



Office for Product  
Safety & Standards

# 2050: Fridge of the Future

## Innovation, environment, safety

September 2021



Office for Product  
Safety & Standards



**AMDEA**  
The Association of Manufacturers  
of Domestic Appliances

**LFB**  
LONDON FIRE BRIGADE

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#### Office for Product Safety and Standards

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#### Organised by



Office for Product  
Safety & Standards



**AMDEA**

The Association of Manufacturers  
of Domestic Appliances



## Executive summary

The purpose of the event was to bring together a “fridge of the future community”, covering all Large Domestic Appliances LDAs, to promote thought leadership on the fridges and appliances of the future in order to improve the safety and environmental impact of domestic appliances and reduce barriers to innovation.

A conference – **2050: Fridge of the Future** – attended in-person and online, exploring this subject was hosted at City, University of London on 16 September in partnership with the Office for Product Safety and Standards (OPSS), the Association of Manufacturers of Domestic Appliances (AMDEA) and London Fire Brigade (LFB). It was divided

into three themes: Innovation, The Road to Net Zero (Sustainability) and Safety. This was the first event of its kind in the UK.

Expert panels and audience Q&A debated key themes around LDAs, including: Smart features and using a smart energy network; how lifestyle changes will change appliance design and function, to better suit the needs of a wider demographic; the recyclability of white goods now and in the future; how new materials will affect how we manufacture cookers, fridges and appliances; why LDAs should adopt specific standards and regulations and how standards are collaborative and need user input.

### “2050: Fridge of the Future” covered these key points:

- The challenge: How can industry design and make LDAs that do what consumers need them to do, be energy efficient, intelligent & work with the energy system and integrated into a “smart home”, are as safe as possible, and on retirement can feed back into a circular economy with maximum recyclability?
- LDAs are carbon intensive to both manufacture and dispose of. The volume of material in LDAs that are currently effectively recycled into useable second generation material is comparatively low, about 35% according to Bressanelli et al<sup>1</sup>. Recycling and reuse of used LDAs is improving but experts say products should be designed for repair and recycling, not disposal. The energy efficiency of LDAs is rising, but manufacturers must improve the carbon footprint of the machine across its whole life cycle.
- Smart features can improve energy and water efficiency, usage, maximise lifespan, reduce food waste, improve usage for younger and older demographics, work with a smart energy system to draw power at the optimum times and save consumers money.
- Can the domestic energy system be modified from a gas boiler-based heating system to one using heat pumps that work like a reverse refrigerator? What are the benefits, challenges and costs of moving from gas to a heat pump system?
- Safety: LDAs are sometimes recalled and have caused fires, some catastrophic. How can innovation be harnessed to design in enhanced safety features?
- Consumer behaviour: many smart appliances can do many of the things this report outlines or will do in the near future. But often consumers do not connect their appliances to use smart features; research estimates that between 25%-44% of users do not connect smart features<sup>23</sup>. Consumers are missing a lot of efficiency and safety value-added features by not connecting them.
- Product registration is typically low which can affect the efficiency of product recalls. Research shows that 53% of people register LDAs and 30% register products more generally<sup>4</sup>.
- Usage models including purchase vs. lease vs. shared ownership and communal refrigeration.
- Standards in the LDA industry. Participation and creating new standards and why.
- Data: As consumers increase interaction with manufacturers, more of their usage data is shared. Privacy can be compromised. But using artificial intelligence, consumer behaviour is analysed to make smarter, more efficient product systems.
- Inclusive design: it is more important now to design LDAs for all demographics including people with health conditions and impairments.

“Ten percent of the world’s electrical energy is used for cooling.”



**Professor Rajkumar Roy**  
Executive Dean, City, University of London

Professor Roy set the scene and highlighted several areas to develop moving forward, including:

- Evolve future technology and standards together.
- Efficiency and emission from transport, manufacturing and end of life need to be further improved to meet the net-zero target.
- Regulations could drive better through-life performance of appliances.

## Opening address

“We can’t trade off people’s safety against environmental protection. We must do them all. It’s about proper management of risk and communication.”



**Graham Russell**  
CEO, Office for Product Safety and Standards,  
The Department for Business, Environment and Industrial Strategy (BEIS)

### There are three main reasons for the OPSS to be involved in this event:

#### 1. Importance of collaboration.

Effective regulation is achieved through effective partnerships between the state, business, and citizens. Here we have brought together industry, manufacturers, regulators, researchers, engineers, policymakers, consumer organisations and academic experts to guide our thinking and our approach.

#### 2. Regulation is not an end in itself. It is a means to an end.

Regulation exists to protect people and places, to enable responsible businesses to thrive, and to meet the needs of citizens. Product regulation keeps people safe, maintains confidence, supports fair markets, and has a real part to play in the journey to net zero and in reducing carbon impact on the planet.

#### 3. We must regulate for the future.

Regulations are often formed around the events of the past and this can hamper our ability to adapt to changing technologies and circumstances and can leave us with regulation that doesn’t work well or that holds back progress.

Forward looking regulation can be difficult because the future is uncertain. We are aiming to regulate to enable change and innovation whilst keeping the protection of citizens at the heart of product regulation.

The conference is available to watch on YouTube, split into four videos [here](#)

# The current state of Large Domestic Appliance product development and consumer usage

## Key drivers for Large Domestic Appliances

Taken from **Fridge 2050** report, by Dr. Sam Brookes and Professor Rajkumar Roy, Executive Dean, City, University of London.

### Society



#### 1. Greater connectivity

In recent years, many new appliances have been introduced which can be connected to and controlled from our phones. More recent trends are for appliances that actively make decisions and learn using AI (artificial intelligence) and machine learning. This trend will continue and consumer demand will increase as these appliances become more affordable and develop more useful functionality. Household penetration is expected to increase from 9.1% in 2021 to 22.7% in 2025, according to Statista<sup>5</sup>.



#### 2. Ageing population

The UK has an ageing population, and more citizens are manging mental and physical disabilities at home. Technology should focus on assisting everyday activities rather than taking over the care required. For example, ovens that recognise food to set the right temperature automatically and fridges that detect where desired food is located in the fridge.



