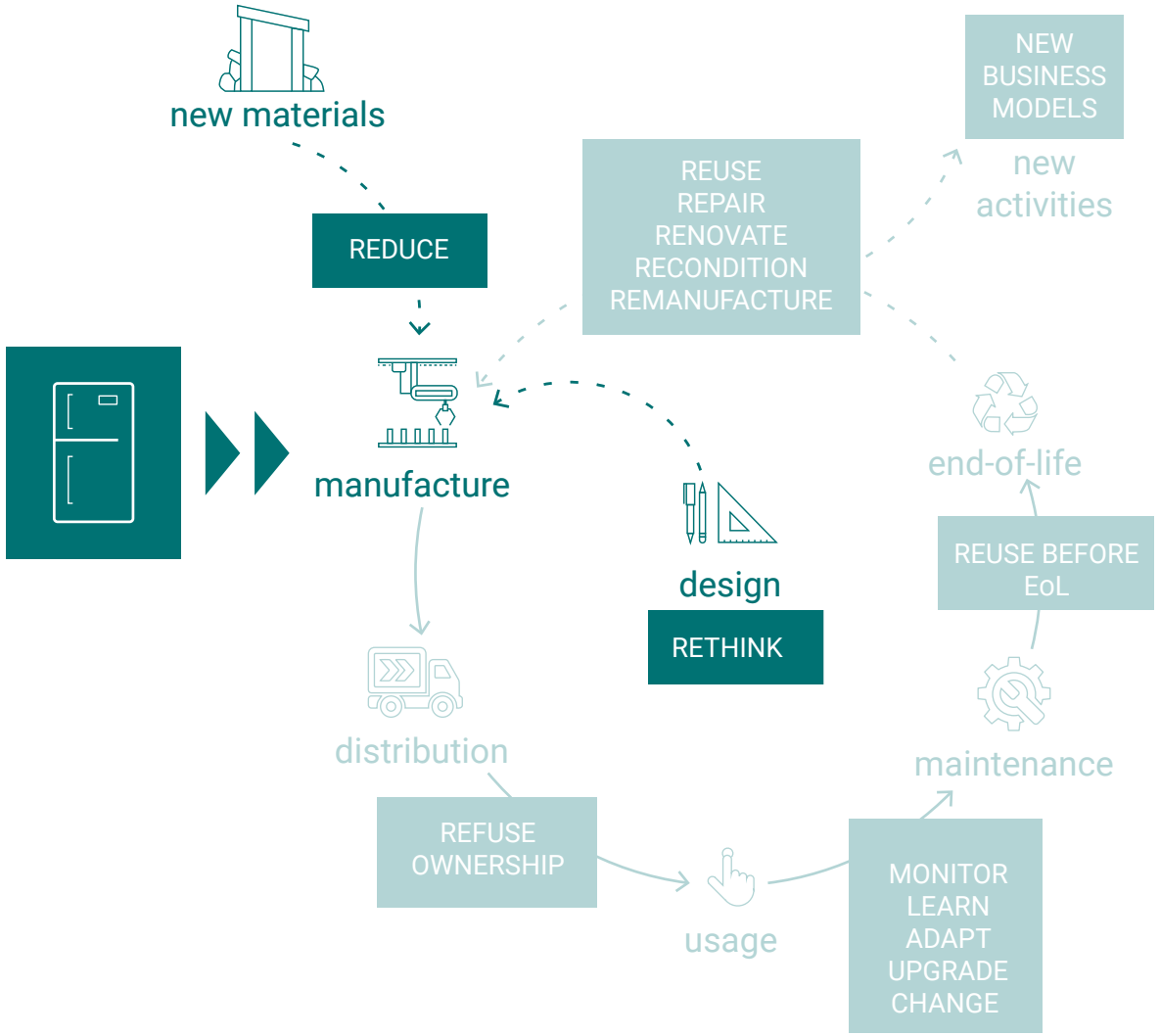
Replacing and (eventually) disposing of products creates an environmental burden because it produces waste and uses up **scarce resources** to produce new consumer durables (Mugge et al., 2005). Proper recycling of refrigerators can allow to reuse metals, help **preserving this limited supply of materials**,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

