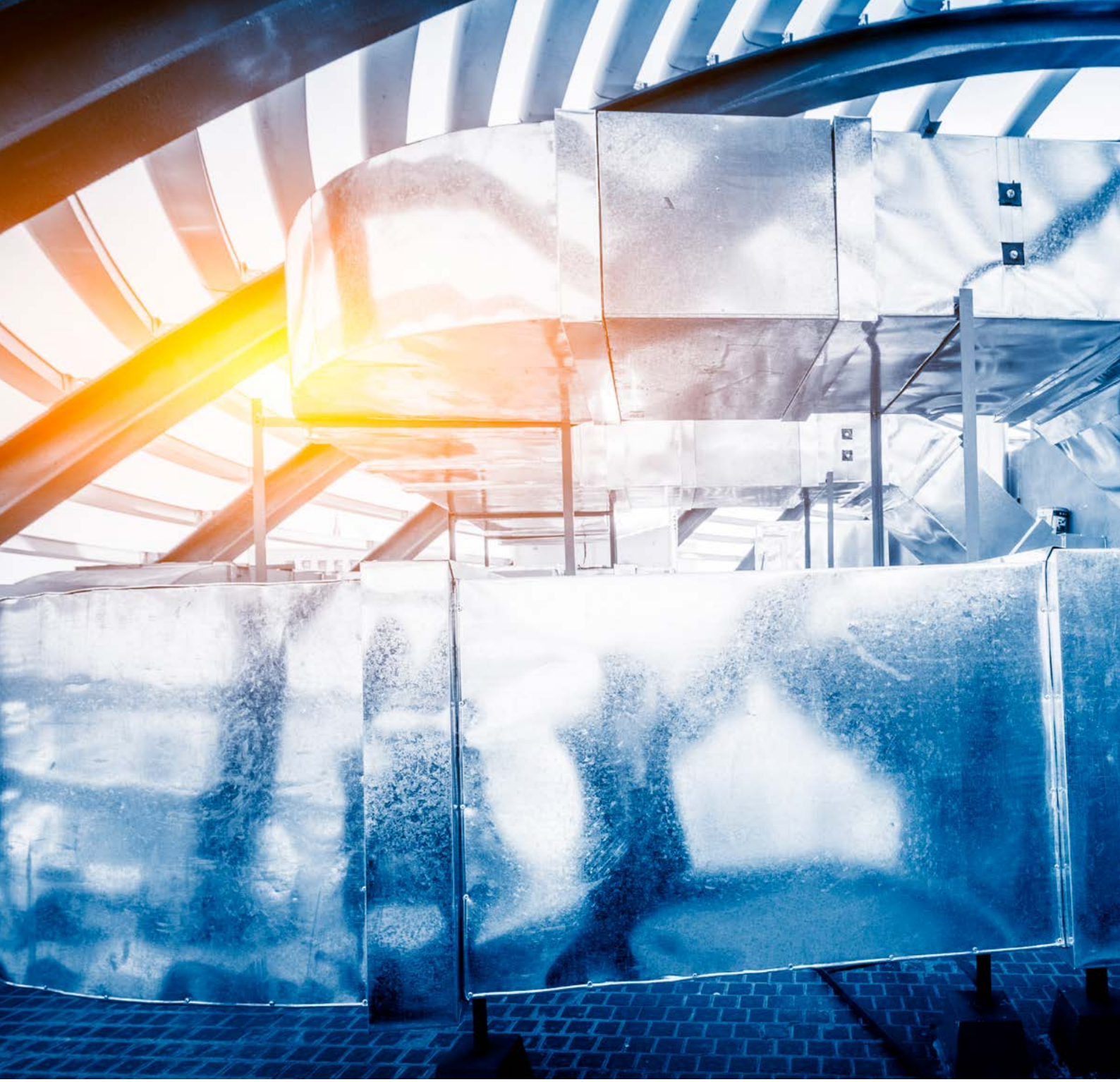
Innovate UK

# Defining the challenges for Net Zero cooling in the UK

November 2023



## Climate Change Adaptation Innovation Network

This report is produced by the Innovate UK Climate Change Adaptation Innovation Network (CCA IN).

The new CCA IN, which launched in September 2023, is a collaborative community that supports resilient and thriving businesses across the UK to innovate and overcome the challenges posed by climate change.

We have shared the report with DESNZ, Innovate UK and the relevant Research Councils to shape future support for Net Zero cooling in the UK.