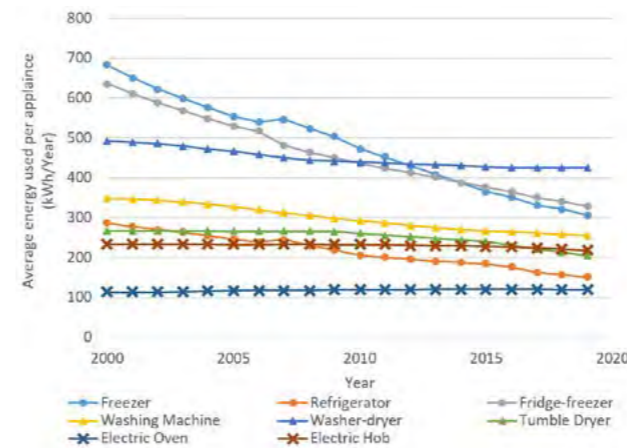
#### 3. Changing diet and eating habits

To maintain a sustainable and healthy diet, we will have to shift to a plant-based diet with less meat and dairy. It may be that we look to grow food in our homes to ensure fresh supplies of plant-based food. Alternatively, a bigger change is likely to come as people order food kits, eat more takeaway food, or eat out more frequently - habits that have all increased in the last 20 years. This could result in less demand for cooking or refrigeration appliances, or smaller and adjustable sizing to provide more space at home and create appliances that can change to fit our lifestyles.

#### 4. Changing living spaces

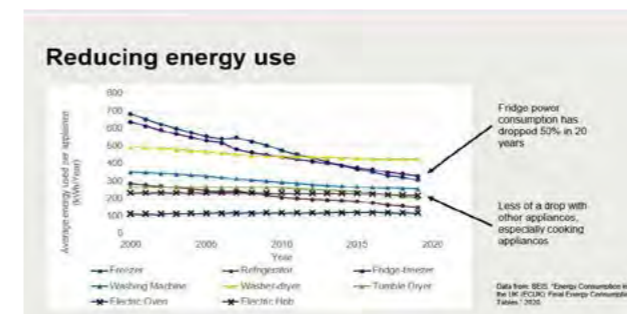
Within densely populated cities, the high cost of land has led to smaller living spaces. This leads to the need for smaller appliances completing a greater number of functions, or shared appliances. There have been several fridge concepts designed for shared living spaces. Modular designs have also been presented by Samsung for small, stackable fridges.

## Environmental



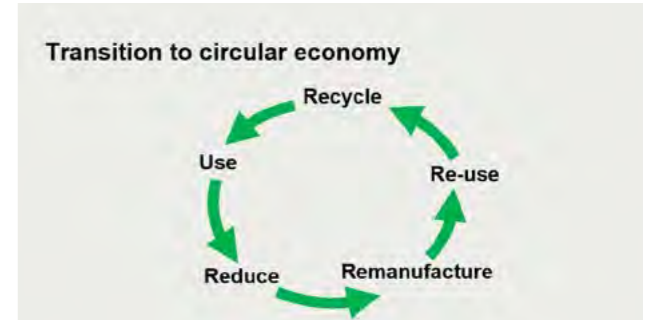
#### 5. Energy supply

The use phase of appliances is where the greatest environmental impact occurs; switching to cleaner energy sources is the best method of reducing the environmental impact of LDAs. But renewable energy sources are more variable in reliability. Appliances need to respond to the changing power provided and reduce their power demand during peak times.



#### 6. Reducing energy use

Energy labelling and technology improvements have led to big reductions in the energy usage of LDAs. The greatest efficiency gains have been for fridge/freezer appliances, energy consumption of which has fallen around 50% in the last 20 years, where the efficiency gains for washing machines and cookers are less. As our climate gets warmer, refrigerators will need more energy as higher condenser temperatures will be needed to remove heat effectively.



#### 7. Transition to a circular economy (CE)

Four key practices of CE include reduce, recycle, reuse and remanufacture - the "4Rs". Research shows that most appliance manufacturers do not pursue all 4R practices and mainly focus on reduction and recycling. With the new "Right to Repair" law, we could see a growing industry in the repair of appliances. One trend that we can expect in the future is more servitisation business models where appliances are rented to consumers in a pay-by-use system. This could allow businesses to maintain appliances for longer, and find new users for older appliances that would typically be discarded.

#### 8. Net Zero

New technology is a key enabler of net zero; increasing efficiency ensures that, despite the increasing number of appliances, energy production does not increase and becomes harder to decarbonise. More policies are needed to encourage trading-in old, low efficiency appliances (20+ years old) and ensure that more expensive, energy-efficient models are accessible to a wider audience.



Other environmental and technology aspects of future LDAs are covered in the "Fridge 2050" report by City University that accompanies this report.

Credit: All graphics courtesy of City, University of London

# Keynote: Heat pumps – energy and heat

Professor Ahmed Kovacevic  
City, University of London



Prof. Kovacevic gave a presentation on the efficiency of heat pumps.

60% of all energy used in homes, and even more energy (c. 70%) in industry, is used for heat. Refrigeration is modified heat pump technology.

The first heat pump, a convection pump for cooling that could redistribute heat, was produced in the 1740s. The inventor of one of the earliest systems lived on Russell Square, close to part of City University. Today, fridges are three times as efficient and three times smaller than they were in 1930s.

“ 60% of all energy used in homes is for heat. EU data says that 70% of industrial energy consumption is used for heat energy. ”

The market size: about 3.2 million fridges are sold annually in the UK<sup>6</sup>.

About £200m worth of small rotary compressors that are used for heat pumps (refrigeration and air conditioning) are made per year worldwide. They could be more efficient, saving thousands of tonnes of carbon. And Using heat pumps in homes can be three times more efficient than using them in industry.

Heating efficiency is measured by “heat advantage”, the comparison of the energy input versus the heat energy output. A gas boiler typically has heat advantage of less than one, for electric heat it’s about one. A heat pump can have an efficiency higher than one, sometimes up to four, making it more efficient than gas/electric.



The challenges for migrating from a conventional (gas) heating system to heat pumps are threefold:

## 1. Technical

Heat pumps in homes and industry need to reach higher temperatures than a refrigerator, the most common type of heat pump. Refrigerators have a condenser. To take the water temperature from 20°C to 90°C, a high-pressure compressor is needed. Standard pressure rating for ammonia heat pumps would be 60 bar, but the refrigeration standard is about 30 bar. This requires a big change in infrastructure.

