Written evidence submitted by the Institute of Refrigeration

Heat Resilience and Sustainable Cooling - Environmental Audit Committee Inquiry 2023

Response from the Institute of Refrigeration Technical and Environmental Experts

The first part of this document provides high level summary answers to questions relevant to the science and practical application of refrigeration, air conditioning and heat pump technologies. It is supplemented by a Technical Annex at the end that provides more extensive technical information.

Part 1 - Introduction to Institute of Refrigeration

The Institute of Refrigeration is a registered scientific and educational charitable organisation with no commercial ties or representation. It is membership body for individuals working as engineers, technicians, teachers, researchers, and other relevant roles including technically knowledgeable users of refrigeration, air conditioning or heat pumps. It has over 2000 individual members and is registered with the Engineering Council as a professional affiliate. It represents the UK at the International Institute of Refrigeration. Its charitable objectives include the development of the science and practice of refrigeration in all its applications for the public benefit and to reduce its environmental impact. Reg charity no 1166869. Website www.ior.org.uk

The Institute has a programme of technical activity to help its members and users of cooling systems to reduce carbon emissions and achieve net zero. This activity "Beyond Refrigeration" identified seven areas to address: improved system performance (efficiency), using best low carbon technology, balancing heating and cooling demand, reducing the need for cooling (passive ventilation) , using energy intelligently, developing people and skills, working together to share expertise and achievements and finally whole system sustainability including circular economy.

Refer to Technical Annex section 1 for a list of essential activities that fall within cooling.

Part 2 – Answers to inquiry questions

How can sustainable cooling solutions and adaptation strategies be implemented in such a way as to minimise overheating, reduce energy consumption and prevent overloading of the electricity grid during peak demand?

To achieve these aims a policy makers need to gain a better understanding of what solutions are available and how they can be implemented and what policy mechanisms could support them.

The following inter-related factors are essential to achieving effective cooling solutions as part of an adaptation strategy.

1. Clear understanding of the types of cooling and where they are used, particularly for essential services such as medical and food related, as well as occupied buildings.
2. The co-ordination of policies for the adaptation of existing buildings that make up the majority of UK built environment, the improved the design standards for new buildings and the proactive maintenance of mechanical cooling in all buildings.

3. Specific strategies that target action at either an individual business/location, local network, regional or national level.
4. The need to recover, reuse and store waste heat and/or energy from cooling processes so that refrigeration is treated as flexible national asset, which supports demand side management policies.
5. Guidance, awareness and training for those responsible for specifying, setting design standards and most importantly using and maintaining mechanical cooling systems in buildings. This is essential to ensure that correct use of such systems and innovations to achieve maximum designed and operational efficiencies possible.
6. Better understanding of the impact of policy measures in these areas, how they interact and support sustainable cooling options.

In summary, effective sustainable cooling policies are going to be a critical solution to addressing overheating, energy management and emissions reductions issues. It must be recognised that cooling current provides essential services and is only going to be more critically important in the future in addressing climate change.

Refer to Technical Annex Section 2 for list of Opportunities for improving sustainability of cooling to support heat resilience.

What actions can be taken to protect those most vulnerable to the impacts of extreme heat?

Both passive design and efficient mechanical cooling plays an essential role in settings providing a safe environment for the vulnerable such as healthcare, schools or residential locations. This role is likely to increase given the aging population, the over-insulation of certain buildings and in many cases lack of natural ventilation. Actions to support the availability of safe cooled spaces during extreme heat events could include – ensuring mechanical cooling is functioning when needed by implementing mandatory seasonal system checks before they are expected to be put back into operation in the summer months. Strategies for managing mechanical or passive ventilation in existing and new buildings and support for local authority cool hubs will also be needed. Consideration should be given to extending Part O of the Building Regulations covering overheating of buildings to planned refurbishment and retrofit operations and not just new buildings.

To what extent do the Government's Climate Change Risk Assessment and National Adaptation Programme (as well as other related strategies such as the Net Zero Strategy and Heat and Buildings Strategy) identify and address the risks from extreme heat? (Note: The third NAP, covering the five-year period from 2023-2028, is expected to be published in the summer of 2023).