**Authored in January 2024 by:**
**Jenni McDonnell MBE, KTM Thermal Energy Systems, Innovate UK Business Connect**

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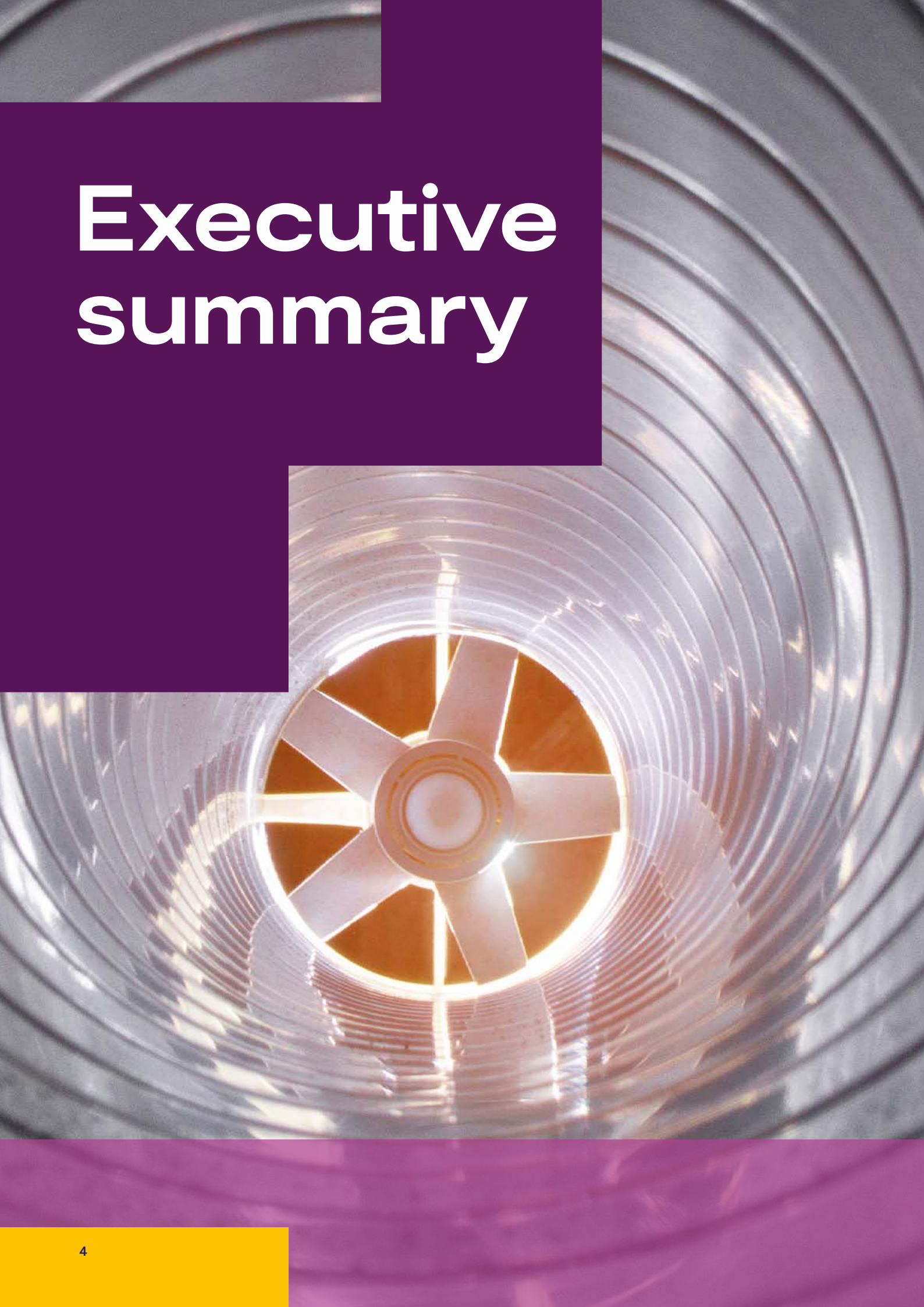
# Executive summary



**In November 2023, Innovate UK brought together industry and academia from the cooling sector as well as businesses, local authorities and community groups requiring Net Zero cooling.** The group explored the technical, social, regulatory, economic, and environmental challenges stopping the adoption of Net Zero cooling solutions to help the public sector understand the interventions required to support business tackling the cooling challenge. A list of participants in the workshop is provided in the appendix.

The participants examined two main areas of Net Zero cooling:

- How do we cool the buildings we live and work in? (building design, passive cooling, air conditioning)
- How do we provide refrigeration for process cooling, storage, and transport? (retail, manufacturing, data centres)

The top ranked challenges identified by the workshop participants were:

**Cooling Buildings**

- Retrofit of existing buildings
- Lack of installation skills
- Lack of innovative business models

**Refrigeration**

- Cost of Net Zero technologies
- Lack of skills relating to optimisation
- Inadequate regulation and compliance

The workshop participants made the following recommendations for public sector engagement to support the adoption of Net Zero cooling in the UK.

## Reduce the cost of switching to Net Zero cooling

Public support is required to catalyse the business case for transitioning to Net Zero cooling solutions. Financial options that drive good practice and incentivise the adoption of Net Zero cooling solutions could include:

- Government-backed bank loans for retrofit based on expected performance
- Tax credits which incentivise the adoption of energy-efficient practices
- Public capital investment to reduce the cost of retrofit
- Cooling-as-a-Service business models to reduce the operating cost of innovative solutions

## Improve and enforce regulations to encourage the adoption of Net Zero cooling

There is a need for regulatory review for refrigeration and cooling within buildings. New regulations that encourage the adoption of Net Zero cooling approaches will deliver energy savings. Areas to be considered include:

- Building design
- Monitoring performance over time
- F-gas phase-out
- Temperature-controlled transport and storage standards

## Train a skilled workforce to deliver Net Zero cooling

The lack of technical expertise to install and operate the innovative cooling solutions is a major barrier to adoption. A skilled workforce is required, with knowledge of what innovative options are available and an understanding of how they operate. This workforce can then advise and encourage companies who require Net Zero cooling to consider the Net Zero alternatives. The workshop participants identified the need for further training for the following workers:

- Installers
- Architects
- Refrigeration technicians
- End users of cooling

Overall, the group agreed that there are areas for improvement where innovation support could help (building design, low GWP refrigerants, thermal system approaches and process optimisation), but there is a greater need for regulatory review and financial support to remove the barriers to adoption of existing Net Zero cooling solutions.

# Introduction

**As the UK's temperature continues to rise annually, the need for space cooling and refrigeration and the cost associated with operating these forms of cooling is increasing.** It is quite rare for UK homes to have air conditioning but, with summer temperatures regularly reaching 30°C for large parts of the UK, it will become a more common occurrence, putting a greater strain on the energy networks and increasing the cost of energy for consumers. Likewise, businesses with retail space or offices, as well as public buildings like schools and hospitals, will see their energy costs increase as the cooling technologies we use today struggle to maintain a comfortable environment.