## 2. Commercial

Heating features some “brutal economics”. The heat pump must be more efficient than the incumbent system or it won’t be viable. If the heat advantage it delivers is not sufficient, the new pump system may be more efficient than gas but it will either be too expensive for most consumer budgets or not provide enough heat for the building.

## 3. Political

In September UK had the most expensive electricity in Europe (day-ahead base price, source S&P Global) and the third cheapest gas in Europe (at the time of publication). The ratio between electricity and gas prices is the **spark ratio** or spark spread, a figure used to trade the spread (price difference) between the ICE UK Nature Gas Futures and ICE UK Base Electricity Futures. The UK has the highest spark ratio in Europe, meaning there is a weaker market incentive to shift from gas to heat pumps at scale.

## Session 1

# Innovation

### Innovation explored these topics

- Connected technologies including artificial intelligence
- Consumer behaviour
- Innovation for net zero
- Food waste
- Data and AI
- Inclusive design: design for the consumer’s life

# Innovation

“How we use fridges over 30 years has not changed much, but the technology has come far. I wonder if culturally we will now be looking at fridges in a different way.”



**Wendy Middleton**  
OPSS  
Panel chair

The innovation panel was chaired by Wendy Middleton, Deputy Director Science, Engineering & Analysis, Office for Product Safety and Standards.

Wendy told the conference, “How we use fridges over 30-years hasn’t changed that much, but the technology has come far. I wonder whether culturally we will be looking at fridges in a different way now and in the future.”

## Getting connected

About 14 million units of white goods are sold in the UK each year, according to AMDEA. During the pandemic the market grew by 20% as people have spent more money on home improvement. The smart appliances market has boomed in lockdown, said Steve Macdonald of Candy Hoover Haier. The three brands have sold 3.5m connected appliances in the UK market since smart suite of appliances introduced in 2015.

Steve remarked the market is developing all the time – his brands are seeing an uptake in people connecting with their appliances more. “I think the future is in connectivity, as manufacturers need to understand the consumer more and how they use the products,” he said.

Dr Ashwini Natraj’s team at London Economics were commissioned by the OPSS to do a safety and performance review of domestic connected technologies. It revealed many exciting opportunities for connected technology

in domestic appliances. Drivers include greater convenience, durability and more energy efficiency, e.g. more cost-efficient times of use. Connected appliances can also improve safety. For example, learning about consumer usage patterns can identify issues before they become a safety liability and help design appliances to match the way that people actually use them. Steve said that apps can send push notifications, for example if the oven is left on. Ashwini added that greater connectivity with customers can make product recalls more effective.

Steve said: “As a company we’re at a stage where, in a few years’ time we’ll be able to detect when a product may be at the point of breaking down.” He added there are issues with people connecting their LDAs to wifi, which is essential to realise the benefits of smart technology. Ashwini said only 2/5ths of consumers with connected appliances actually connect them.



**Dr Ashwini Natraj**  
London Economics



**Prof. Nick Colosimo**  
BAE Systems



**Steve Macdonald**  
Candy Hoover Haier



**Prof. Ahmed Kovacevic**  
City University



**Bio-fridge: concept fridge from a competition run by Electrolux. Credit: Electrolux and Yuriy Dmitriev**



**Researchers from Purdue University, Air Squared and Whirlpool built a refrigerator that can keep food cold on long missions in space, at zero gravity. Credit: Whirlpool**

## Consumer behaviour

The connectivity of LDAs is low, meaning just a proportion of owners are benefiting from many smart features that could reduce energy usage and bills. One delegate from BSH Home Appliances said all the smart features to connect people to their machines exist, but very few people are using them.

Ashwini said that product recalls are corrective actions and depend on consumer participation, which varies and is a human behaviour issue. One challenge is to identify consumers that possess appliances that would be affected by a recall - that is difficult if people don’t register their appliances.

**Q: Can we influence consumer behaviour using technology? Such as reducing energy consumption.**

Steve said that LDA consumers had little concern for energy efficiency

20 years ago, but education means the market has seen far more demand for this in the last five years.

Prof. Ahmed Kovacevic said we can try to engineer society to use these LDAs better. However, there is not just technology innovation, but political and economic innovation. Prof. Nick Colosimo, a technologist and engineer from BAE Systems, suggested using gamification - the use of game mechanics in problem solving – to meet greener goals. Ashwini agreed with this approach, that the technique could be used in sharing social norms – e.g. revealing how much energy people in their neighbourhood are using.

“Technology can influence consumer behaviour, tweaking the choices presented – you can nudge them to make decisions,” said Ashwini. “Reduce the frictions for the choices that you want consumers to make.”

## Innovation for net zero

The panel discussed several ways that smart appliances could develop to improve our environmental impact. Nick said that artificial intelligence (AI) will affect future LDAs. In a truly smart fridge, AI detects what temperature each food type requires to stay fresh; some zones of the fridge are more chilled than others and food is redeployed in zones. New appliances monitor and adjust the temperature more effectively to reduce energy consumption. Saving incremental energy for 30 million fridge owners in the UK would save many megawatt hours of energy.

### Q: Can the fridge be used as an energy centre?

Nick suggested people could reuse waste heat from a fridge. Surplus, expelled heat would be reused in the home or shared with the community. Ahmed said home appliance infrastructure would need redesigning.

## Food waste

Nick suggested that “convenience is king if Amazon and Netflix are anything to go by.” From stocking the fridge automatically and intelligently - knowing when you are at home or away, knowing the weather forecast, your mood, learning what you prefer to eat – when and in what circumstances, right through to offering recipes to make use of what’s in the fridge approaching a use by date.

The fridge of the future could detect when food is going off, and could potentially detect food allergens for people with food intolerances and allergies. Steve said that future fridges may have a “smart nose” sensor to tell you when items are close to their sell-by date – this technology is already available but not applied to mainstream fridges.

Future fridges have the potential to grow food like salads and mushrooms in compartments, contributing to “vertical farming”, and driven by a growing plant-eating society. Also some food is now being 3D printed. It’s possible that a future fridge could “print a meat-free burger” on demand.