Rethink-reduce

Top: Compressor collection
Source: Source Riaz and Sons

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

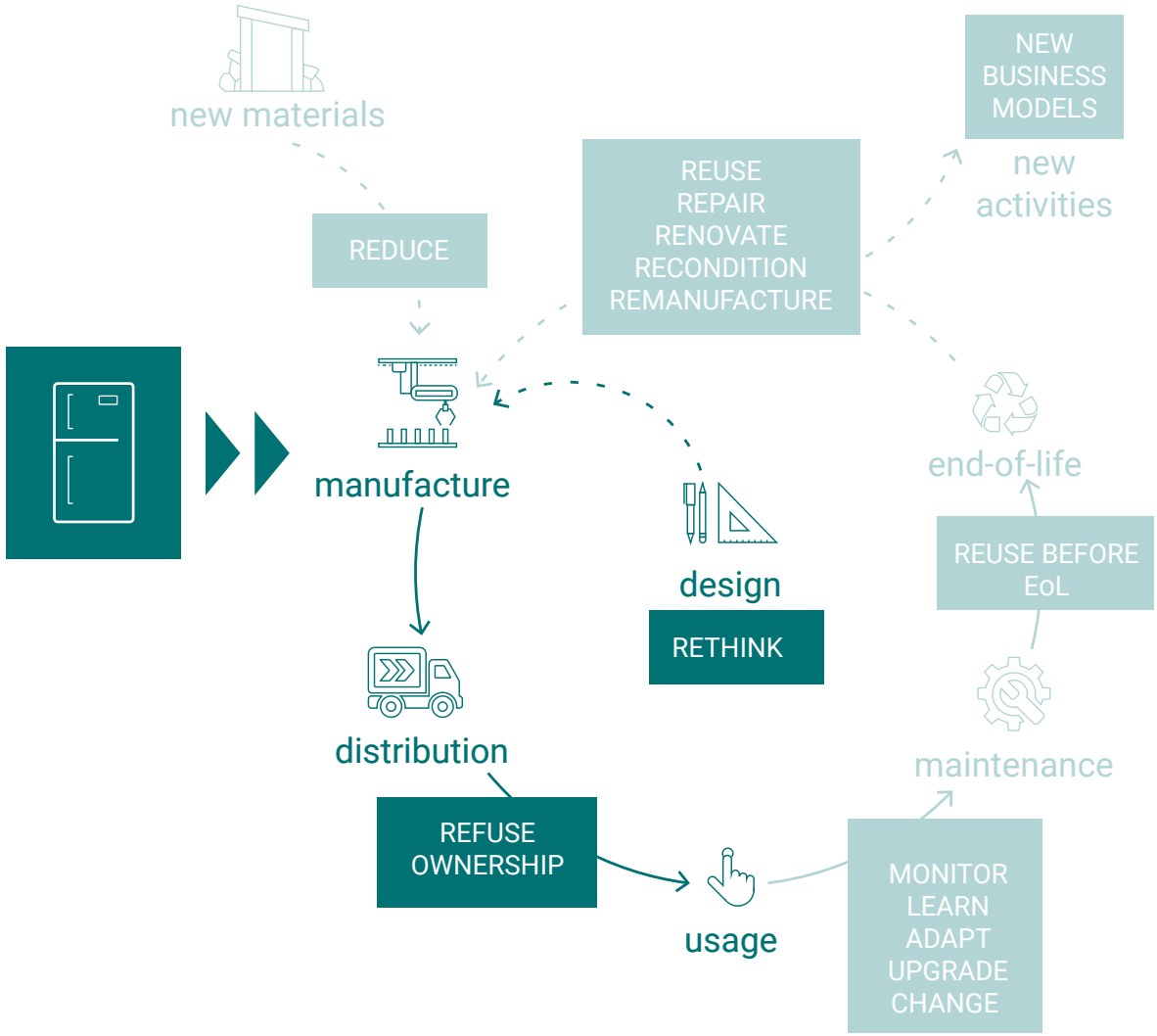
Rethink-reduce



Rethink the use of the components involved:

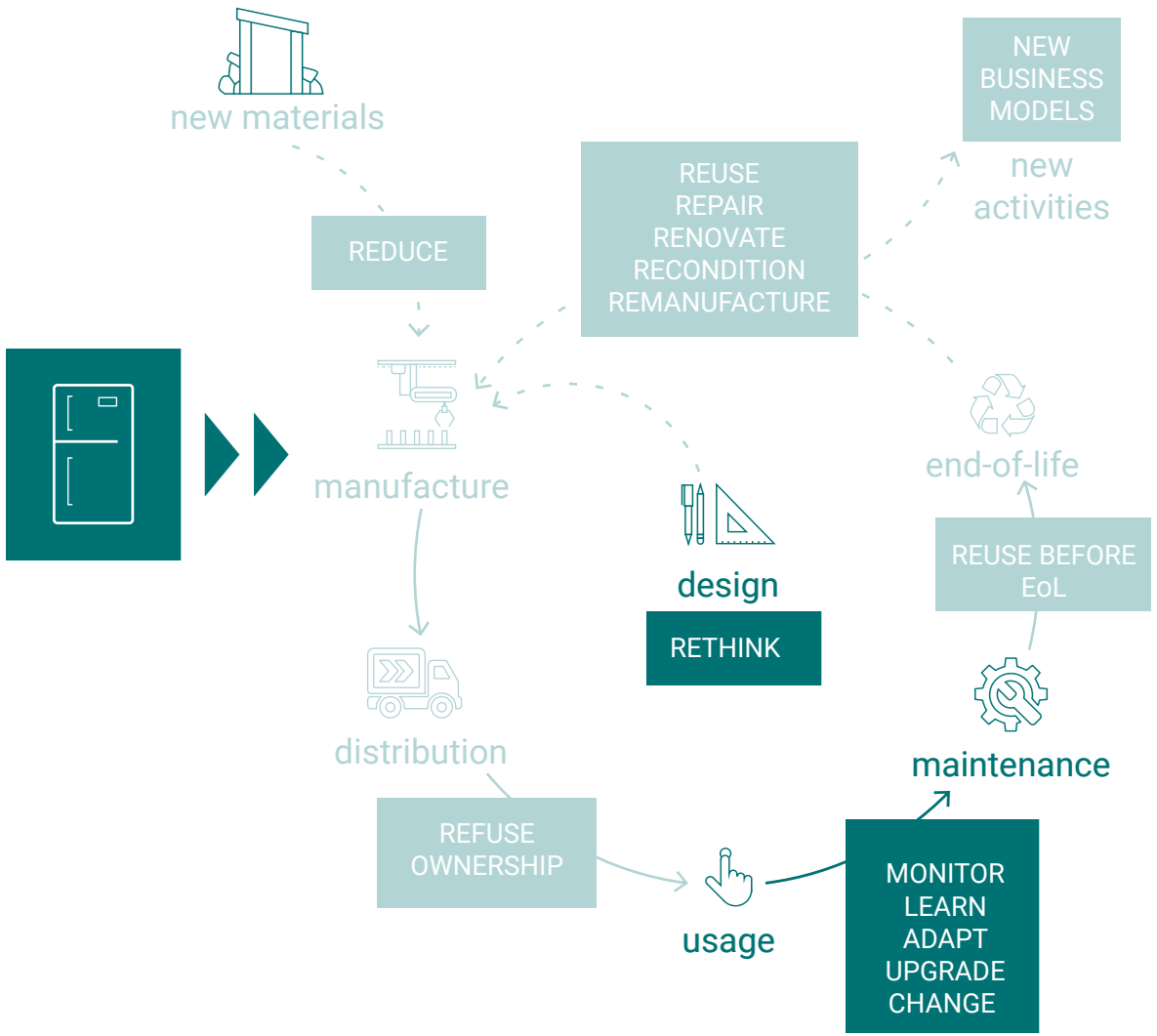
1) design the recovery of parts and materials through a complete disassembly
3) database of materials for recycling purposes
2) find more sustainable materials for performing tasks (eg. refrigerant)