Another area of cooling to be impacted by climate change is the use of refrigeration. Many of the different manufacturing processes operating in the UK use refrigeration, not just to store the products they make but also during the manufacturing process itself. Manufacturing industries such as food & drink, ceramics, chemicals, metals, and medicines rely on refrigeration technologies that are very expensive to operate. As ambient temperatures rise in the summer, these technologies work harder, increasing operating costs.

In November 2023, Innovate UK brought together industry and academia from the cooling sector as well as businesses, local authorities, and community groups requiring Net Zero cooling.

The group explored the technical, social, regulatory, economic, and environmental challenges associated with the adoption of Net Zero cooling solutions in the UK to help understand how government support could help solve them. A list of participants in the workshop is provided in the appendix.

**The participants examined two main areas of Net Zero cooling:**

- How do we cool the buildings we live and work in? (building design, passive cooling, air conditioning)
- How do we provide refrigeration for process cooling, storage, and transport? (retail, manufacturing, data centres)

**Within these two areas, the participants considered the following themes:**

- Social: What impact will increasing global temperatures have on people's health and well-being, on their ability to work or learn at school?
- Economic: What impact will increasing global temperatures have on the cost of running a business (retail, manufacturing), and on the cost of living (energy bills, price of goods)?
- Technical: What impact will increasing global temperatures have on the equipment that we currently use for cooling: air conditioning, refrigeration, cold storage, and transport?
- Environmental/Regulatory: What impact will increasing global temperatures have on the current regulatory and environmental standards? Are they fit for purpose? What needs to change?

Once the participants had identified the challenges within the two main areas, they were asked to prioritise them based on which challenge would deliver the greatest benefit if solved. A ranked list is provided in the appendix.

Finally, the participants discussed what public support might be needed to solve the top-ranked challenges.

- What solutions to the challenge already exist and why haven't they already been adopted?
- What skills and training might be required to solve this challenge?
- How do we ensure the solution is adopted by end users?

The output from this report will be shared with the following organisations to shape their understanding of this sector ahead of the next Comprehensive Spending Review.

- Dept. for Energy Security and Net Zero (DESNZ)
- UKRI Innovate UK (IUK)
- UKRI Engineering and Physical Science Research Council (EPSRC)
- UKRI Economic and Social Research Council (ESRC)

Representatives from DESNZ and IUK attended the workshop as observers.

# Summary of discussion

The following section summarises the main challenges associated with the adoption of Net Zero cooling in the UK, as identified by the workshop participants. It is not intended to be an exhaustive list, but common themes emerged from the discussion.

# Cooling internal spaces in buildings

**Spaces within buildings, whether they are domestic (apartments, terrace housing, detached houses and single-storey houses) or non-domestic (offices, schools, hospitals, care homes, community centres, retail and commercial) can be cooled by reducing the amount of heat that is absorbed through passive approaches or by actively cooling the space using energy.**

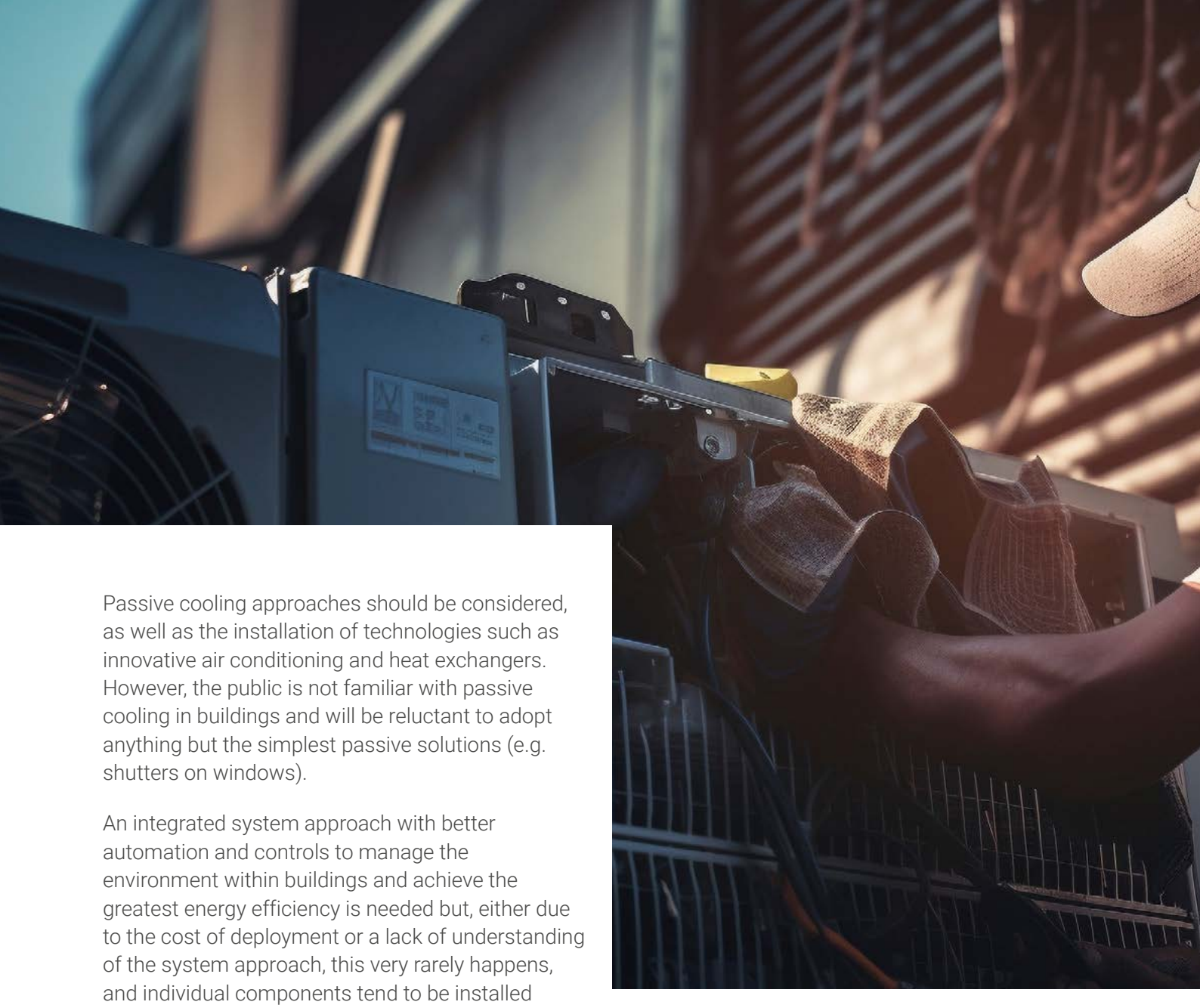
The building design and the materials used in the fabric of the building will determine how much heat the space within the building absorbs and stores on a hot day. Similarly to heat escaping on a cold day, most of the heat on a hot day enters through the windows, so shutters or blinds can be used to deflect the heat. The fabric of the building (stone, bricks, wood) and the type of insulation used can help to reduce heat gain too.