CCRA and NAP3 should acknowledge that the increase in extreme heat events and changes to the range of temperatures experienced will pose a risk not only to human health, but also to working and living environments. This applies equally to essential services and processes that require controlled temperatures – such as food manufacturing, storage and distribution, hospitals, pharmaceuticals and other essential high cooling demand infrastructure such as datacentres, switchgear operation and transport. Addressing the increasing demand for cooling to achieve heat resilience will require a "whole system" approach to energy policy that takes into account passive design, balancing the supply of electricity, the integration of local generation of renewables, the opportunities for load shifting afforded by refrigeration and heat pump systems, waste heat recovery and energy storage and the robustness of the supply grid in light of all of potential peaks in demand.

Does the current planning framework do enough to encourage heat resilience measures such as cooling shelters, water bodies, green infrastructure and shading to be integrated into urban planning? Where such measures are incorporated, how accessible and successful are they?

There is very little in the current planning framework that addresses the need to reduce the heat demand on buildings. Most national planning focusses on reducing heat losses through insulation. Rising average temperatures and increased extreme heat events are leading to overheating, insufficient ventilation and reduced indoor air quality that are having an impact on human health and economic activity in terms of suitability of building stock as a working environment. More needs to be done to ensure buildings have adequate natural or mechanical controlled ventilation strategies, as well as indoor air quality monitoring. Planning control should include an assessment of location of new buildings and location of installed cooling equipment to minimise heat gains – for example positioning cooling equipment on the north side of buildings in shade will provide more efficient and reliable operation, and positioning equipment to ensure an adequate fresh air supply onto equipment improves efficiency by avoiding warm air recirculation.

What can be done to protect the UK's existing public and private sector housing stock from the impacts of extreme heat while ensuring that homes are sufficiently warm in the winter months?

Whilst older building stock (pre-war) tends to have higher thermal mass (stone walls, heavier construction) and so is less affected by short term rises in air temperature, there are problems in achieving the same resilience in newer buildings which tend to overheat in summer and cool down quickly in winter. Strategies such as reducing draughts and air leakage that keep cool air out are not suitable for all homes. The balance between thermal mass of construction, thermal insulation and suitable ventilation is complex and suitable guidance is needed to more efficient use of energy in all housing stock. Technical guidance on retrofitting heating to old buildings is required to ensure adequate ventilation and insulation to avoid overheating, poor indoor air quality or other negative effects.

What role might reversible heat pumps (which can act as both heating and cooling systems) and other emerging technological solutions, such as the development of smart materials, play in meeting future cooling demands?

Reversible heat pumps used in domestic and small commercial environments offer the opportunity to achieve affordable, efficient and flexible heating in winter and alleviate the worst of the overheating in summer. But they must be correctly specified, installed and operated which remains a challenge. They should be seen as a cost-effective solution for existing and new builds, both in terms of cost of installation and operation. There are risks however that they will place an additional demand on the electric grid and peak demand loads.

Additional technical solutions are emerging rapidly. Policy makers, installers and building/homeowners will need to be kept up to date and should be provided with reliable information about when are how they can be deployed, cost/efficiencies achievable as well as information and awareness about how to use them most effectively to achieve predicted efficiencies.

How can cleaner refrigerants with low or zero global warming potentials support the UK's cooling needs while contributing to the national emission reduction targets?

Mechanical cooling systems using refrigerants can be responsible for either indirect (energy use) or direct (leakage of GWP gases) emissions. The indirect emission making up a far greater proportion of their total environmental impact. Refer to Technical Annex Section 3 for an explanation of refrigerant GWP categorisations, technical, safety and legislative considerations and limitations and Section 4 for explanation of the more significant impact of indirect emissions from energy use by cooling systems.

National policies to support direct emissions reduction should encourage:

- The design and use of systems containing a lower volume of refrigerant to avoid risk of direct emission through leakage or end of life.
- More stringent enforcement of current leak prevention, management and reporting requirements under the F Gas Regulations (currently under review by DEFRA) and more effective action to restrict the supply of banned high GWP equipment or refrigerant to the market.
- Mandatory training related to the use of the lower GWP refrigerants (as part of the forthcoming UK F Gas legislation review) to include refrigerant management practices to prevent leakage and ensure system operational efficiencies are achieved and maintained. System efficiency is adversely affected by leakage of even low GWP refrigerants. A national register of trained operatives to ensure the use of only skilled workers is also recommended.
- A requirement for planned preventative maintenance regimes will significantly reduce the risk of leakage and identify opportunities to improve efficiency, where system users currently rely on reactive service work to carry out remedial activity.
- Other policy measures that will help to achieve national emissions reduction targets in the face of increasing demand for cooling systems include: EcoDesign (equipment), PEERS (commercial buildings), Climate Change Levy (sector energy reduction targets).

