Reducing carbon emissions in Transport, Industrial and Commercial Refrigeration

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eurammon Symposium, 26th June 2023

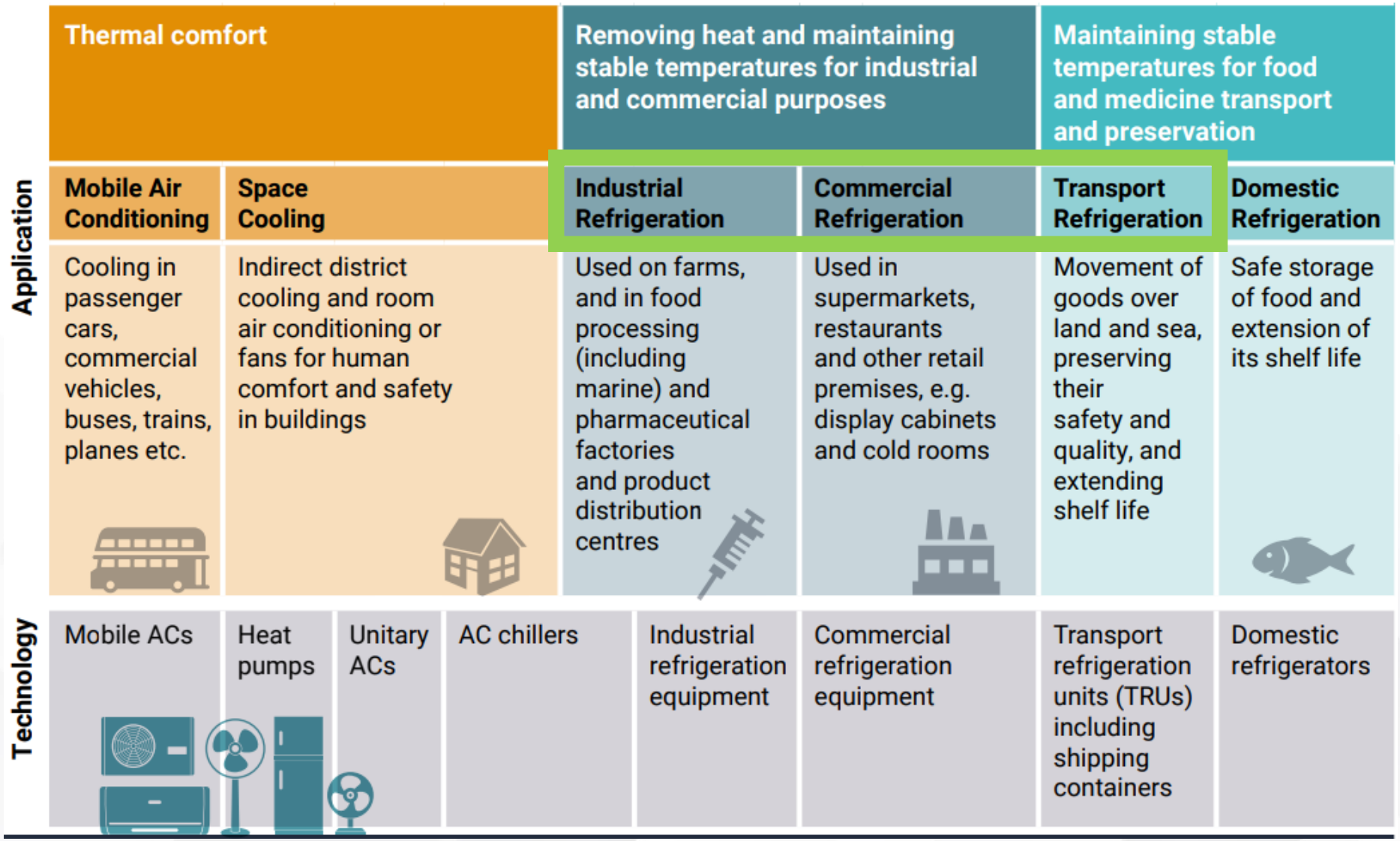
eurammon

refrigerants delivered by mother nature

OUTLINE

- Cooling applications
- Transport, Industrial & Commercial Refrigeration (TICR) project scope
- UK TICR scope 1 and 2 emissions – initial research
- Future work: benchmarks, roadmaps and training materials
- Net zero refrigeration by 2050:
    - What TICR could look like in 2050
    - How to get there: barriers, enablers and opportunities

COOLING APPLICATIONS



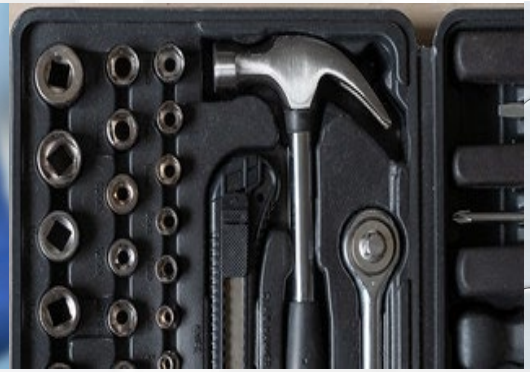
TICR PROJECT SCOPE

A **data driven whole-systems approach to support decarbonisation** and **innovation strategies across all six sectors**