### Q: Is there a trade-off between efficiency and convenience?

Nick said that machine learning should make the trade-off easy to calculate in the most optimum way. Machine learning makes predictions for you, giving you options for the best combination of performance, energy saving, carbon reduction and

budget. Scheduling your fridge activity means you can optimise the system “the way you want it” within its constraints.

## Data and AI

Artificial intelligence (AI) can pool consumer usage data and make greater sense of it, said Nick. “We can make the food and domestic regime much more efficient because humans are predictable and AI can see the patterns.”

Steve remarked that consumers must put good information in for manufacturers to pull useful information out, to understand how the consumer is using it to make the product better. Ashwini said that with so much data we need to ensure transparency.

Nick advocated more collaboration and technology transfer between white goods companies and the defence industry, automotive, motorsport, and marine. “There should be best practice transfer, to share the methods and technologies used to reduce cost, quality, safety and sustainability.”

### Q: Trust and data – how much of an obstacle is trust?

The panel said you need to explain risk and reward to consumers. Give them frameworks to operate in. What data are they trading, what do they receive in return? Nick said more intelligent devices including LDAs means the trust relationship changes. There is a change in psychology between users and machines as machines get smarter and industry needs frameworks for that.



## Inclusive Design: design for the consumers’ life

More inclusive design is important, to make LDAs fit for purpose for all types of consumer. There are lots of opportunities here with smart technologies, but there are also aspects to be cautious about.

A strong current theme is that more design thinking should be spent on LDA designs that match different user groups’ actual behaviour. Designing LDAs for the young and old, the visually impaired, busy families, smaller fridges for smaller living spaces – even suspended or “floating fridges”, which was suggested by school children as part of City, University of London research.

Steve pointed out that some products are connected by Google and Alexa, devices that detect consumer habits. There are 1.5m people in the UK with partial eyesight or blindness. Products with flatscreens can be more difficult for the partially sighted. A connected product can talk to the owner, they can then verbally set the temperature, time, alarms etc.

Younger people are more likely to engage with new technology - but don’t leave older people behind. Similarly, certain smart features for improved efficiency and safety may only make sense for premium models, meaning a risk that segments of the population are left behind in this tech push.

## Conclusion

The white goods industry must accelerate innovation to improve the safety, convenience, and sustainability of domestic appliances but it needs to ensure some consumers are not left behind, that white goods remain affordable. We must ensure we achieve the balance of collecting data in order to understand consumer behaviour and improve appliances, while ensuring this is collected and used in a transparent and responsible way.

“Most of the connected technology being discussed is already available, but consumers don’t use it.”

Delegate from BSH



Domestic appliances can now grow food. Urban Cultivator supplied by Intelligent Appliances. Credit: Intelligent Appliances

“We must ensure that the “brutal economics” align with the benefits. We must avoid the state where safety benefits come at a premium cost.”

Dr Ashwini Natraj  
London Economics



### **A new law: Right to Repair**

From June 2021, manufacturers will be legally obliged to make spare parts for products available to consumers for the first time – a new legal “right to repair”. The aim of the new law is to extend the lifespan of products by up to 10-years. In addition to this, officials estimate that higher energy efficiency standards will save consumers an average of £75 a year on bills over their lifetimes and the rules will help reduce the 1.5 million tonnes of electrical waste said by the government to be generated in the UK each year, and to contribute to reducing carbon emissions overall<sup>7</sup>. The panel said Right to Repair can be accelerated by 3D printing, to identify and print the specific spare part, and use AR (augmented reality) glasses to enable consumers to better follow instructions.

## **Session 2**

# **Road to Net Zero**

### **Road to Net Zero explored these topics**

- Appliance efficiency
- Regulation: Right to Repair
- Predictive analytics can reduce waste
- The circular economy
- Alternative business models
- Energy Smart Appliances
- Empowering and educating customers
- The covid pandemic and human behaviour



## Overview – Road to Net Zero



**Paul Hide**  
CEO, AMDEA



Paul Hide gave an overview of the changes being made in the domestic appliance industry to reduce carbon emissions and improve customer experience.

He said that appliances are a key part of every home's makeup and have a critical role to play in future sustainability and helping to achieve the net zero home. Due to restrictions imposed by Covid, during the past 18 months consumers now have an increased perception of the value of appliances in the home.

Appliances are improving constantly; they are smarter, safer and more energy efficient than they have ever been. Sales of small appliances have increased in the pandemic. Large appliance sales have risen 20% in the last year (now 16 million units) and are up 17% versus the pre-pandemic 2019 sales. In 29 million UK homes there are at least 130m large appliances and over 300m smaller appliances. The market is worth several billion pounds a year and supports thousands of jobs. Demand for all appliances is likely to grow further, therefore continual improvement in appliance efficiencies on water and energy consumption are needed to drive down domestic environmental impact.

If the changes to our working and living practices remain, as many are forecasting that they largely will, then the demand for appliances, both large and small, is likely to continue to grow.

On the environment: New build houses are fitted with more efficient appliances and are being built at far higher efficiency standards. Smart meters are fitted in 16m domestic locations. Appliance efficiency has increased greatly in the last decade. The typical annual cost of a A+++ rated fridge freezer is just £38, compared with over £150 for a C-rated fridge freezer. Washing machines can now detect half loads and adjust water usage accordingly. 80% of washing machines today and 90% of fridges and

fridge freezers reach the two highest efficiency ratings. Today's most commonly purchased fridge-freezers use about 40% less energy than those in use in homes a decade ago.

The industry must educate consumers on purchasing appliances which best suit their needs, and to persuade them to use machines on the most efficient settings, like eco-cycles on washing machines. The appliances of the future will be even smarter, greener and safer. But consumers have to "get their machines online" to use the digital functions to get the best out of them.

Modern refrigerators and freezers will keep food fresh for longer than older appliances. Food fresh technologies deliver a big opportunity to reduce food waste, which is, in itself, a major waste contributor with negative environmental impacts," he said, but pointed out that although manufacturers can design product that will help keep food fresh for longer and significantly reduce food waste, household behaviour needs to change.

This is only likely to come about from some consistent and impactful consumer education messaging, which leads to a cultural/ societal change but there is still a major challenge getting customers to register their products.

On safety: The challenge to ensure appliance owners can be reached in the event of a safety notification or recall continues to be a major one. In spite of regular messaging on the benefits of appliance registration, through platforms such as the AMDEA-run Register My Appliance, it is still only the minority of purchasers who register their appliances.