Whilst passive cooling approaches can help to reduce the temperature in a building, it may also require technologies such as air conditioning and refrigeration to reach a comfortable temperature for its occupants. These solutions require electricity and are known as active cooling technologies.

## Challenges

### 1. Retrofitting existing buildings

The adoption of Net Zero cooling will involve retrofitting existing buildings. This presents a challenge, as many of these buildings were not designed to maintain a cool environment. The fabric of a building is unlikely to be thermally efficient and the site may not have the additional space.



Passive cooling approaches should be considered, as well as the installation of technologies such as innovative air conditioning and heat exchangers. However, the public is not familiar with passive cooling in buildings and will be reluctant to adopt anything but the simplest passive solutions (e.g. shutters on windows).

An integrated system approach with better automation and controls to manage the environment within buildings and achieve the greatest energy efficiency is needed but, either due to the cost of deployment or a lack of understanding of the system approach, this very rarely happens, and individual components tend to be installed in isolation. Innovation is needed to design and refine building systems, including the impact of Net Zero cooling solutions on good indoor air quality. Improving the fabric of a building to improve cooling efficiency should not deliver poor air quality leading to health problems for vulnerable occupants.

## 2. Installation skills

It is widely acknowledged that there is a lack of skilled and experienced workers within the energy sector to facilitate the transition to Net Zero. The lack of knowledge of what Net Zero cooling options are, as well as the lack of skills to build or install them, is a major barrier to adoption.

More support should be provided to train installers with a combined knowledge of heating and cooling systems, as well as a better understanding of more passive approaches such as better ventilation and shading.

## 3. Innovative business models to make cooling affordable

There is a need to develop business models to make the cost of Net Zero cooling affordable for all, including both the capital cost of retrofit and the ongoing cost of providing active cooling.

Business models such as “Cooling as a Service” support low-income families to adopt innovative new solutions without large upfront costs and lead to the growth of the cooling sector in the UK. This is an approach that private investors and social housing organisations are keen to support. The investor provides the capital expenditure to retrofit the home and the social housing association pays back the investment over a long period of time, making it affordable for all.

*Retrofitting older homes with cooling innovations can be challenging*

The Future Homes Project (Birmingham City University) funded by Innovate UK is exploring how to reduce the energy demand for Net Zero heating in social housing. However, business models need to address the thermal comfort of a building rather than heating and cooling in isolation.

## 4. Constrained energy networks impacting adoption

Some Net Zero cooling technologies could lead to an increased demand for electricity, putting an additional load on local energy networks that may already be constrained. Renewable generation such as solar PV with storage could ease this burden but will be an additional expense to an already expensive retrofit.

The Distributed Network Operators (DNO) may also be reluctant to support the deployment of new devices at properties connected to their network without understanding what impact it will have and the variability of demand. This reluctance has already been experienced with the rollout of heat pumps and EV charging points.

Flexibility services and demand-side response techniques may help the DNOs to manage the flow of power on the system and ease constraints caused by high demand but these options are not yet established across the electricity network.

## 5. Equitable access to cooling

Whatever Net Zero cooling solutions are deployed, they must be available to everyone in society, regardless of their personal needs. This adds a level of complexity as the “one size fits all” method doesn’t apply.

*Low-income families may choose not to use cooling technologies due to cost*

*Changing behaviours needs to be encouraged such as closing windows and shutters during the day*

As we age, our bodies become sensitive to extreme temperatures, whether hot or cold and, as a result, older people struggle to regulate their internal body temperature. Retirement homes tend to be tailored for vulnerable occupant needs but private homes may not have any form of air conditioning or passive cooling. Often, homeowners have lived in the same home for 20+ years and have not adapted it to their changing needs.

People with chronic health conditions are also vulnerable to the increasing temperatures in the summer months. The need for warmth is recognised as a prescribed medical requirement under the NHS, but not the need for cooling.

Low-income families will struggle in hot temperatures, choosing not to use cooling technologies that require energy as they cannot afford it. There is a need for cold spaces where people can go when temperatures rise, similar to the "warm hubs" that are made available when temperatures plummet in the winter.

The Climate Change Committee (CCC) estimates that 2,000 heat-related deaths occur in the UK annually and that this could grow to 7,000 by the 2050s without intervention.