Determine refrigeration Carbon emissions

Develop Models & Roadmaps

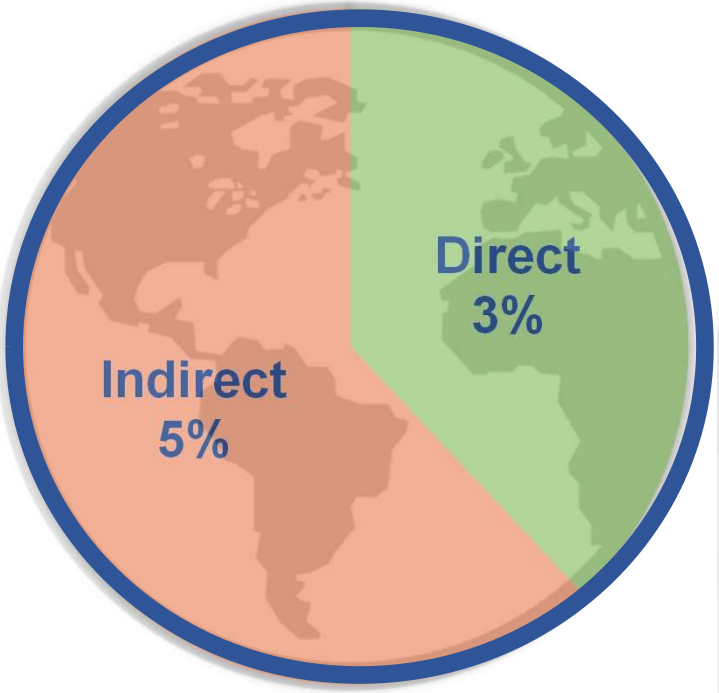
Develop Benchmarks



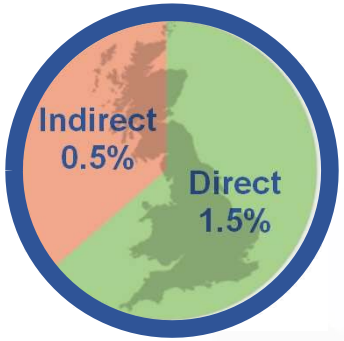
Develop Training materials

Identify Policy opportunities

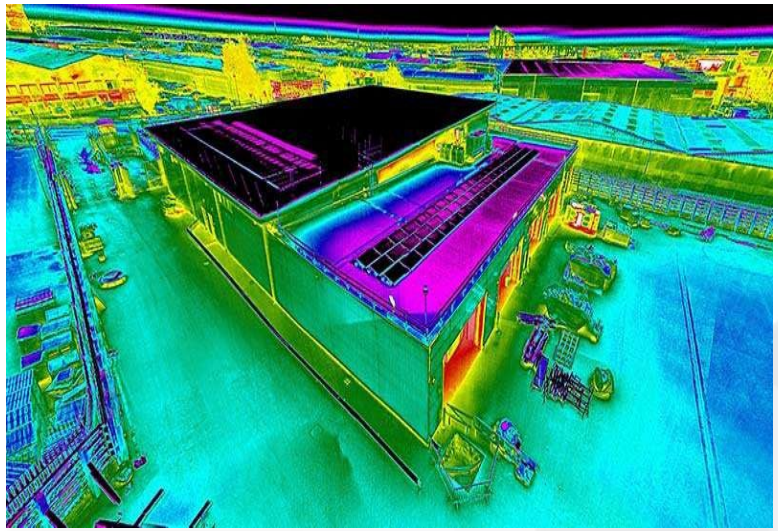
REFRIGERATION CARBON EMISSIONS



Global Emissions



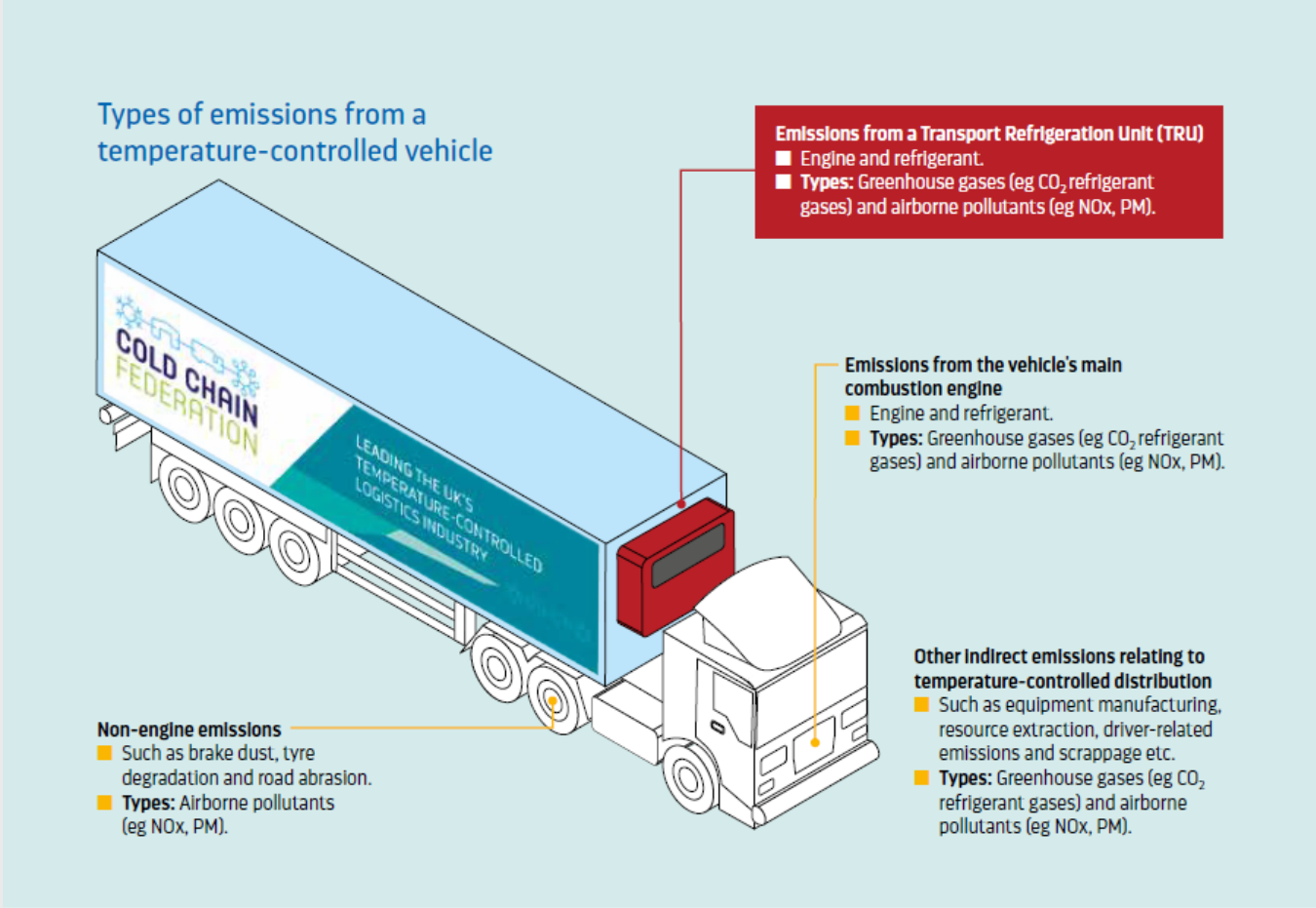
UK Emissions



Site surveys

https://www.gov.uk/government/statistics/digest-of-uk-energy-statistics-dukes-2022

TRANSPORT REFRIGERATION



Cold Chain Federation (2020)

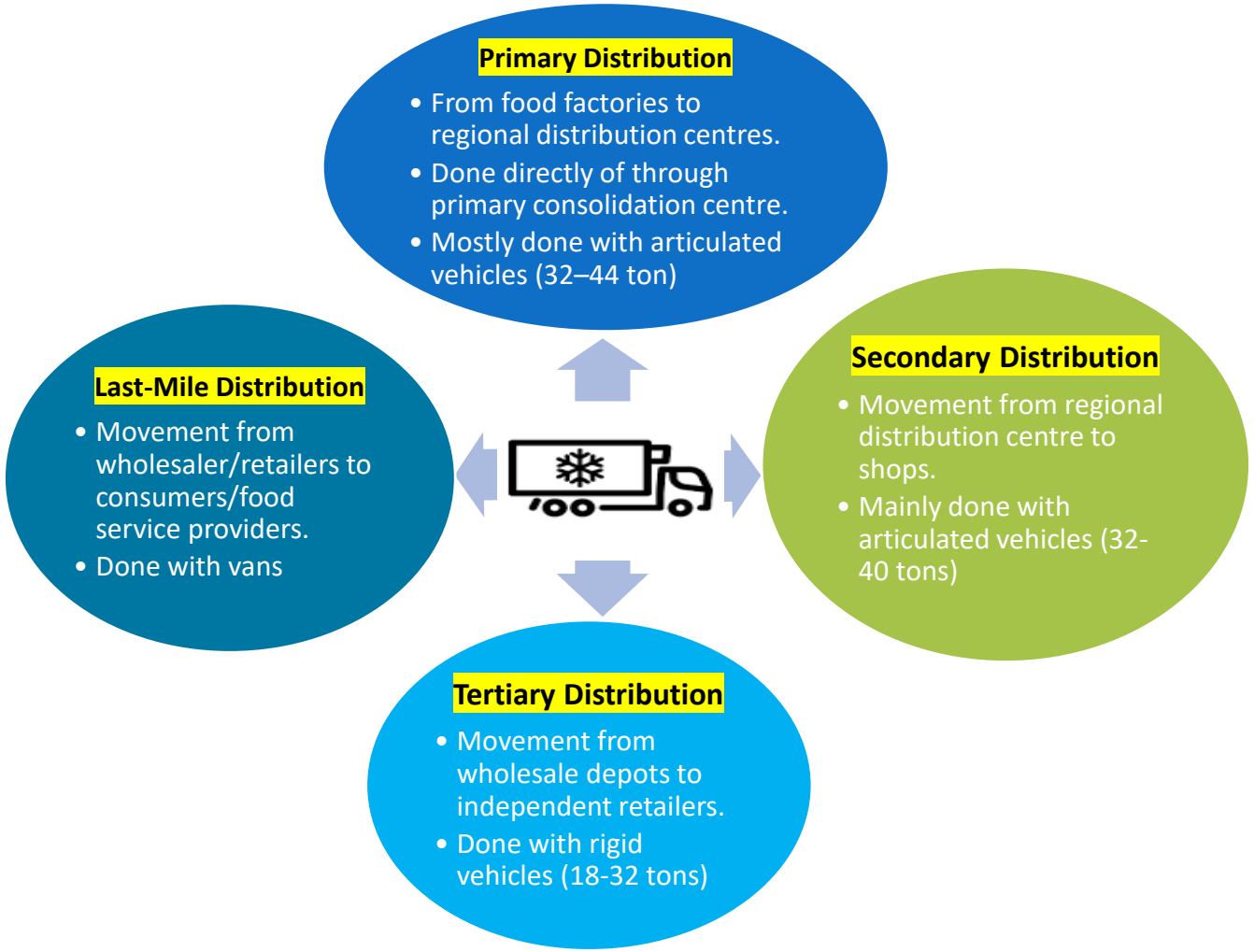
The current size of the fleet in the UK is not accurately known

- Cold Chain Federation estimated 70,000 TRUs:
  - 30,000 of trailers
  - 15,000 trucks
  - 25,000 vans
- CENEX (2021) estimates 100,000

refrigerated vehicles operating within the UK

Survey being carried out in partnership with DfT to estimate total no. of TRUs in the UK

TRANSPORT FOOD DISTRIBUTION



Refrigerated Transport Sizes:

Depending on the place along Cold value chain, various sizes of vehicles are used:

High Goods Vehicle (HGV): A lorry with a plated weight of 3.5 tonnes or more. This can be rigid (>3.5 <26 tonnes) or Articulated (>26 tonnes)

Light Commercial Vehicle (LCV)/Light Goods Vehicle (LGV)- Vehicles with gross weight of under 3.5 tonnes