On sustainability and achieving net zero, AMDEA is calling for greater collaboration between the supply chain and other stakeholders, but many factories across the world are already achieving zero waste to landfill by using closed loop water systems to avoid taking water from the local supply chain, and sourcing non-fossil fuel-generated power. No-one in the global appliance industry is under any illusion that the path to net zero for the total circular economy cycle of appliance manufacturing, shipment, use and disposal is a must and the pace of change must accelerate.

## Timeline of washer / dryer future evolution



“ The most common fridges and fridge freezers are now using c.40% less energy they used just 10-years ago. ”

**Paul Hide,**  
AMDEA

## Appliance efficiency

Product efficiency has increased greatly in the last decade. Beko told the event organisers that some LDAs cost just £28 per year in electricity. Paul Hide said the most common fridges and fridge/freezers today use 40% less energy than they used just 10 years ago. They can detect laundry loads and adjust the amount of water accordingly.

Ian Moverley at Whirlpool said that the global appliances industry wants to become a net zero industry. Whirlpool sees quality and safety going hand in hand with sustainability – they are not mutually exclusive. The company is working to develop the whole product cycle: manufacturing, delivery, usage, better usage and recyclability.

The message was that LDA energy efficiency has come a long way and we should now also focus on other parts of the product lifecycle.

## Regulation: Right to Repair

Appliances now have extended life and repairability. The government's Right to Repair rules, introduced in July 2021, mean manufacturers must supply simple-to-fit spare parts to customers, and make their machines easier to repair at home.

Ian at Whirlpool said manufacturers welcome Right to Repair. He said, "It's a chance to give consumers choices. Often, we see products for disposal that just have a minor scratch, there is no reason to change the appliance."

Judith Peacock at Curry's referenced product longevity and cost, that under Right to Repair we must take care that repairs are made by competent people. If consumers do it themselves and the appliance doesn't work will the scrappage rate increase?

Professor Fiona Charnley of the University of Exeter said Right to Repair is only an incremental change. Industry needs to look at leading research in design, materials, reuse, production and consumption models and examine how we manufacture goods and capture value.

## Predictive analytics can reduce waste

Predictive maintenance technology tells a user when a part might fail before it does, so for example airlines can predict when to repair or replace aeroengine parts. Could this be adopted practically for fridge/freezers and other LDAs?

Technology like smart sensors can also make the delivery and logistics of LDAs more efficient.

## The circular economy

Fiona said adopting circular economy principles is vital. Even with 100% energy and usage efficiency, it would only solve 55% of the problem she said, because 45% of the carbon footprint is the production, consumption and disposal of products.

The recycling of LDAs is very sub-standard, Fiona said. At a visit to a recycling specialist, many products were brand new with just minor cosmetic damage, like scratches. Self-healing materials could prevent such cosmetic damage. Used goods were just smashed up and sorted for more valuable parts, discarding the rest. LDAs should be designed for disassembly and remanufacture, she argued.

Ian said there is pressure to design appliances that can be recycled more effectively. Paul added it needs to be easier to dispose of end-of-life products.



**The panel featured:** Ian Moverley, Director of Public Affairs and Communications, Whirlpool | Judith Peacock, Dixons Carphone  
Prof. Fiona Charnley, University of Exeter | Dr. Nina Klein, Senior Energy Engineer, BEIS

"Net zero and cradle to grave product care – this is not up to manufacturers alone. All the actors in supply chain need to support."

Judith added that manufacturers are trying to reduce packaging consumption and move away from expanded polystyrene, but it is difficult to find a suitable alternative that doesn't result in products being scrapped due to transport damage. Judith advocated for academia and industry to work together to drive innovations in packaging.

Judith asked if, for example, regulations like REACH (the Registration, Evaluation, Authorisation and Restriction of Chemicals, an EU regulation) are potentially raising barriers to using recycled materials. This is because it is difficult to track materials as they are transported around the globe.

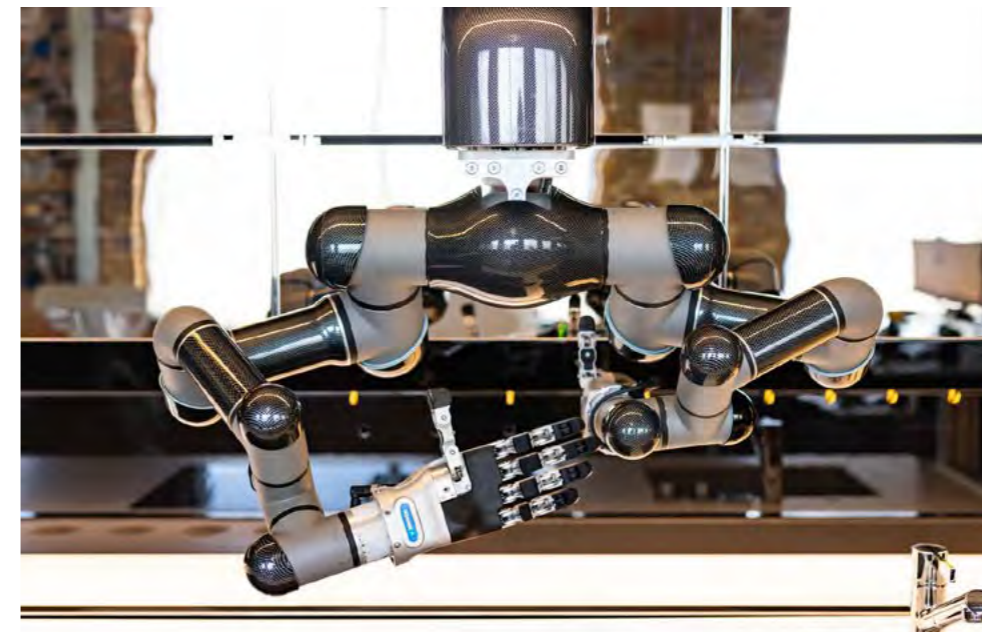
## Alternative business models

Fiona said we can do much to improve how LDAs are used, such as new pay-per-use models. Owners could lease their white goods and have access to more durable, efficient machines through the usage life cycle – like upgrading mobile phones. This has manufacturer advantages, creating a stream of material that is reclaimed that they still own and put into the next manufacturing cycle, creating value.