Rethink-refuse



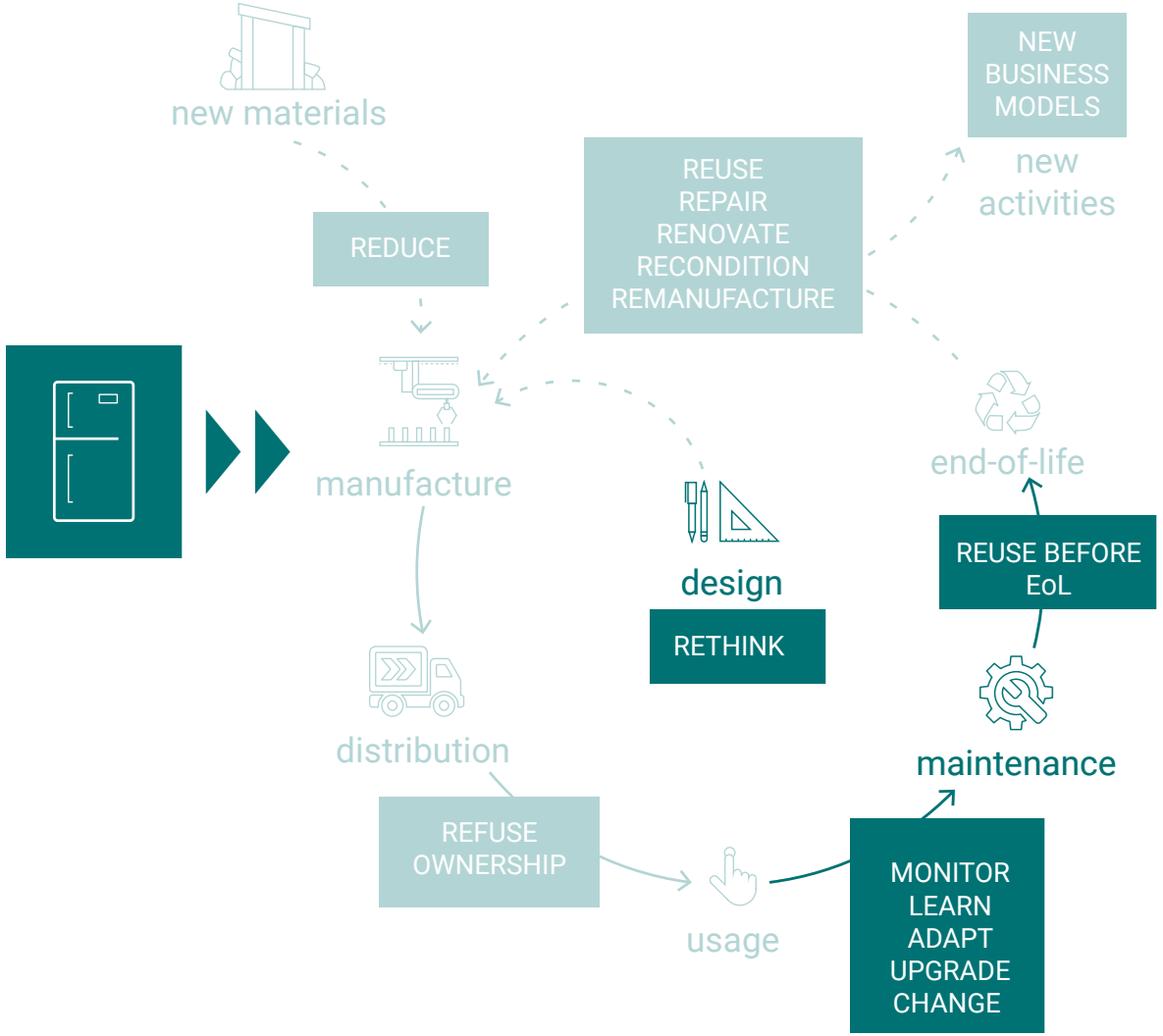
Refuse ownership
in favor of other
revenue strategies
- sharing economy
- pay per use
are just two examples

Usage strategies



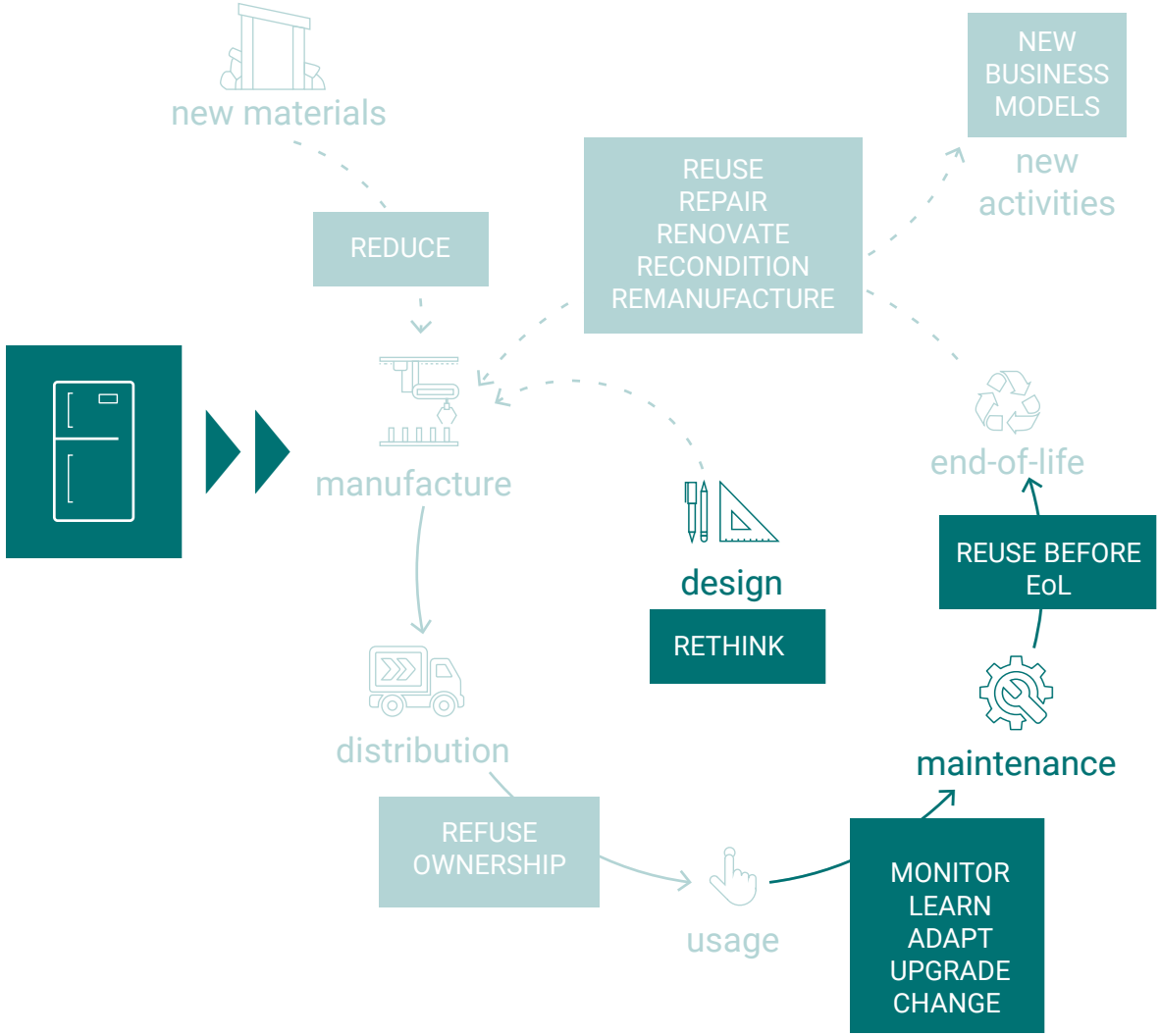
More than “repair”
- interact with the user (advice, provide aggregate data for users, visualization)
- facilitate predictive maintenance
- facilitate the upgrading, the replacement of parts, the improvement of the product
- allow the product to adapt to changed conditions (environmental, use, social)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