## 6. Changing behaviours

A lot of energy is wasted every day by homeowners and building occupants through a lack of knowledge. For instance, people open their windows wide during the hottest part of the day because they think it will cool them down. It is a reasonable assumption, but it is allowing the heat into the building rather

than letting it out. Closing windows and shutters to deflect the heat would reduce the internal temperature much more effectively.

A public awareness campaign is needed to help home owners and building occupants understand how they can adapt to increasing summer temperatures. Behavioural change is a challenge and not one that will be solved in a day. It requires consistent and repeated messaging. However, if people understand the benefits of Net Zero cooling quantitively and in a way they can relate to, they will make the change.

Better digital tools would make energy consumption relating to heating and cooling more visible to the occupants, potentially driving a behaviour change, but the digital displays and controls need to be simple and accessible to all.

## 7. Inadequate regulations

Defra's National Adaptation Programme describes some of the risks of overheating in buildings and how to mitigate them, but this has not translated into policy. The current building regulations relating to the energy efficiency of new build do not take into consideration the need for cooling and do not encourage the use of innovative building designs for passive cooling. In addition, there is no incentive for existing buildings to meet any new regulatory requirement for cooling. The regulations need to be revised and enforced.

A policy option for government could be to incentivise the rollout of Net Zero cooling in existing properties as they did with the Renewable Heat Incentive for Net Zero heating. However, changes need to be made to the way the grant is provided to avoid unscrupulous companies installing inappropriate solutions that don't provide the expected outcome, leading to public mistrust.

Another area where regulatory review is required is refrigerants, particularly the fluorinated gas regulation originally established by the EU and adopted by the UK Government (EU 517/2014). Refrigerants used in air conditioning, refrigeration and heat pumps use fluorinated gases (F-gases). F-gases were originally introduced as an alternative to ozone depleting refrigerants (CFCs) and, whilst F-gases do not damage the ozone, they do have a high Global Warming Potential (GWP), some even higher than carbon dioxide. Natural refrigerants like water, carbon dioxide and ammonia have been developed and are slowly replacing the high GWP HFC gases, though some of them carry their own risks such as toxicity and high operating pressures. There is a reluctance from equipment manufacturers and the refrigerant supply chain to move away from high GWP F-gases, which are thought to provide better performance. The Government is reviewing the current F-gas regulations, but it may require a ban on F-gases to ensure the move to Net Zero cooling happens.

# The business case for retrofit

## What solutions to the challenge already exist and why haven't they already been adopted?

Passive cooling and innovative ventilation technologies exist but are very rarely utilised. This is partly because consumers aren't aware of this type of cooling solution, and partly because they can be difficult to retrofit onto existing buildings. A toolkit of mitigation strategies and cooling solutions need to be developed to help homeowners, local authorities and social housing associations make informed decisions and to raise awareness with investors that there are alternatives to 'powered' technologies.

Heat pumps are a form of low-carbon heating in homes and commercial buildings. However, many heat pumps can also work like an air conditioning unit to provide cooling as well (these are known as reversible heat pumps). The Government has a target for 600,000 heat pumps to be deployed annually in homes by 2028, but the number of heat pumps being deployed is falling short of this figure despite Government grants to reduce capital costs.

Whilst most homes don't have air conditioning units, most commercial properties do. Air conditioning technologies for commercial properties are at their efficiency limit, but even a 1% improvement is meaningful, and this can be achieved with retrofit.

A publicly funded programme to stimulate private funding to demonstrate at scale some of the developing retrofit technologies and strategies would help to raise awareness with consumers and investors and drive growth in this sector.

## What skills and training might be required to solve this challenge?

Training is required across the supply chain, from building developers to installers, building managers and servicing. Training should provide a holistic view of thermal management rather than focussing on one technology solution.

Government policy options include creating a retrofit minimum, with regulations to enforce it and training to ensure a skilled workforce can deliver it. Skilled expertise in passive cooling approaches, energy efficiency in refrigeration and optimisation of the cooling requirement within a building is currently limited in industry.

Building regulations (PAS2035 (domestic) and PAS2038 (commercial)) don't currently include any aspects of cooling in a building. The Energy Performance Certificate rates the use of energy to condition the indoor climate, but the assessment criteria are not specific enough and need to be expanded to include passive cooling approaches.

## How do we ensure the solution is adopted by end users?

First, we need to build a better understanding of the scale of the challenge for the UK. How much will it cost to cool buildings in 2030, 2040, 2050? How many people will be affected by rising temperatures? How many skilled jobs will be required to meet future demand? What does the variance between the winter load and summer load look like?

We need an evidence base to support the development of a roadmap to 2050, so action can

## Sources of information

- BRA (British Refrigeration Association)
- HVCA Association UK (Heating and Ventilating Contractors Association)
- FETA (Federation of Environmental Trade Associations)
- AECB (Association for Environment Conscious Building)
- HEVAC (Building Engineering services)
- HPA (Heat Pump Association)
- UK Green Building Council
- GreenSpec
- Royce Institute
- CIBSE
- Passivhaus Trust
- BSRIA
- "Affordable heating and cooling of buildings" challenge for Mission Innovation
- "Addressing overheating risk in existing UK Homes" Arup on behalf of Committee on Climate Change

be taken by government, businesses and academia to support the adoption of Net Zero cooling. The Transport, Industrial and Commercial Refrigeration (TICR) project funded by DESNZ is developing a roadmap and benchmarks for refrigeration. A similar project is needed for cooling within buildings.

Retrofit Academies or Retrofit Hubs are needed to ensure mitigation measures and design concepts for cooling are considered by builders and developers. They should encourage thermal management of a building rather than managing heating, cooling, and power demand in isolation.