Judith, for retailers, discussed ownership models: buying, leasing or shared ownership. "We must examine the real demand for leasing," she said. "Is it the rate of technical change similar to phones, is it about cost or is it about other factors such as convenience? The cost reductions in LDAs have driven private ownership over the years. "In terms of shared ownership, consumers are now hooked on convenience, like home delivery. Would consumers visit a shared launderette and wait for two hours to save on materials in a world demanding convenience?"

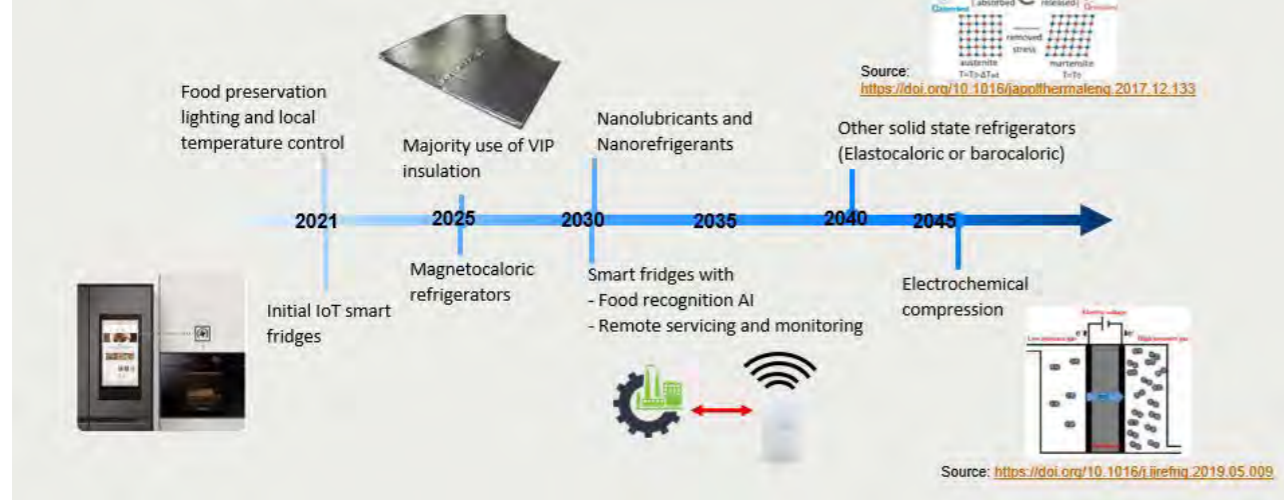
“Socially responsible businesses can gain commercial advantage. How can we help businesses flourish in the right direction, for example, using ESG principles?”

**Professor Rajkumar Roy**  
Executive Dean, City, University of London



**A future we all want: Robotic dishwashing and cooking.**  
Credit Moley Robotics and the product inventor, Mark Oleynik

## Fridge technology



Potential timeline of fridge technology to 2050. Supplied by City, University of London

### Energy Smart Appliances

BEIS (government department) has developed standards for Energy Smart Appliances and Demand Side Response, called PAS 1878 and 1879 (Publicly Available Specification), published in 2021.

“Smart” means balancing the amount of energy an appliance uses, the time of day when the energy is needed and the sources of energy and cost, to build a smarter energy system.

Dr Nina Klein at BEIS said smarter appliances need to react flexibly to energy supply and prices. One example is electrical appliances that can respond to the supply of renewable energy, drawing more when these sources are more available. This could help balance the demand for renewable and non-renewable power systems.

This can also be done locally, on local grids supplying appliances and cars more intelligently. A smart appliance can detect if the local provider wants to move users to a low-demand time of day, like night time, and operate then. Users of this service could be incentivised with discounts and benefits.

The electricity challenge: UK electricity demand could double by 2050 when we electrify heat and transport (BEIS forecast) – a huge scale of change and models show the UK will need 15GW of flexible demand<sup>8</sup>. Nina said this could be met by these energy smart appliances (ESAs) connected to a smart energy network. Having these ESAs and consumption flexibility can reduce the cost of our energy system by between £30bn and £70bn between now and 2050.

*More details of ESAs in the PAS 1878 – <https://standardsdevelopment.bsigroup.com/projects/2019-01576#/section>*

### Empowering consumers

Ian said keeping a fridge running for 30-years is not superior to buying a more efficient one. What is best practice? When is the right time to change a machine? Manufacturers have to help consumers to make choices that improves the use and recyclability of LDAs.

“Even with 100% energy and usage efficiency, it would only solve 55% of the problem, because 45% of the carbon footprint is the production, consumption and disposal of products.”

Prof. Fiona Charnley  
University of Exeter



### Q: An audience question asked about providing information and sustainability.

To better educate, consumers must look at the whole-life cost rather than just the upfront cost of purchase. The industry can better educate customers by making information more accessible – rather than reading the manual. Fiona said the landscape is very confusing for LDA consumers who want to be more sustainable. Amazon is selling more products on their sustainability credentials. A key point, Ian said in many cases an LDA is a distressed purchase, you need it quickly. If the landscape is confusing people go for the cheapest, not always the greenest.

Need to keep the process simple – show lifecycle costs, allow consumers to make informed choice. Greater visibility of options – right to repair, recycled and new. Transparency should continue to improve.

### Education of consumers

Modern products are more efficient but there are consequences. Judith commented on washing machine cycles. New machines can take longer to wash on economy cycles. Faster programmes often use more energy, and people often want their washing quickly. Is this explained to the consumer?

The mass effect of small, individual actions can make a big difference. Improved consumer behaviour will lead to optimum usage and reduce wastage. The industry must empower consumers to pick the best option for them. For example, explain the environmental benefits of buying a new machine vs extending life of old model. It was suggested that an app could be developed to assist this, a comparison calculator.

### The covid pandemic and human behaviour

#### Q: How is the pandemic changing LDA usage?

Nina said that consumer behaviour change is essential. Year 2035 emissions targets will be 60% down to consumer behaviour change. The pandemic showed the scale, but also the conditions of change; forced change versus choosing to change – which is more effective in the long term? We are starting to see some people change behaviour back after pandemic, but with education and engagement consumers see the benefits, it does not have to be “sold”. This motivates behaviour change and is more enduring.