Except for the last mile all distribution stages use HGVs

TRANSPORT & LOGISTICS STAKEHOLDERS

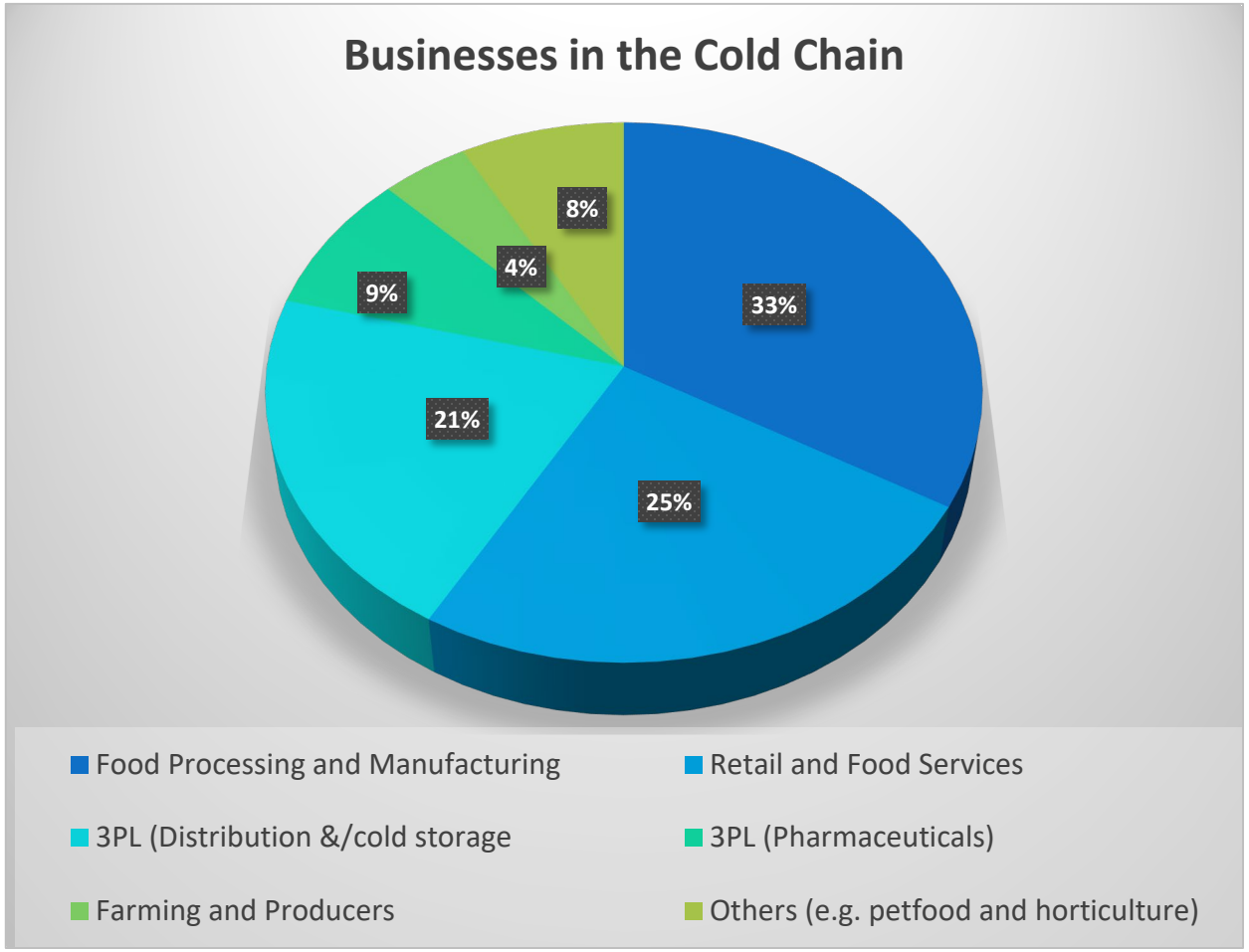
- **Third Party storage**: Public' cold stores operated by independent third-party logistics providers (for chilled and frozen customers along cold food chain)
  - Uses HGV (trailer and rigid trucks) and LCV)

- **Retail and Food service**: 'Private' cold stores operated by major retailers and food service providers (regional distribution centres and hubs by e.g. Aldi Sud).
  - Uses HGV (trailer and rigid trucks) and LCV)

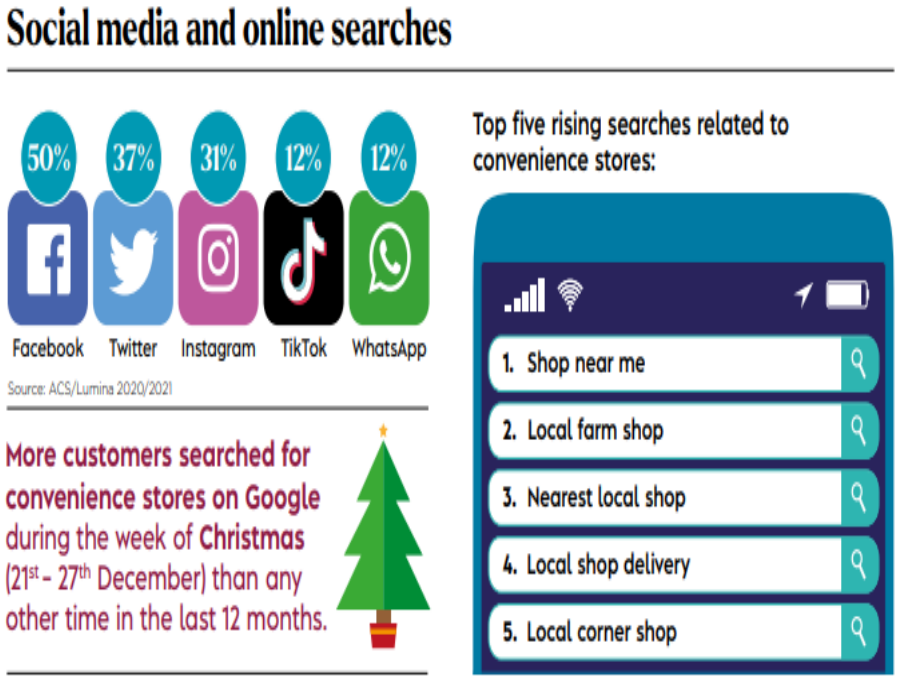
- **Processing and manufacturing**: 'Private' facilities owned manufacturers. Uses HGV (trailer and rigid trucks)