Before EoL strategies



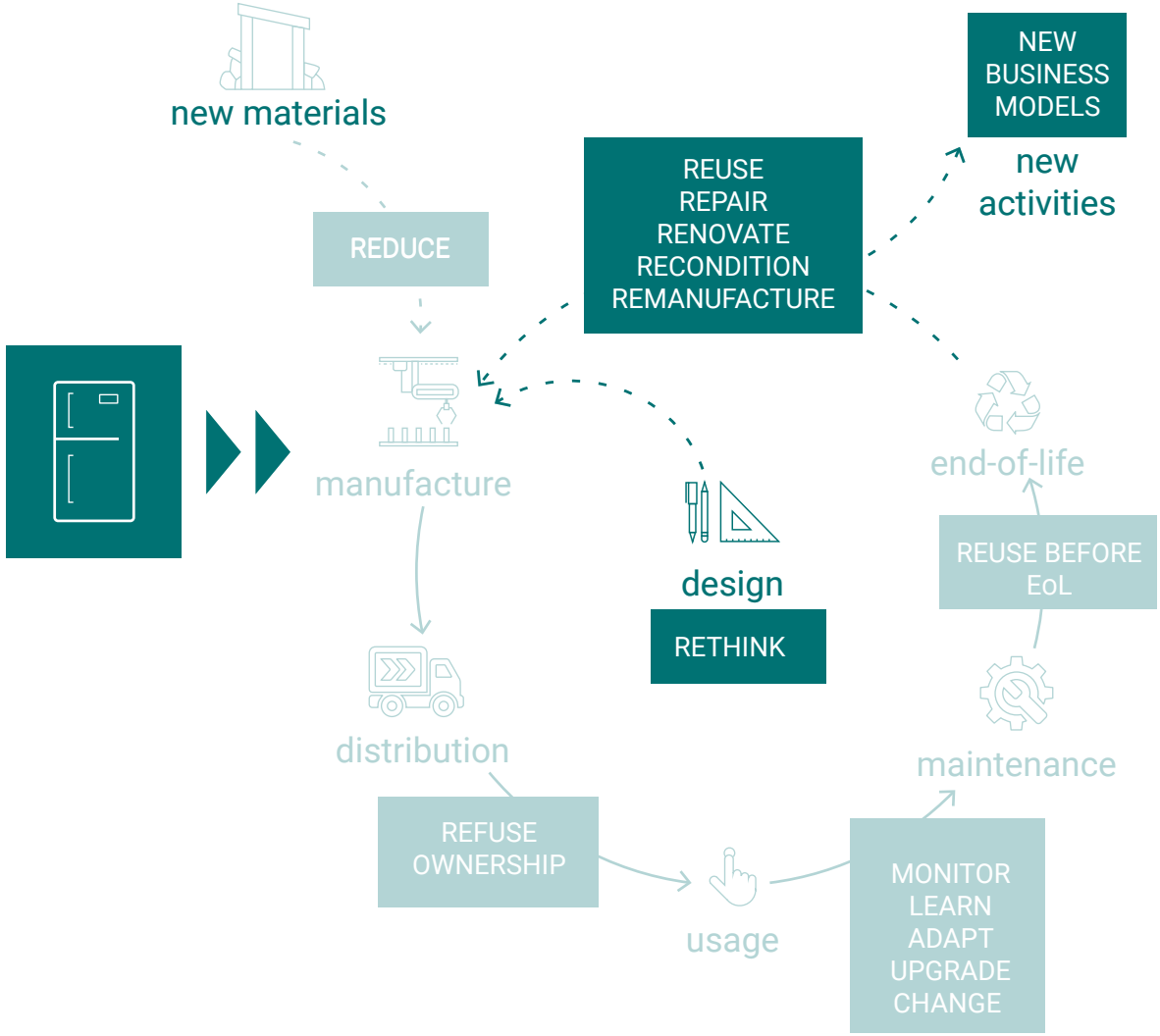
15.1% of cold appliances discarded were donated for free to family or friends, 0.8% were donated to charity and a further 6% were sold on (second hand shops, dealers) (Haines et al., 2010).
Consumers prefer to think their product being reused rather than abandoned in landfills.

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.