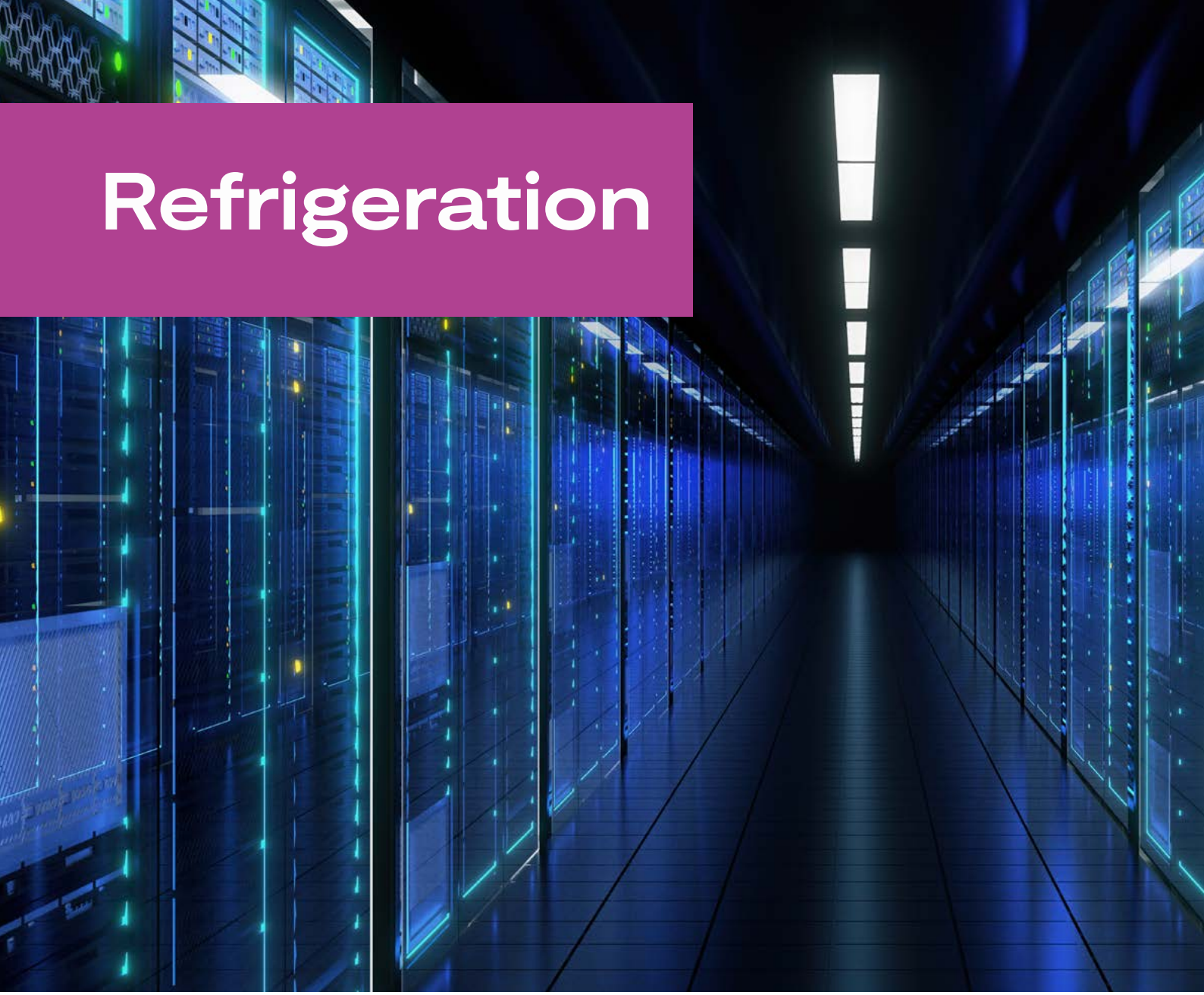
Likewise, action is required to educate homeowners on how to create the comfort needed within a building whilst maintaining energy efficiency, encouraging a thermal management mindset. Smart thermostats and dashboards can be used to manage the environment automatically for more vulnerable homeowners.

There needs to be a fast-track process for the energy efficiency rating of emergent technologies to build confidence with consumers. The current process is expensive and slow, which has delayed the adoption of alternative cooling solutions.

Financial support is required initially to support the business case for transitioning to Net Zero cooling solutions. Financial options that drive good practice and incentivise the adoption of Net Zero cooling solutions could include:

- Bank loans for renovations based on building performance
- Mortgages which incentivise energy efficiency
- Council tax based on the energy performance of the property
- Public capital investment to reduce the capital cost of retrofit
- Cooling-as-a-Service business models

# Refrigeration



**Refrigeration is a well-established technology in the UK. Refrigeration or cold chain systems can be chilled, frozen, or cryogenic (mainly used in the medical sector).** The challenges are therefore associated with the drive to make these technologies more sustainable, encouraging the move towards natural refrigerants and improving the energy efficiency of units.

## Challenges

### 1. Too expensive to finance

Adopting new innovative refrigeration systems can be difficult for a lot of companies due to capital and operating costs. Companies will choose to buy carbon credits as a cheaper alternative to switching to Net Zero cooling technologies. This needs to be discouraged.

Companies report that greater support from government would stimulate private investment from companies developing solutions to transition to Net Zero cooling. Most companies require a two-year payback on an investment before they will consider making it. Developing finance models for cooling is a challenge, and it is therefore difficult to make an economic case for the move to Net Zero cooling.

The distributed nature of some industries makes it hard to adopt Net Zero refrigeration or to achieve energy savings. For instance, Tesco Express require lots of small chiller units at their small corner shops due to limited space, rather than the more economical centralised cooling system that might be installed at a large site. This compounds an already expensive investment. Flexible tariff billing may help, but is not currently available for the non-domestic sector.