- **Farming and Producers:** 'Private' facilities on farms associated with the storage of fresh produce after picking.
  - mostly HGV (trailer and rigid trucks)

- **Specialist warehouses** (mostly rigid trucks and LCV)



TRANSPORT EVOLVING BUSINESS MODEL



Association of Convenience Stores (2021). The Local Shop Report 2021

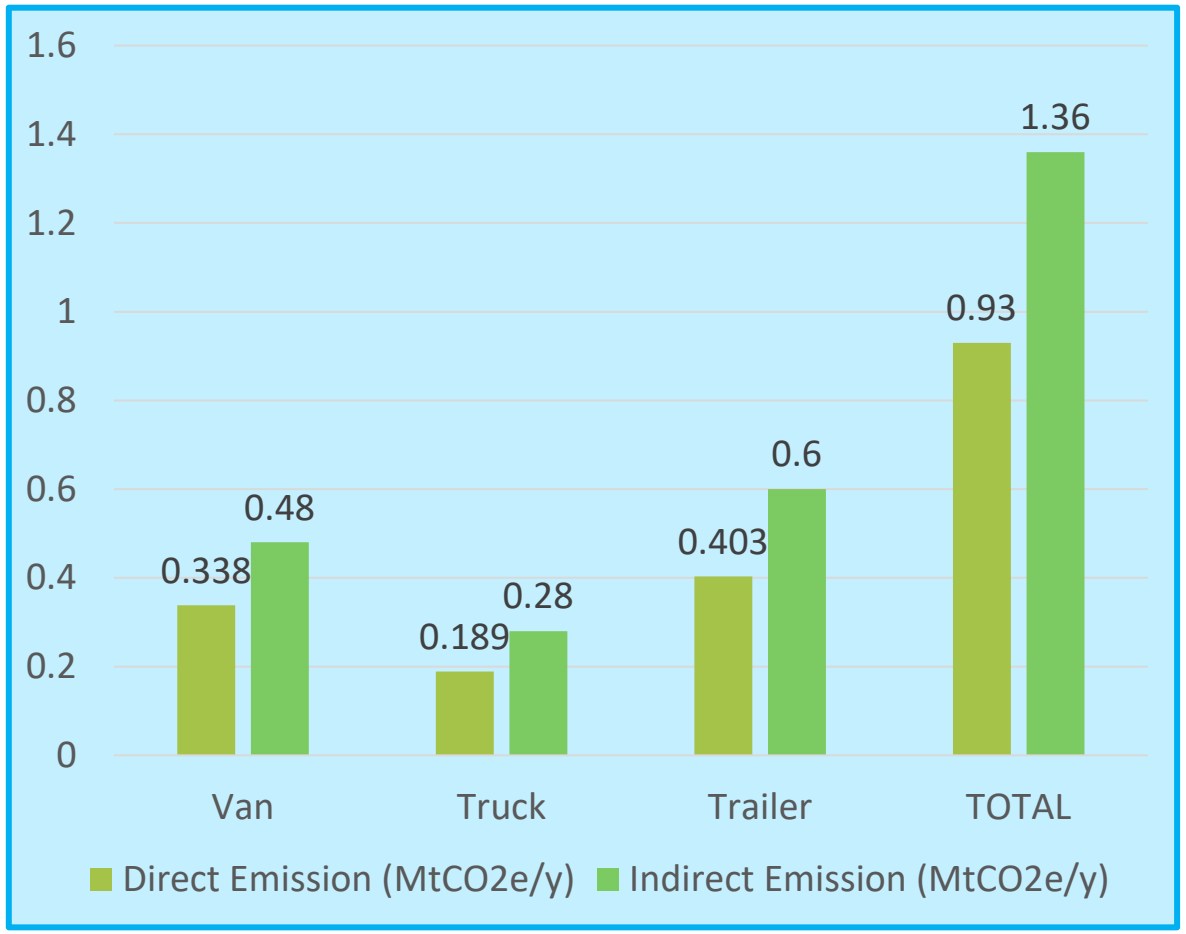
Changing in consumer preferences towards **online shopping, purchase of local foods, increasing preference for frozen foods** are shaping the future business model. The trend is changing towards:

- Shifting towards online purchase will lead to increase number of LCV on the roads.
- Increased preference for local purchase of food is pushing big retailers towards Local Shops or Convenience Stores.
- Transportation modal shift to rail system and reduced usage of articulated HGV for primary and secondary distribution may be possible soon.
- Use of e-bike for last mile delivery is becoming more pronounced. ASDA is currently on a pilot with Deliveroo

TRANSPORT EMISSIONS

- **Scope 1 emissions-** Direct emissions from fugitive refrigerants of TRU units.
- **Scope 2 emissions –** Indirect emission from fuel consumption or electricity used to drive TRU unit while on standby.