How effectively is the Government working across departments and with local authorities to ensure a coordinated approach is taken to heat resilience?

The cooling sector deals with many different departments such as DESNZ, DEFRA and DLUHC as well as agencies such as Local Authority Planning, Environment Agency and across many schemes such as Energy Labelling, Enhanced Capital Allowances, Climate Change Levy Energy Technology List. This is a potential weakness in introducing effective policies and regulatory frameworks.

An example of this is the proposed acceleration of F Gas Regulation phase down of higher GWP refrigerants at an EU level that, if adopted in the UK, would have a negative impact on the ability to meet government targets to encourage wide scale take up of heat pumps that rely on those refrigerant types.

An example of success is one Government Department taking the lead to clarify that the reduced VAT scheme for reverse cycle heat pumps needed to be reintroduced as this technology would reduce energy use.

There are opportunities for improved co-ordination across departments in the areas such as Training programmes that include heat resilience content in apprenticeships, T levels, upskilling of existing operatives working at all levels, registration schemes (e.g., MCI), potentially a role for Department for Education. Awareness programmes that ensure those involved in Planning Control as well as those managing public sector buildings such as schools, hospitals and the government estates have an understanding these issues and mitigation opportunities. National energy supply strategies that support low carbon options for heating and cooling technologies such as heat pumps and networks, energy storage and distribution, DSM. Where current polies act as a disincentive on the financial viability of some of these options. See Technical Annex section 5 Energy Policy for further details.

Does the UK need a dedicated Heat Resilience Strategy**? **What lessons can be learned from other nations when it comes to national strategies for heat resilience?

A heat resilience strategy would be welcomed but on its own is not considered sufficient. It must be coordinated with a national energy strategy and a national cooling strategy that will provide a robust and comprehensive approach to achieving net zero decision making. This would take into account not just the adaption of existing buildings, but the opportunities for reducing national reliance on less environmentally benign energy sources and achieving the potential to recover waste heat from cooling processes.

There is considerable potential to support British businesses and innovations in this area. UK engineers are globally acknowledged experts in cooling. This would lead to job creation, increased skills and training, expertise and technology export, and a global showcase of case studies to demonstrate what can be achieve both in terms of adaption to climate change and emissions reduction.

This would also lay the foundation for co-ordinated Government action taking a more proactive role in supporting effective legislation or financial incentives, as well as having a direct role in ensuring that initiatives and activity currently managed by industry groups are more widely adopted and adhered to such as the Climate Change Levy, Cold chain temperature monitoring policies and development of Green Skills.

This sector recommends that a national heat resilience strategy should focus on achieving the following:

1. Long-term commitment to policies and priorities that provide those investing in buildings and developing technologies a degree of certainty around both short- and long-term purchasing decisions.

2. Reduction of carbon emissions from cooling (direct and indirect) to reduce potential increased or spikes in the load on the energy grid due to extreme heat events and rising temperatures. It should be supported by an assessment of areas of future electrical constraint due to climate driven cooling and electric vehicle uptake.
3. Specific proposals for action by businesses, cities, combined authorities/local/national authorities and standard setting bodies and the identification of critical assets at risk from climate change (such as hospitals, food chain, pharmaceuticals, transport etc).
4. Support for the adoption of innovative technologies and wider take up of low carbon technologies, particularly wider adoption of integrated of heating and cooling across businesses, waste heat recovery/storage/reuse, local energy generation and grid sharing, local energy storage and distribution, demand side management and load shedding.
5. Setting of minimum Performance Standards. For example, using existing policy frameworks EcoDesign, PEERS (Nabors) ECA, CCL to introduce minimum standards and incentives to invest in more efficient technologies as well as requiring proactive planned maintenance to ensure continued efficient operation is achieved and monitored.
6. A requirement for businesses to carry out Climate Risk Assessments to identify and reduce the risks resulting from climate hazards and explore opportunities to build adaptive capacity and to produce individual Adaptation pathways to identify and prioritising specific actions over time in line with BSI standard BS 8631:2021 Adaptation to climate change – Using adaptation pathways for decision making – Guide.
7. The production of long-term Resilience Buildings Plans to ensure new projects are being planned to adapt for the future and take into account predicted weather changes during their lifetime. This involves an integrated design practice so that at each stage of a project, decisions are reviewed to ensure heat resilience risks and opportunities to reduce carbon are incorporated.
8. Actions that address skills shortages in engineering at all levels and improve the skills of the existing workforce to specify, install, maintain and explain how new technologies are used.
9. Improved international collaborative research in order to share UK expertise and to learn from other country adaptation strategies on a rolling basis.
10. Co-ordinated Awareness campaign to influence behaviour of sectors of the public of practical solutions and technology options/operation.