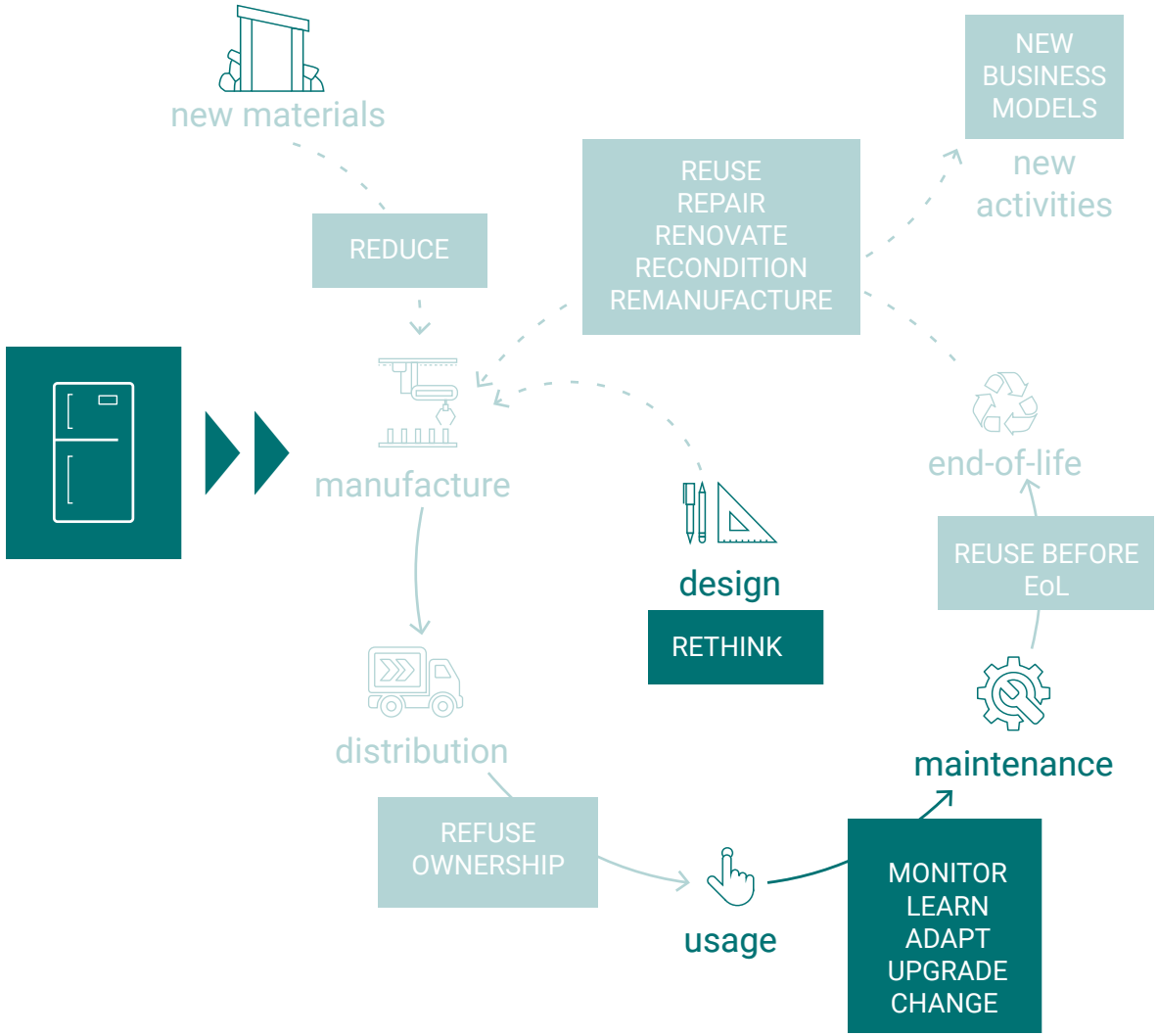
Rethink - EoL strategies



Reuse the whole product or part of it

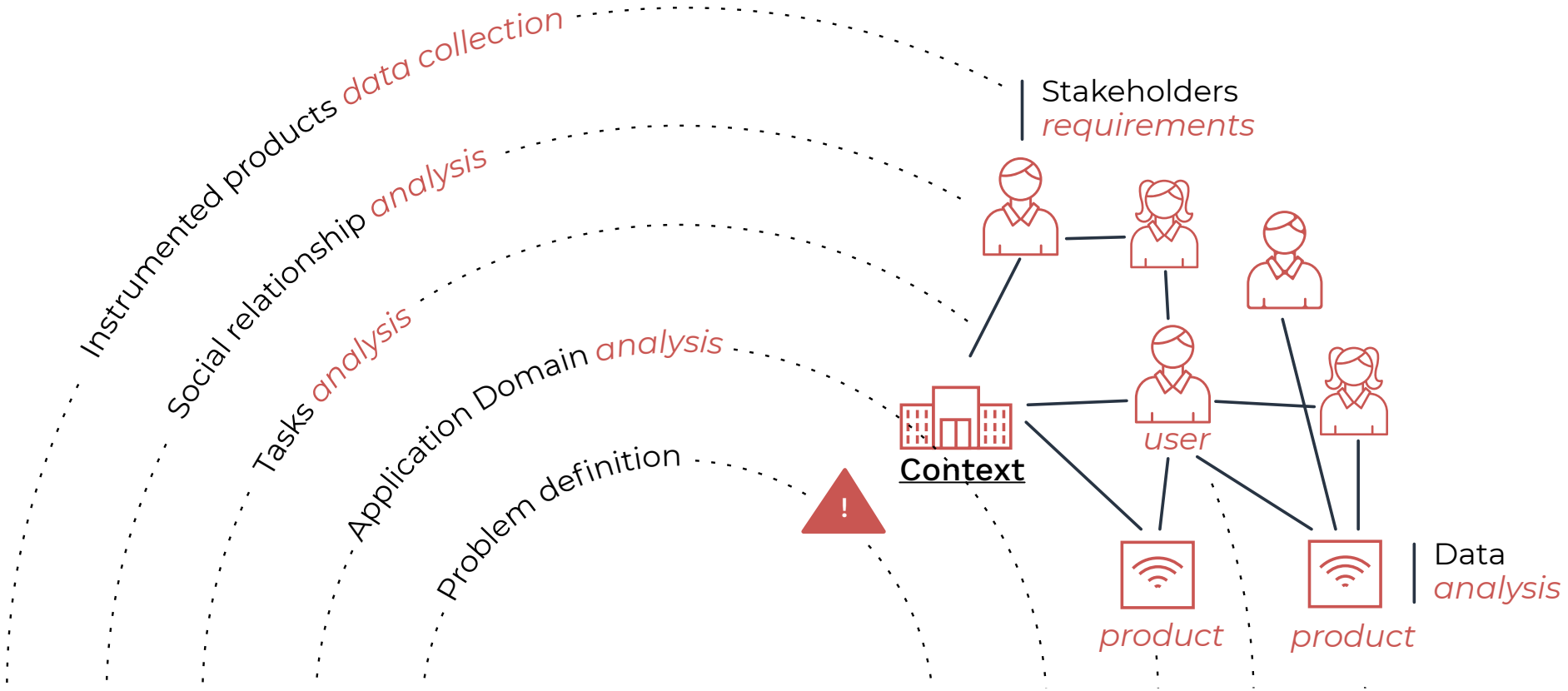
1) for second use/ other targets (replacement of part, recondition, ...)
2) reuse parts of product as components for completely new products
3) design alternative lives