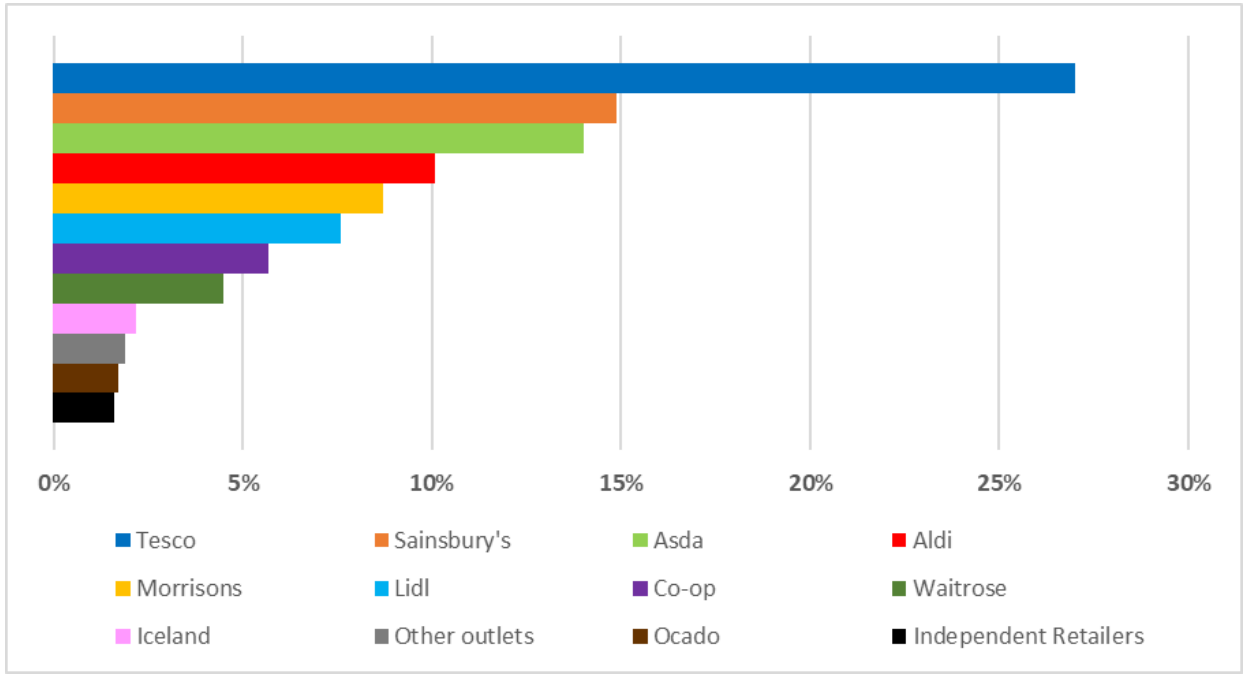
The total road transport refrigeration emissions within UK is estimated at **2.30 MtCO2e/ year** of estimated **100,000 road transport refrigeration vehicles** currently in use.



COMMERCIAL: RETAIL & COLD STORES

Major energy users within the UK food industry

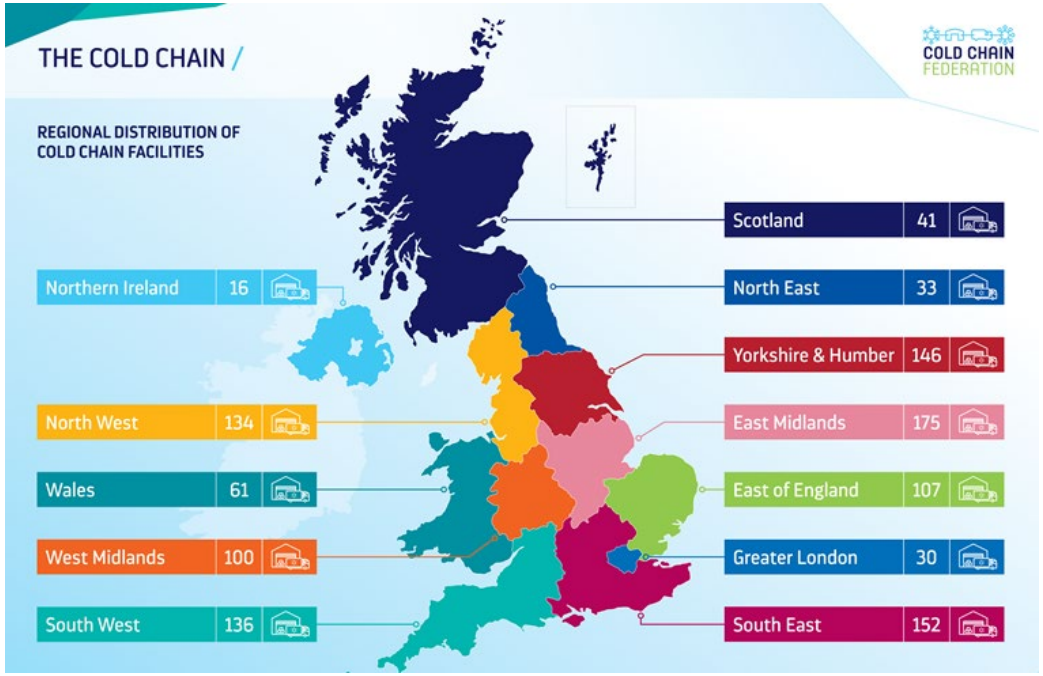
Retail Refrigeration



Market shares for major retailers in the GB grocery market [Kantar Group, 2023].

- 6,578 supermarket stores (>280m^2) in 2010 [Tassou et al.]
- Biggest sector in the agri-food chain (31% of total GVA)
- 10.9 TWh and 4.01 MtCO_2e from 10 major retailers

Cold Stores



Distribution of UK Cold Chain facilities [CCF, 2022].