Part 3 – Technical Annex

Section 1 - What do we understand by "cooling"?

The term Cooling is very broad and incorporates refrigeration, air conditioning and heat pumps to control temperature - technologies that play a little recognised but essential role in day-to-day life for the general public, the majority of business activities and many public sector services.

Mechanical refrigeration is essential for product cooling, freezing and storage at ambient or freezing temperatures, and temperature control. This applies to food and drink production, storage and distribution, retail and supermarkets, hotel and catering, industrial & manufacturing production such as mining, textiles, papers, chemical processing, pharmaceuticals and medical applications.

Air Conditioning is general considered to be refrigeration of spaces with additional air management requirements (ventilation and humidity control). This may include populated spaces such as offices, shops, medical facilities, schools, leisure facilities and public transport. It also includes industrial and commercial premises that need to provide safe working environments including scientific and research labs requiring controlled environments. It is also essential for Datacentres and Telecommunications such as dedicated datacentres, computer rooms and similar facilities.

Heat Pumps embraces a variety of technologies and applications using refrigeration technology, from basic reversable heat pumps that can be used in small commercial premises or homes that can provide both heating and cooling and larger scale integrated systems to recover waste heat and distribute cooling in schools, offices, hotels, housing complexes (district heating/heat networks) etc. Ground Source & Water source Heat Pumps extract heat from natural resources and distribute this to a building, using refrigeration technology to provide sustainably sourced heating but not necessarily providing cooling.

The number of people employed directly in the RACHP industry is large and includes service and maintenance businesses, technicians, designers and consultants, contractors and installers as well as other areas such a manufacturing, distribution and wholesale of equipment. It is estimated from F Gas Regulation registration figures that there are at least 50,000 individuals working as service technicians alone and 7,000 businesses operating in the service sector. In many cases, most are micro businesses or SMEs, although there are some companies employing 500+. In addition, many more people are employed indirectly in management, manufacturing, research and design processes and applications involving RACHP. There are over 1000 apprentices currently studying RACHP.

Employment opportunities are growing in the sector and there are reported skills shortages throughout – from new entrant trainees, qualified technicians through to design engineers.

Section 2 – Opportunities for improving sustainability of cooling to support heat resilience.

a) An integrated approach to building and processes / building services design to ensure that new buildings that require cooling are planned to achieve efficient low energy operation and provide sufficient flexibility to address changing use and forecast temperature changes.
b) Robust design standards for new buildings including reducing of cooling load, improved materials of construction (i.e., insulation properties), orientation of the building, reduced air ingress, minimising solar gain and optimising business operation to avoid cooling where possible. This should include evaluation of potential to avoid mechanical cooling (e.g., passive ventilation) altogether whilst acknowledging that there are many circumstances where it is essential to preserving human health and economic activity (e.g., medical, food supply etc)
c) Reliable guidance to encourage specification and use of new low carbon technologies that are proven to reduce emissions, provide acceptable return on investment.
d) Attention to planned preventative maintenance and building/cooling system performance to ensure it continues to operate to design efficiencies (recommissioning), identifying barriers and opportunities to improve.
e) Adaption of existing buildings and incentives to retrofit more energy saving technologies. Many existing buildings will contain cooling systems over 10 years in age and make up the largest proportion of mechanical cooling systems currently in operation.
f) Use of low carbon cooling technology solutions
g) Recognition of opportunities to use cooling as a flexible asset – demand side response and load shedding, energy and thermal storage, heat recovery from various sources including river water, mines, industrial processes, datacentres, waste management facilities etc.

h) Skilled, trained and knowledgeable workforce to carry out design, installation and maintenance activities and well informed and incentivised building owners operating and managing the buildings.

The following are some examples to illustrate sustainable cooling approaches:

Heat rejected from cooling applications i.e., from cold stores, supermarkets, datacentres, industry, etc. can be recovered, thus improving the efficiency of cooling system/reducing heat rejection to ambient/reducing heating demand in the building and potentially supplying surplus heat to nearby buildings via heat networks.

Integrating of cold and hot thermal storage with reversible heat pumps and renewable power (solar PV and wind) allows for demand side response avoiding overloading the electricity grid and minimizing grid reinforcement required.