Usage strategies

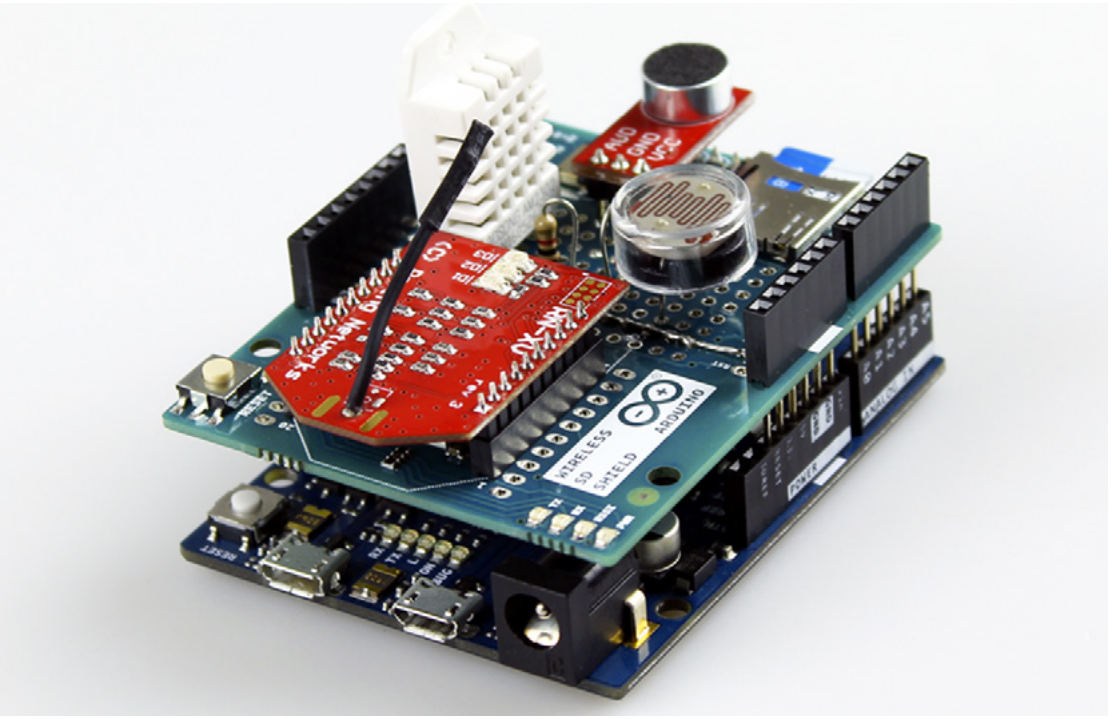


Usage stategies are the most underestimated, to the point that there are no official circular strategies to satisfy this part of the chain

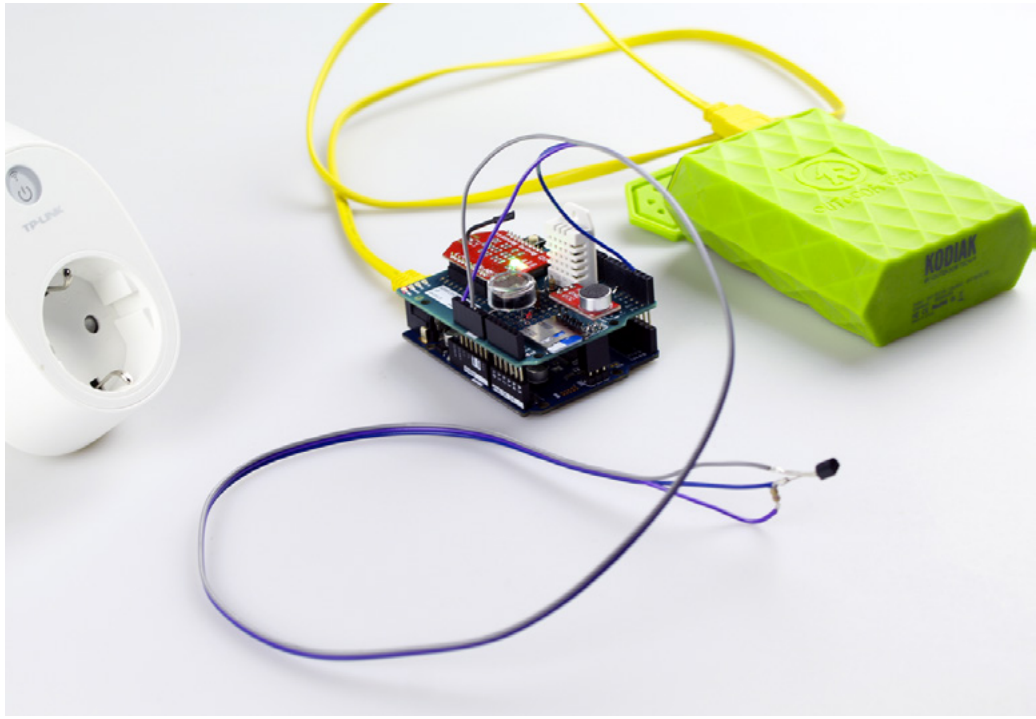
Collecting data with instrumented products