## 2. Skills and Mentoring

As with cooling in buildings, the lack of technical expertise to install and operate innovative refrigeration solutions is a barrier to adoption. We need a skilled workforce with knowledge of what innovative options are available and an understanding of how they operate, so they can advise and encourage companies who require refrigeration to consider the Net Zero alternatives.

A project funded by the Department for Energy Security and Net Zero, "Transport, Industrial, Commercial Refrigeration" estimates that the Food and Drink industry could save 25% energy through a better understanding of how cooling systems are performing. However, there is a lack of skilled technicians on manufacturing sites who can interpret the data to make informed decisions that optimise cooling systems. Refrigeration contractors are not required to make their customers aware of improvements in technology or regulation changes and may not feel comfortable servicing cooling innovations that they are not familiar with, so there is no incentive for them to recommend these alternative solutions.

Industry and academia do work together on the development of new cooling solutions, but the practical skills they develop need to be shared. Likewise, there needs to be a career progression within the cooling sector in the UK to encourage the next generation to want to work in this sector and develop the skills that are required.

## 3. Regulation and compliance

The current regulations and standards for refrigeration, both for cold storage and for refrigerated transportation, require improvement.

Manufacturing sites are not required to monitor or report on the performance of their process cooling equipment. Energy consumption is measured and reported at site level. However, as a large percentage of the energy demand for the site will come from the cold chain system, sub-meters are required. The Food and Drink industry has a voluntary Climate Change Agreement target to incentivise the adoption of energy-efficient refrigeration which has led to a decrease in energy demand for cooling. However, this is not the case for every manufacturing site where refrigeration is used. Regulations to mandate the adoption of energy efficiency measures may be required.

Temperature compliance on transporting perishable goods is set at -18°C, but there is no technical reason for this being the benchmark temperature, so it could potentially be using more energy than is required to avoid food waste. We need a better understanding of what the optimal temperature should be to balance safety and carbon emission reduction. Raising the temperature from -18°C to -15°C could provide substantial energy savings, but it could be a trade-off between the cost of energy and food safety.

There is a lack of regulation on refrigerated vehicles relating to vehicle fuel. The vehicles are treated as non-road mobile machinery, so they are not subject to the same charges in urban "Low Emission Zones". Any new regulation in this respect needs to include vans which have been converted for refrigerated transportation of goods as well as vehicles manufactured for this purpose.

There is a lack of data on cold chain logistics more generally. A registration system to monitor how many refrigerated trucks and vans are using the road network and how they are performing is required to allow the Department for Transport to enforce a minimum emission standard.

## 4. Refrigerants

As discussed earlier in this report, the current F-gas regulations are under review as some of the F-gas refrigerants have a high global warming potential (GWP). The choice of low GWP refrigerants is growing, including very low GWP solutions like carbon dioxide, ammonia, and hydrogen. However, an outright ban on F-gases for refrigeration may be required to encourage the adoption of new low GWP alternatives. The challenge is that not all low


*R32 is a lower global warming potential (GWP) F-gas refrigerant*

*Consumers need to be encouraged to think differently about how they chill food*

GWP refrigerants will be suitable for retrofitting into an existing cooling system to replace a high GWP F-gas.

Limiting the use of F-gases will increase the demand for natural refrigerants, putting pressure on the supply chain. There is also a reluctance from the chemical companies who manufacture the high GWP refrigerants to switch as F-gases tend to provide better performance than low GWP alternatives.

Note: Hydrogen has been suggested as an alternative to F-gases for refrigeration. However, the hydrogen supply chain in the UK is still immature and there will be competing demands on the limited supply of hydrogen in the 2030s.

## 5. Consumer behaviour

Consumers need to be encouraged to think differently about how they chill food. Educating consumers on how to get the best performance from their chiller and the impact of something as simple as leaving the door open for more than a few seconds will change behaviours for the better. Many people do not understand how much energy they could save by making small changes.

Some Net Zero cooling solutions are quite expensive, which has been a barrier to adoption. However, there will be social pressure to switch as Scope 3 emissions are counted, impacting revenue and product cost.

## 6. Refrigerated transportation and power storage

A reliable electrical supply is required to electrify logistic fleets, which will in turn reduce the carbon emissions associated with refrigerated transport. Energy storage will be an important factor in enabling this transition.

We need to encourage the uptake of emission-free refrigerated transportation by reducing the cost, ensuring technical certainty, and providing the roadside infrastructure for electricity to be a reliable alternative to diesel.

## 7. Performance of existing equipment

When a new refrigeration system is installed, a 'cooling' model of the cold space will be created to optimise the cooling efficiency. However, over time the number of chillers cooling the space and the way the space is being used could change, which in turn will affect the energy efficiency of the system. Manufacturers will decrease the temperature produced by the chiller rather than revisiting the model to see if it is still performing as it was designed, increasing their energy costs and carbon emissions.

Modelling will also help manufacturers understand the impact that an increase in ambient temperature will have on their cold stores for future planning. There is a need for better monitoring to improve energy efficiency and awareness.

The use of heat recovery and reuse should be encouraged. Heating and cooling across the manufacturing or retail space should be considered as a system, but each component tends to be installed in isolation.

Likewise, the use of thermal storage to allow waste thermal energy to be used when needed will help to make the system more energy efficient. Process optimisation should be the first step in decarbonising cold chain systems.


# The business case for refrigeration

## What solutions to the challenge already exist and why haven't they already been adopted?

There are a range of data-driven tools and processes used by energy consultants to evaluate an industrial site's energy performance. These tools can be used to model the site and identify where the greatest energy savings could be made. However, the cost of an energy audit can deter manufacturers from taking advantage of these assessments.