- CCF members: 453 stores w/ ~40x10^6 m^3 total volume
- Estimated to be worth ~£20 billion to UK economy
- 3.5 TWh of primary energy and 0.46 MtCO_2e emissions

RETAIL REFRIGERATION

Research methodology to estimate energy use and emissions

UCL data from CaRB2 model

5,984 stores

Filtering relevant VOA SCats

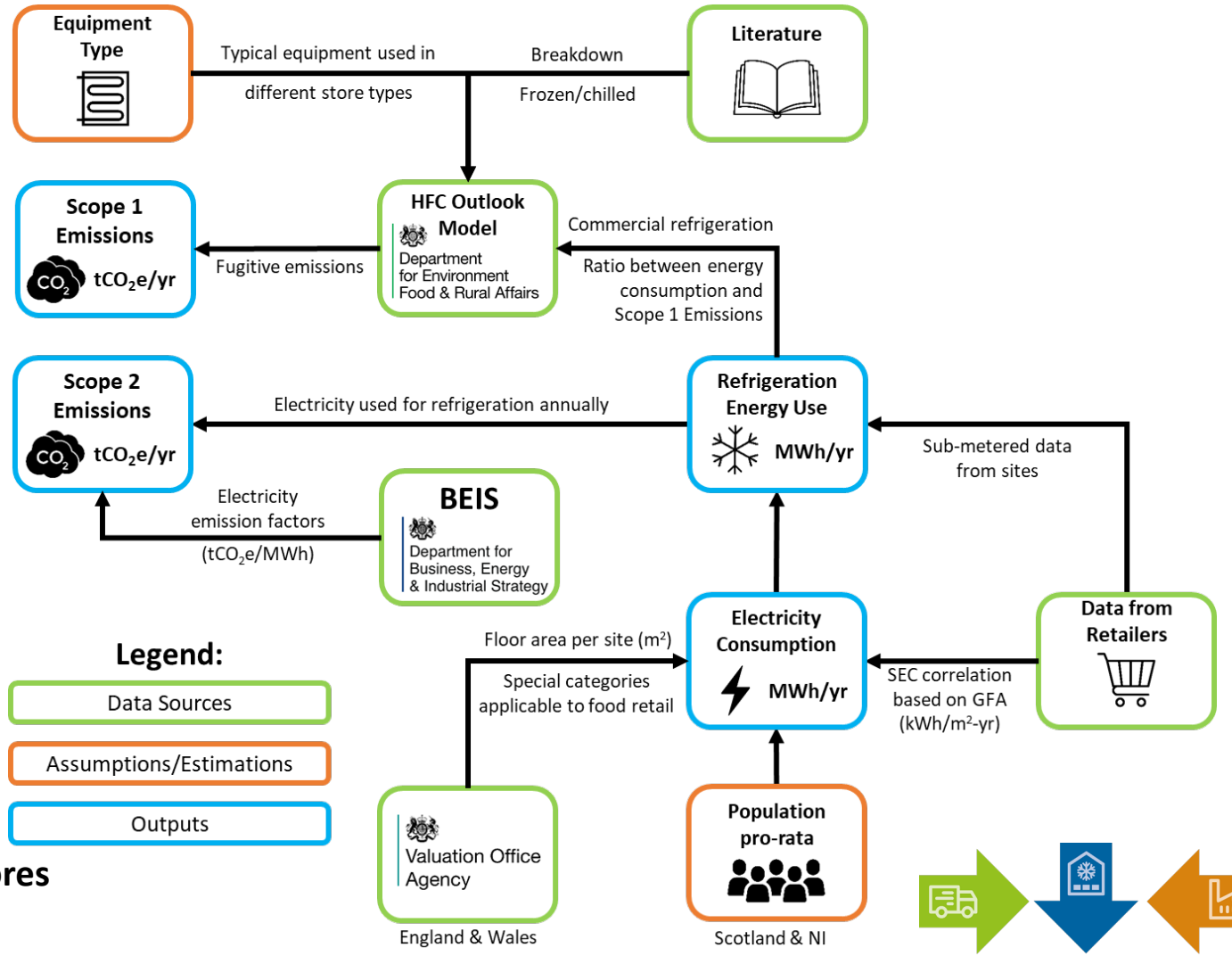
6,475 stores

Search for major retailers and keywords

1,336 stores

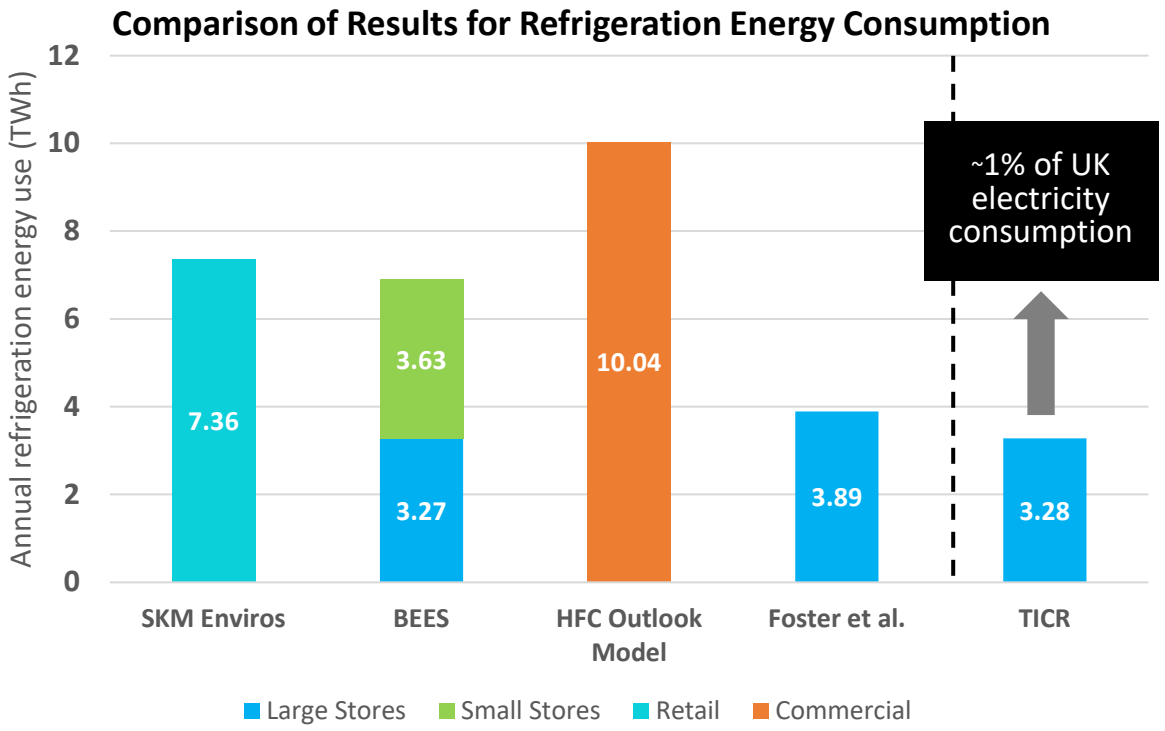
7,400 convenience stores (<280m² SFA)
6,395 supermarkets (>280m² SFA)