Field research: instrument a product



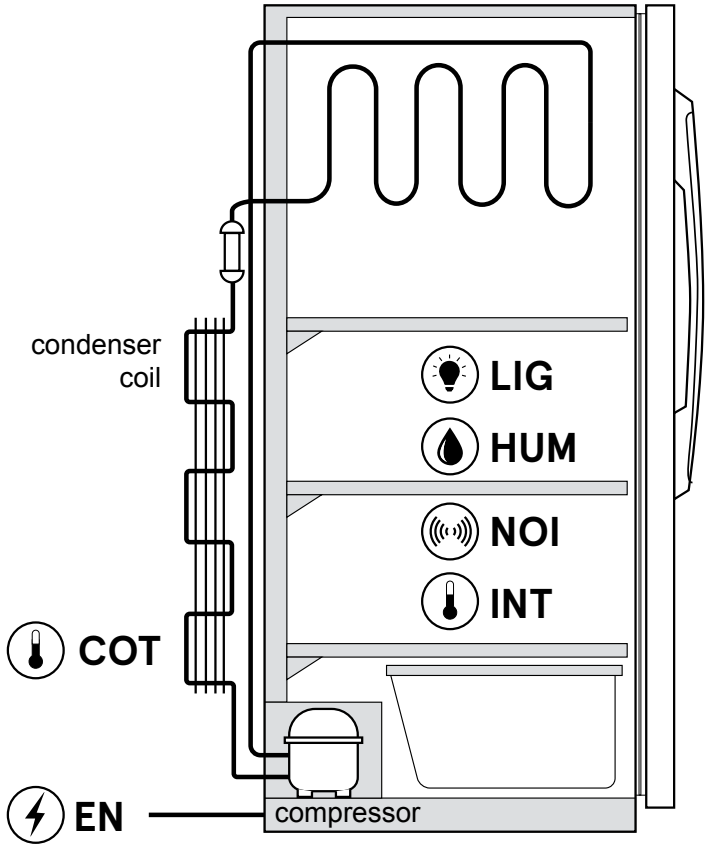
Prototype: shield with sensors



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.



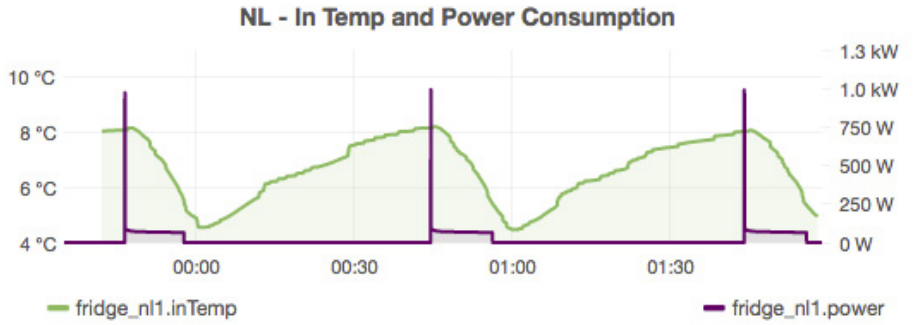
Field research: instrument a product

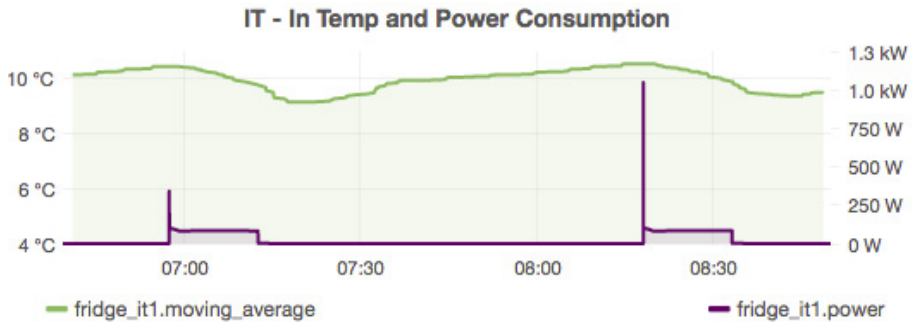
We assume the **power consumption** as a reflection of the **refrigerator's activity** and the **light** as a reflection of **user interaction**. They are two standalone systems able to affect several other variables.