The following are examples of common problems associated with poor maintenance or location:

Air recirculation at condensers is a problem which can add several degrees to the condensing temperature for any given ambient and so can add up to 10% to the power requirement. The location of the equipment is a factor, but positioning of other equipment nearby can also have an effect. Condenser fouling with dirt over time also has an effect. Surveying equipment to see whether benefit can be achieved through re-engineering, repositioning or even just cleaning is valuable and as ambients increase it can make the difference between continued operation or system failure.

Equipment location is often neglected and located in wells or tight spaces, resulting in recirculation which increases air temperature on condenser. This leads to higher energy consumption and reduced reliability.

Section 3 Refrigerant GWP

Use of a low GWP refrigerant will only affect the smallest element of emissions from cooling systems – that of direct emissions (if refrigerant is allowed to be released form the sealed system). Whilst it is recommended that where possible and in line with safety priorities the refrigerant with the lowest possible GWP should be used it must be recognised that many other aspects associated with the design of a system, such as type of cycle, heat exchanger design, compressor selection and control strategies and effective maintenance regimes, can have a far greater impact on efficiency than selection of refrigerant. For many types of equipment, there already exist minimum efficiency requirements (EcoDesign) so that irrespective of the refrigerant used, equipment has to achieve or exceed an efficiency threshold. Whilst most refrigerants will be able to meet such requirements, some may require greater investment in system materials than with others.

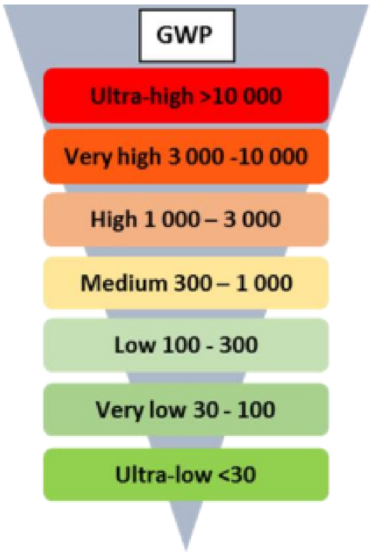
The wider adoption of hydrocarbon refrigerants with negligible GWP might offer the opportunity to gain system energy efficiencies as well as ensuring low global warming potential in the event of a refrigerant release. Current fluorinated refrigerants proposed for heat pumps are R-32 (with a "moderate" GWP of about 675) or R-1234yf (with an ultra-low GWP of about 1). Hydrocarbons Propane and butane have more suitable thermal properties, but their flammability is currently considered to be a risk factor.

Refrigerants are classified between Ultra-high and Ultra-low by the United National Environment Programme TEAP Task Force Report (see below from UNEP OzonAction Kigali Factsheet 4 on Low GWP Fluids and Technologies).

Selection of Lower GWP Alternatives:

The most widely used HCFCs and HFCs all have "high" or "very high" GWP. Ideally, all applications would switch to the "ultra-low" category. This category includes the three most common not-in-kind (NIK) fluids – ammonia, CO_2 and hydrocarbons (HCs) together with several recently introduced fluorocarbons called HFOs[2].
However, not all applications are suited to the currently available ultra-low GWP fluids. For example:

- HCs are well suited to small sealed refrigeration products (such as domestic refrigerators) but cannot be used for many types of larger equipment because of the safety issues related to flammability.
- HFOs are well suited to medium and large sized air-conditioning water chillers, but cannot achieve the same level of energy efficiency as higher GWP fluids for small and medium sized split air-conditioning.



Based on TEAP Task Force Report

The designers of products and equipment that currently use HFCs need to seek lower GWP alternatives that provide the best compromise in terms of a range of different performance criteria, including:

1) High energy efficiency
2) Safe operation
3) Competitive capital and operating costs
4) Good environmental performance

It is important to remember that good environmental performance in most HCFC and HFC markets is a combination of high energy efficiency (to minimise emissions of energy related CO_2) and low GWP. The best overall environmental performance could be based on the use of a medium GWP fluid if that provides the highest energy efficiency and if leakage emissions can be minimised.

Section 4 Direct and Indirect Emissions

Indirect Emissions from energy use during operations makes up the largest emissions factor for cooling systems. A positive impact on reducing both direct and indirect emissions can be achieved by ensuring that systems are well-designed, well-maintained and well-managed throughout their life – improving system efficiency in operation and reducing likelihood of refrigerant leakage.