Fiona said that people are more open to making changes in appliance use based on recent changes to their general lifestyle. The momentum is changing with new business models like leasing and consumers’ willingness to connect other products online.



## Session 3

# Safety and Standards

Safety and Standards explored these topics

- Consumer behaviour
- Electrical safety and Standards
- Data and safety
- Product safety and fire
- Working together
- Repairing appliances

**The Safety and Standards panel addressed the safety of LDAs including electrical safety, consumer behaviour, preventing fire and fire response, and data and safety. Product safety consultant Geraldine Cosh chaired the panel.**

### Consumer behaviour

“Behavioural change interventions” – soft techniques used to try to change human behaviour – can work but they are unreliable, said psychologist Dr Magda Osman. They must often be run alongside hard measures like price reductions to have any effect. Consumers always pay more attention to brand, price and value for money over anything else, which is true in all consumer categories not only LDAs.

### Electrical safety and standards

Safety standards are essential to ensuring products are safe. Even so, every year thousands of complex products are recalled due to safety feature failures.

The purpose of standards especially with electrical products, goes far beyond safety, said Daniel Mansfield of BSI, British Standards Institute. The BSI is involved in standards for Industry 4.0 (the “fourth industrial revolution”) which involves the convergence of safety and other issues such as recyclability, repair, end-of-life, and online security. Consider a smart fridge that orders your shopping; who else might have access to your buying habits and use the information?

Standards are above all collaborative – the BSI wants manufacturers, consumers and users to help it develop standards that are fit for purpose. There is constant iteration to a standard as it develops.

Martyn Allen of Electrical Safety First (ESF) said that most appliance manufacturers are global corporations that sell worldwide. As such they are probably operating at a level that is superior to any individual country’s standards. This prompts the question: do we need certain standards if they are inferior to what the company has built in?

London Fire Brigade’s Charlie Pugsley was most concerned that innovation is outpacing standards, even faster moving standards such as PAS (Publicly Available Specification). Some products reach market very quickly, for example with hoverboards that suddenly appeared on the market and started causing fires. It can be difficult to react that quickly. Martyn agreed that it is a very slow process that needs to speed up.

Daniel said the BSI has “BSI Flex” – faster iterations of standards, to get guidance out there quickly if there is an urgent need and can be updated quickly. However, the potential issue with quick sprints is that some stakeholders, particularly consumers, are shut out because of resource shortage. This needs balance. Data is needed to inform what should be done.

### Q: Whose responsibility is it to raise the need for better safety standards?

Magda said we should look at how future appliances will look and function. Appliances will become more multifunctional. One company is trying to develop a washer, dryer, and ironing device in one machine. The interaction of different regulatory bodies then becomes more challenging.

Can we predict what a consumer should be concerned about in the future in LDAs and what responsibility they should have in the product development?

**Q on standards for design:** Delegate suggested doing a gap analysis of what standards are out there. Martyn agreed, suggesting we need to take a step back and consider what standards we actually need in order to ensure standards are future-proof from cradle to grave. Currently, there may be gaps as the speed of innovation is outstripping standards.

### Data and safety

Data is a fantastic opportunity to drive safety improvements, said Martyn. Usage data can improve product safety, performance and more but there is a lot of mistrust with data; many consumers are still reluctant to share their personal data. If companies can explain that sharing data will improve safety, and data capture will be driven by consumers, it then becomes “pull not push”.

### Question emailed in: With the growth of smart technology, should products register themselves?

Daniel said registration needs novel solutions. Self- or auto-registration removes the person’s involvement, which is not ideal because they should be cognisant of why they’re registering.

Consumers are eager to do all the product registration needed for a mobile phone, which gives the phone manufacturer, network and possible partners access to their data, but that somehow with a domestic appliance the data is more private.

“A code of practice could tell people that to register they will not be pressure-sold warranties and make it

### Experts on the Safety panel were:



**Geraldine Cosh**  
Product safety consultant



**Dr Magda Osman**  
University of Cambridge



**Martyn Allen**  
Electrical Safety First



**Charlie Pugsley**  
London Fire Brigade



**Daniel Mansfield**  
BSI (British Standards Institution)

more explicit what the data collection is and how it can improve safety,” said Daniel. “We must tell customers that this data helps improve products in the future.”

Martyn said much data is exchanged at the point of purchase. This should be shared with manufacturers and standards bodies, if it is consensual and proves useful, instead of asking people to re-enter the data again online. He said we should remove the marketing from the registration of products for safety purposes.

### Product safety and fire

Under the Fire and Rescue Services Act 2004, the Fire Brigade has a duty to prevent fires and reduce the impact of fires on communities, said Charlie. Fires caused by faults in electrical equipment including domestic appliances is well documented – the Grenfell Tower disaster is understood to be caused by an electrical fault in a fridge.

Fires caused by equipment can be reduced by better standards and data. There are gaps in product data in terms of fire safety, Charlie said.

The fire service wants to help companies and standards so that when an appliance causes a fire, it is contained within the appliance and does not spread.

Systems thinking can help: It’s not just about the product that catches fire but about human behaviour, product standards, society and culture that could be inter-relating factors.

### Working together

New legislation and policy. Martyn at ESF talked about the many different government departments involved in changing legislation for products, as well as the BSI: there is OPSS, for connectivity the DCMS, for sustainability there is Defra. We need to make sure these separate

government departments’ views align, and make sure it all fits and works.

For example, for promoting Net Zero, Martyn said “As a consumer advocate, for many years we have said do not use appliances at night, for safety reasons. But this may be the best time to run them to spread grid load, so this needs explaining while understanding the risks.”

### Repairing appliances

#### Nick Colosimo asked whether we should repair old washing appliances, who has the requisite skills and is this a safety risk?

Charlie answered that for lower income owners there will be social drivers for “make-do-and-mend”. With over 40% ethnic minorities in London’s population and many socio-economic levels, some people will know it’s better to buy a new appliance but their first option is to repair.

#### Q: from delegate from Electrolux about the effect of liability on repair culture.

Whose liability is it if the machine we repair fails and damages or kills someone? Would insurance cover a life insurance claim in a road accident if you replaced your brakes badly and your vehicle failed to stop? Many global manufacturers would not be liable for an unqualified repair that then fails.