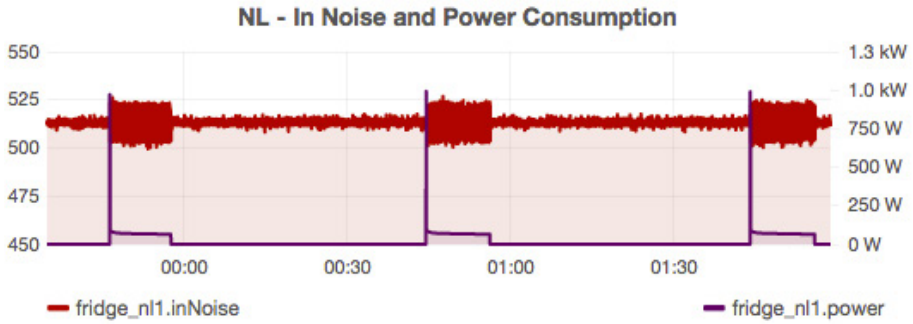
refrigerator's activity

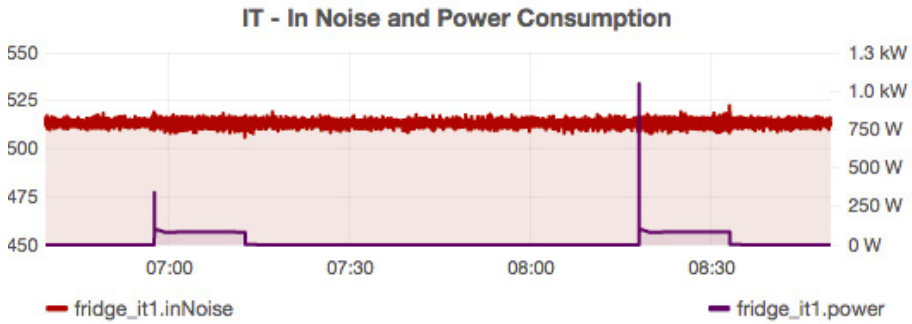
user interaction

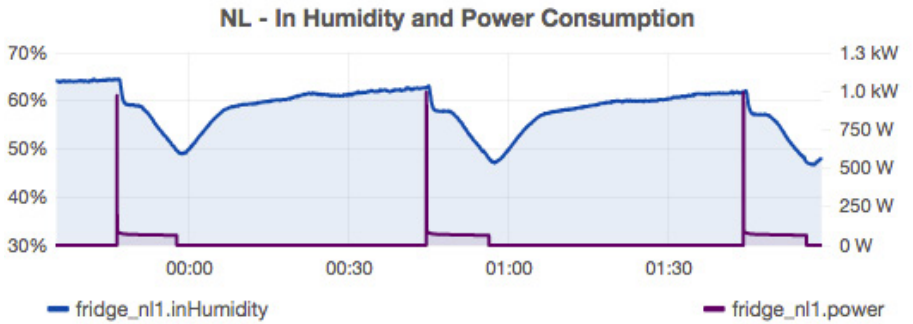
Field research: Results

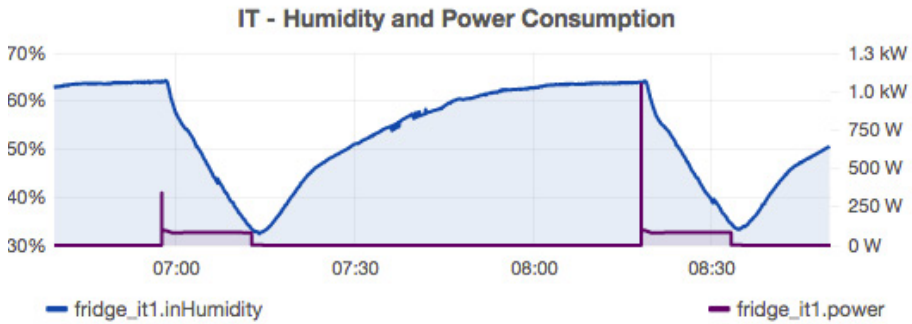




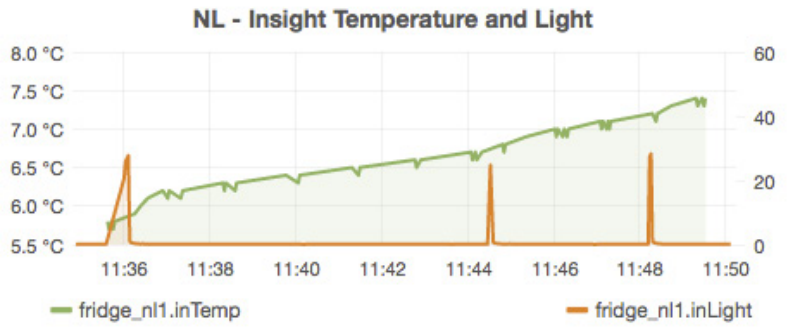


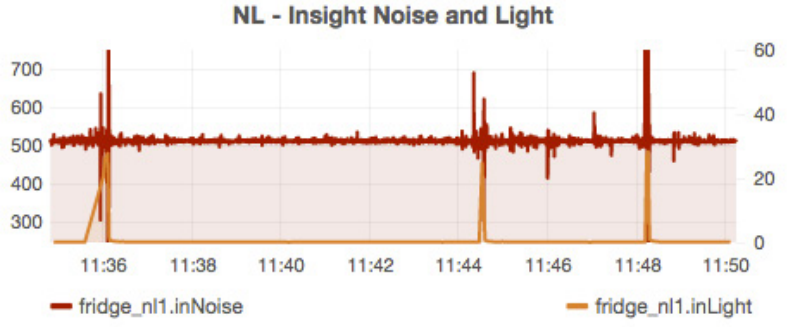


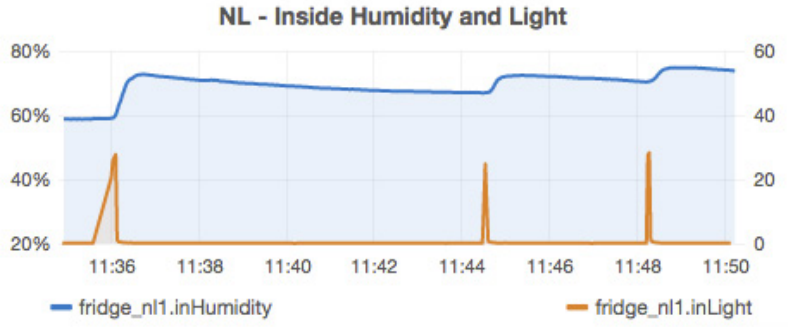


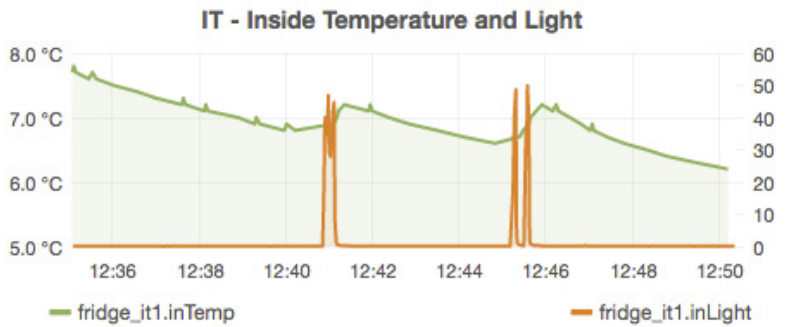


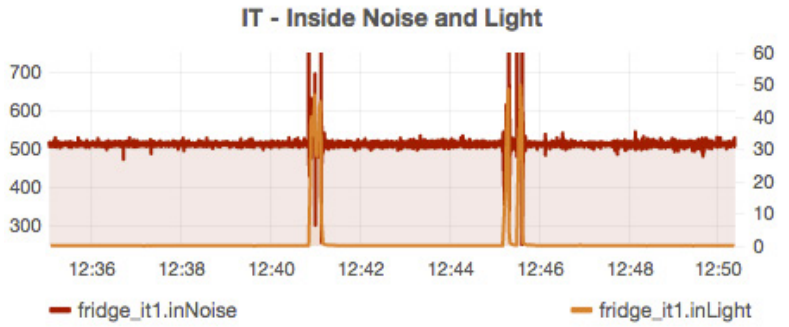
Field research: Results

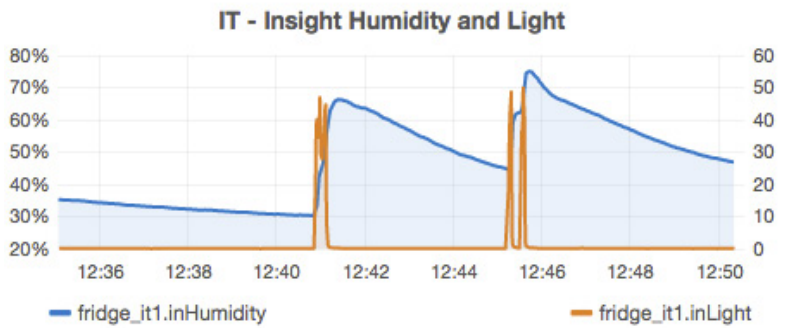












Remarks

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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