A. Energy and carbon emissions (indirect)

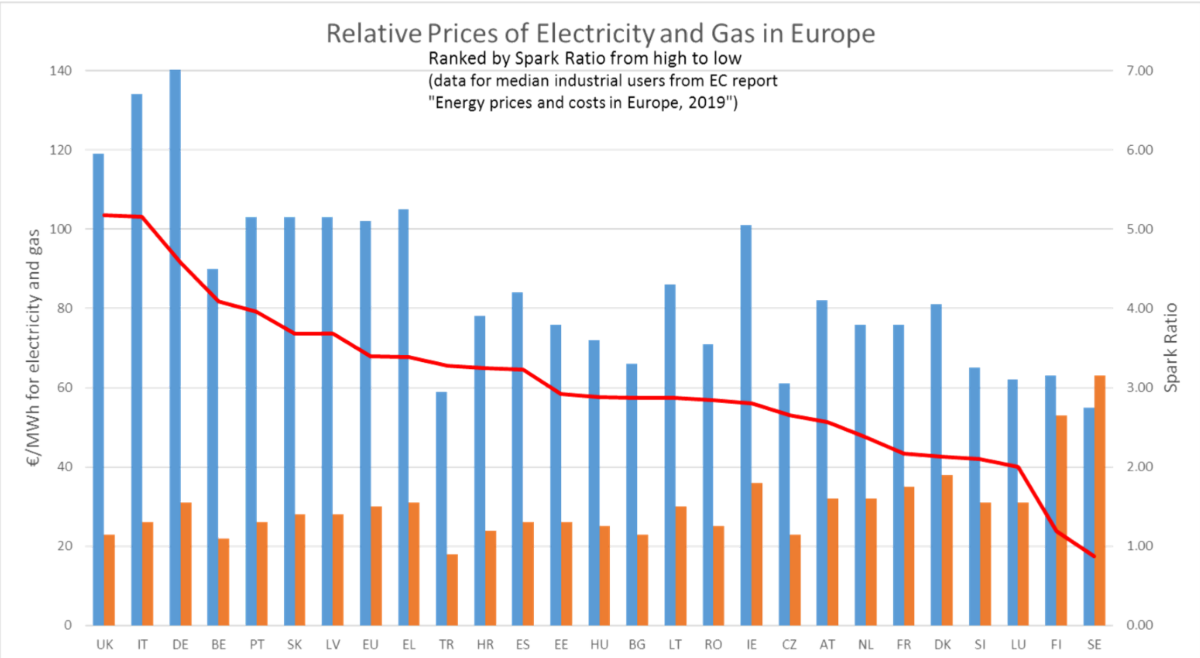
The largest environmental impact of the sector is through energy use. Currently, 10% of greenhouse emissions and 16% of the UK's electricity consumption are estimated to be attributed to the use refrigeration, air conditioning and heat pump equipment according to the Carbon Trust. A good example of such an area is the food industry where refrigeration energy use is high - the food industry is responsible for 12% of the UK's industrial energy consumption and uses over 4500 GWh/yr of electrical energy.

B Refrigerant emissions (Direct Emissions)

The sector has also made considerable progress in moving away from the use of higher GWP refrigerants and towards low or very low GWP refrigerants in recent years. The EU (UK) F Gas Regulations have implemented mandatory phase down programme that have supported these moves. In additional industry training and awareness initiatives and new technologies have made these changes possible for most sectors and continue to encourage the move to lower GWP refrigerants. Leakage rates have reduced substantially since the introduction of the F Gas Regulation leak checking and training, demonstrating that effectively implemented regulation can help to drive change.

Section 5 Energy Policy

There is significant disconnect between government departments in terms of energy policy. For example, heat pumps are promoted (or other forms of electric heating) but the taxation regime in the UK is heavily biased towards gas consumption. Hence the financial case for heat pumps is very weak. In some European countries gas is already more expensive than electricity (on a per kWh basis). The reason for the UK's disparity is primarily the amount levied in taxation on each fuel. The lack of a national strategic planning function for the energy supply system (including electricity, gas, oil, petrol, heat) means that investment is not correctly placed; either because of the need for market operators to achieve short term returns or simply because they are not incentivised. Achieving a coherent response to the specific issues of heat resilience strategy is extremely difficult, therefore.



Recent announcements about investing in oil and gas exploration and blocking the necessary investment in reconfiguring the electricity distribution network to account for intermittency only serve to increase this disconnect, making it more difficult for people to choose to invest in sustainable cooling and heating. The additional grants of oil and gas licences is working against national carbon emissions reduction targets.

Institute of Refrigeration

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