There are programmable logic controllers (PLCs) which can optimise the performance of the cold chain system based on operating conditions. Data visualisation tools can help to identify inefficiencies from the PLCs, but it does require a certain level of skill to interpret the data, which most technicians at manufacturing sites do not have. More training is required to allow for this change.

Most of the waste heat produced by the refrigeration system is released into the environment. The waste heat could be captured and converted to power to feed back into the refrigeration system. Some sites have deployed heat recovery and reuse, but not all.

Phase-change materials (PCMs) can be used to store cold energy on manufacturing sites and in cold chain transportation such as shipping containers, but it has not been adopted extensively to date.

Both ammonia and carbon dioxide are natural refrigerants with low GWP. They are slowly being adopted as a replacement for F-gas refrigerants. However, there are still concerns over the toxicity of ammonia and the high operating pressures required for carbon dioxide compared with F-gases.

A better understanding of the impact that refrigerant charging has on the cold chain system is required to take advantage of opportunities to improve the efficiency of the chiller system and make the most of the thermochemical process.

## What skills and training might be required to solve this challenge?

Training is required for the manufacturers and retailers using the refrigeration technologies, as well as the refrigeration contractors who are installing and servicing the refrigeration units for their customers.

Chilled spaces need to be modelled on a regular basis to get a better understanding of areas that are optimal and areas that are undercooling. Better controls to automate and balance the system to accommodate for the changing use of the space are needed, as well as training for the refrigeration technicians who will be managing the system to optimise performance.

Manufacturers need support to understand the best options for their cooling demand. A directory of 'certified' companies would help end users know who to approach (e.g. ISO9001), but this requires training to ensure the expertise meets the standard of the accreditation.

## How do we ensure that the solution is adopted by end users?

Financial incentives are required to encourage the adoption of energy efficient Net Zero technologies (e.g. tax credits, enhanced capital allowance, interest free loans). Public funding is required to encourage the adoption of innovative temperature-controlled vehicles like EVs (e.g. resell cost for non-diesel alternatives).

Cold chain consumers need access to free advice to identify the measures required to reduce their energy consumption in relation to cooling. Demonstration events and case studies to promote best practice in their sector, as well as support for real options valuation to help select the best technology for the process, will encourage the adoption of Net Zero cooling.

## Potential sources of information

- British Refrigeration Association
- Institute of Refrigeration
- AREA (European trade association)
- DESNZ funded, Transport, Industrial and Commercial Refrigeration (TICR) project (2024)

# Conclusions

**The recommendations from the workshop are listed below. These recommendations are based on common themes from both cooling within buildings and refrigeration in industry.**

## Reduce the cost of switching to Net Zero cooling

Financial support is required initially to support the business case for transitioning to Net Zero cooling solutions. Financial options that drive good practice and incentivise the adoption of Net Zero cooling solutions could include:

- Government-backed bank loans for retrofit based on expected performance
- Tax credits which incentivise the adoption of energy efficiency
- Public capital investment to reduce the capital cost of retrofit
- Cooling-as-a-Service business models to reduce the operating cost of innovative solutions

## Improve and enforce regulations to encourage the adoption of Net Zero cooling

The need for improved regulations for refrigeration and the lack of regulations for cooling within buildings needs to be addressed. New regulations that encourage the adoption of Net Zero cooling approaches will deliver energy savings. Areas to be considered include:

- Building design
- Monitoring performance over time
- F-gas phase out
- Temperature-controlled transport and storage standards

## Train a skilled workforce to deliver Net Zero cooling

The lack of technical expertise to install and operate innovative cooling solutions is a barrier to adoption. We need a skilled workforce with knowledge of what innovative options are available and an understanding of how they operate so they can advise and encourage companies who require Net Zero cooling to consider the Net Zero alternatives. Training is required for:

- Installers
- Architects
- Refrigeration technicians
- End users of cooling

# Appendix 1

## Workshop participants

### Refrigeration

Cold Chain Federation
Envirya (on behalf of Pioneer foods)
Samworth Brothers
Lincoln University (on behalf of Tesco)
University of Birmingham
Sunamp
Cranfield University
Heriot Watt University
Refrigeration Developments and Testing Ltd
Magnavale
Star Refrigeration
Cool Ideas
Highnam Consulting
Environmental Process Systems Ltd

### Space Cooling

Northshore
Together Housing
Whitbread (Premier Inn)
Uni of Warwick
Centre for Sustainable Cooling
Cranfield University
University of Birmingham
Senergy
FeTu
Thermal Integration
Barocal
Camfridge Ltd
Committee on Climate Change
Innovate UK Business Connect

### Observers

Innovate UK
Policy Connect
Dept. for Energy Security and Net Zero

# Appendix 2

**Ranked list of challenges identified by the workshop participants**

**The following is a summary of the main challenges highlighted by the participants in order of priority based on the benefit that could be realised if the challenge was solved.**

## Cooling spaces in buildings

1. Retrofitting existing buildings: 15 votes
2. Building design and installation skills: 13 votes
3. Innovative business models to make cooling affordable: 11 votes
4. Insufficient grid capacity to meet demand: 6 votes
5. Equitable access to cooling: 5 votes
6. Changing behaviours: 4 votes
7. Inadequate regulations: 4 votes

## Refrigeration

1. Too expensive to finance: 22 votes
2. Skills and Mentoring: 19 votes
3. Regulation and compliance: 17 votes
4. Refrigerants (F gases): 16 votes
5. Social/consumer behaviour: 11 votes
6. Refrigerated transportation power storage: 9 votes
7. Performance of existing equipment: 7 votes
8. Resilience: 3 votes


**Head Office:**

Innovate UK Business Connect
Suite 218 Business Design Centre
52 Upper Street
Islington
London N1 0QH

03333 403251

enquiries@iuk.ktn-uk.org

**iuk.ktn-uk.org**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