It was remarked that trained and authorised repairs on authorised spare parts could lower insurance costs.

An audience member remarked that it is easier to obtain parts now than it used to be and YouTube “How To” videos help.

Consumers are pushing for more repairable, modular products. At the moment there is a desire to repair products that are not that easy to get into, manufacturers need to design more repairable products. The panel raised a question over the opportunity for standards to help with repair.

## Concluding remarks

Graham Russell, CEO of the Office for Product Safety and Standards, summarised the event's findings:

- There is a distinction between bringing safe products to market and bringing products to market that will be safe through their entire life cycle.
- Ethical/consumer behaviour – what drives how we behave? How do we influence behaviour ethically?
- Data is key – it drives stories, behaviour, and change. Data is at the heart of improving the “Fridge of the Future” for the benefit of consumers and the planet.
- Product registration – Should we keep trying to change consumer behaviour? Companies already collect data; how can we find a way to use this. Automatic registration was suggested, but does this leave the consumer out?
- Reject the “either/or” of converging priorities, for example:
  - *Personalisation vs privacy – how can we achieve both?*
  - *Design, innovation and regulation – how do we ensure these happen together and the latter does not lag behind? We are increasingly seeing standards that drive innovation.*
  - *Innovation vs inclusion – excluded people will be more vulnerable. We need to innovate for inclusion.*
  - *Net Zero – consumption of product vs consumption to make products - how do we minimise both? Similarly with repair or replace – how do we do these safely and effectively? We must encourage safe repair. When/how products are used vs safety – is government giving clear messages?’*
- The future is closer than we think – 2050 starts here. We must create a better, safer and cleaner place to live.

The conference is available to watch on YouTube, split into four videos [here](#)

“The future is closer than we think – 2050 starts here. We must create a better, safer and cleaner place to live.”

Graham Russell  
OPSS

## Key takeaways

### From the event:

- Connected technology has huge potential to make appliances more convenient, energy efficient and durable, as well as enhancing safety. However, there are challenges to adoption that need to be overcome.
- Data can be used to understand consumer behaviour and optimise appliances for consumers, but trust is a barrier which needs to be overcome. Better transparency is key.
- Appliance efficiency has come a long way, but greater focus is needed to improve circularity and use.
- Consumers are wanting to make “greener” choices, but find it difficult to understand the environmental impact of their decisions: consumers should be empowered to make sustainable choices.
- There are conflicting priorities. Stakeholders need to come together to achieve both: sustainability + safety, personalisation + privacy; innovation + regulation.
- Innovation needs to be inclusive – it has to work for everybody. Innovation should consider consumer behaviour from a diverse range of backgrounds.

### From the Fridge 2050 report by City University:

- New technology improvements should quickly become affordable and implemented in all products. Otherwise, new energy-saving features could be confined to newer expensive appliances.
- Smart appliances should offer us advice on living more sustainably by telling us how to save energy, advising us to use eco settings, or telling us to eat food going off.
- Fridges have seen remarkable efficiency gains; similar gains are needed in other appliances such as cooking and washing appliances, which have not experienced the same level of improvement.
- Manufacturers have played a key role in creating efficient LDAs; they should also take an active part in the end life of LDAs or support other organisations working on reusing (more efficient models only), recycling and remanufacturing old LDAs.

## Next steps

Stakeholders, as part of the “Fridge of the Future” community, to come together and seek to address these key opportunities and challenges.

Stakeholders and interested parties are invited to contact the Office for Product Safety and Standards with questions, ideas and contributions to the challenge. Contact: [opss.enquiries@beis.gov.uk](mailto:opss.enquiries@beis.gov.uk)

## References

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## Participating organisations

Aga Rangemaster	Engineering and Physical Sciences Research Council	Miele
AMDEA - UK trade association for manufacturers of small and large domestic appliances	Enterprise Singapore	Milton Keynes Council
Association of Home Appliance Manufacturers	EPTA Refrigeration	Montpelier Appliances
BAE Systems	Essex County Fire and Rescue Service	North Somerset Council
Bath & NE Somerset Council	Euro Monitor	National Consumer Federation
BEIS	Exergyn	National University, Oman
Beko	Exeter University	Northumberland Council
BFIPR	Finch Consulting	Oakdene Hollins
BHF	Fisher Paykel	Office for Product Safety & Standards
Birmingham University	GDHA	Oldham Council
Brent Council	Glen Dimplex Consumer Appliances	Oxford University
British Cables Association	Gordons LLP	Portsmouth County Council
BSH Home Appliances	Haier, Candy Hoover	Geraldine Cosh Consulting
BSI	Halton Council	Queen Mary University of London
Bureau Veritas	Havering Council	Reuse Network
Child Accident Prevention Trust	Hawk Test	Sainsburys
City and Islington Colege	Hertfordshire Trading Standards	Samsung
City, Univeristy of London	Hitachi	Smeg UK Ltd
Armagh City, Banbridge & Craigavon Borough Council	IKEA	South Tyneside Council
Cleveland Fire	Ipress Media	Stirling Media
Cold Factor cc	JMM PR	Swan Products Limited
Cooley	John Lewis Partnership	Talk Talk
Defra	KCL	The Office for Product Safety and Standards
Derbyshire County Council	Kingfisher	The Royal Society for the Prevention of Accidents
Devon Council	Korea Institute for Advancement of Technology	UL VS Ltd
Dixons Carphone	Lewis Mathys Emmerson LLP	Ulster University
Doncaster Council	Liebherr	United Kingdom Accreditation Service
DSG	Lincolnshire County Council	University of Cambridge
DSL Consulting	London Economics	University of Surrey
East Riding Council	London Fire Brigade	Vestel UK
ECFRS	London Forum of Amenity & Civic Societies	Walsall Council
EDGE Digital Manufacturing	London South Bank University	Which?
EEE Safe	Manchester Council	Whirlpool
Electrical Safety First	Matchstickmem Group	Wirral Council
Electrolux	Mid & East Antrim Council	

To contact the Office for Product Safety and Standards about this work, to connect to other stakeholders quoted in the report and for more information, please contact [opss.enquiries@beis.gov.uk](mailto:opss.enquiries@beis.gov.uk)



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