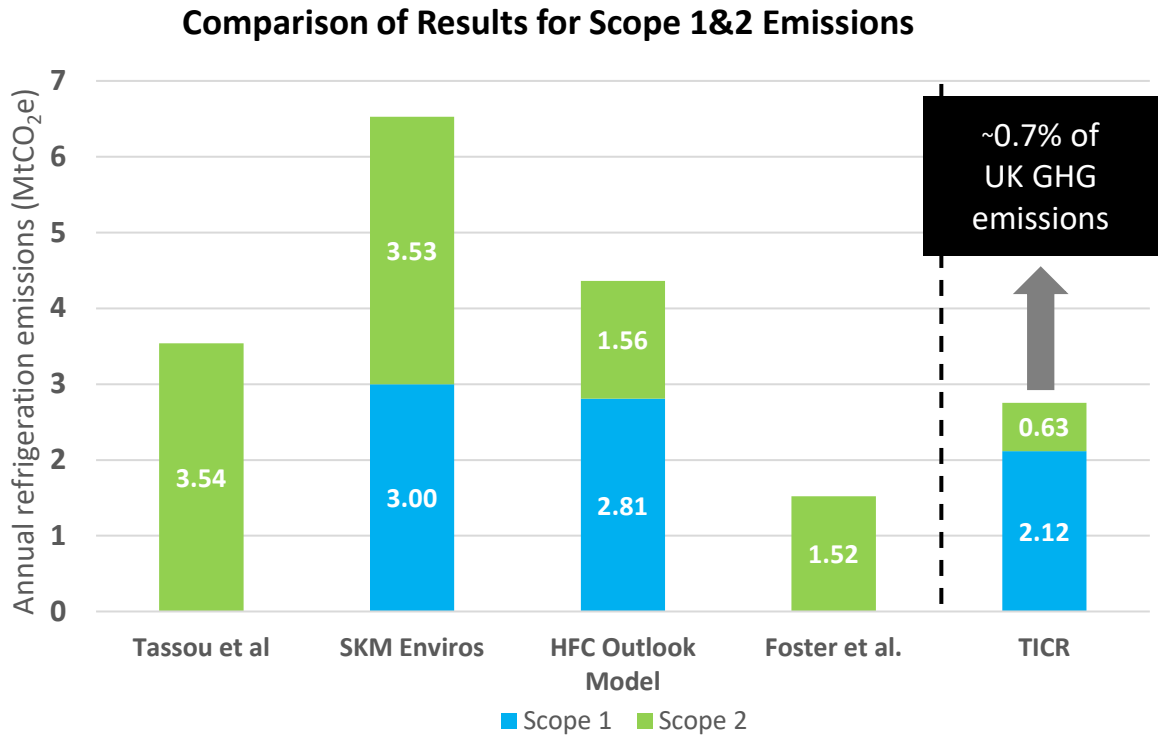
13,795 stores



RETAIL REFRIGERATION

Results suggest a good match for large stores (supermarkets)

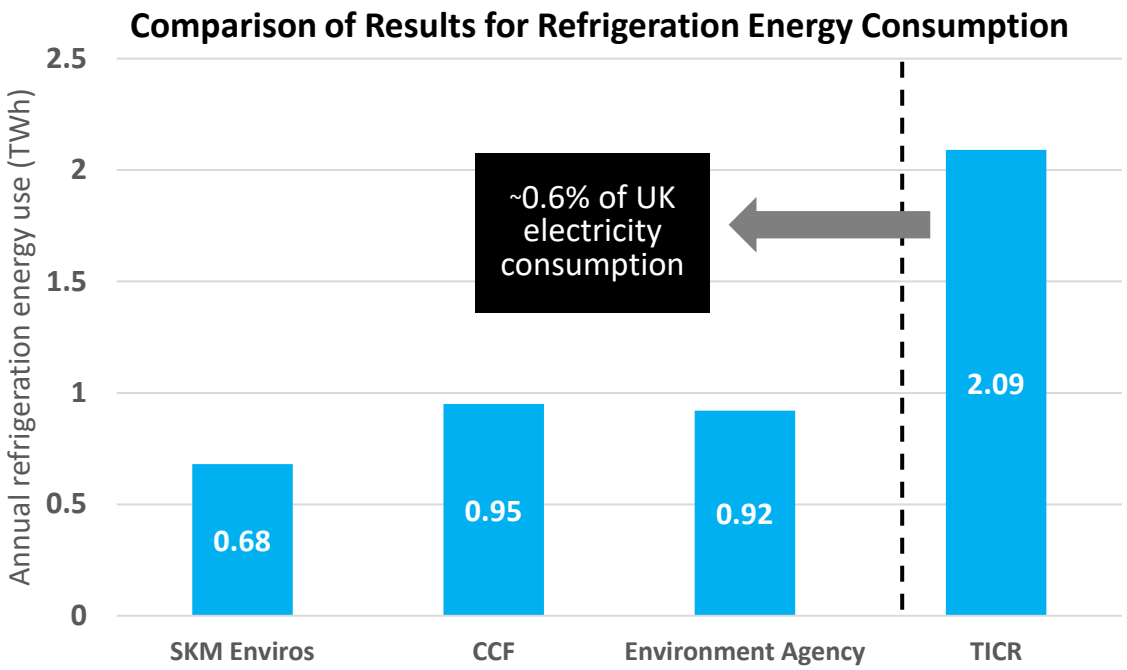


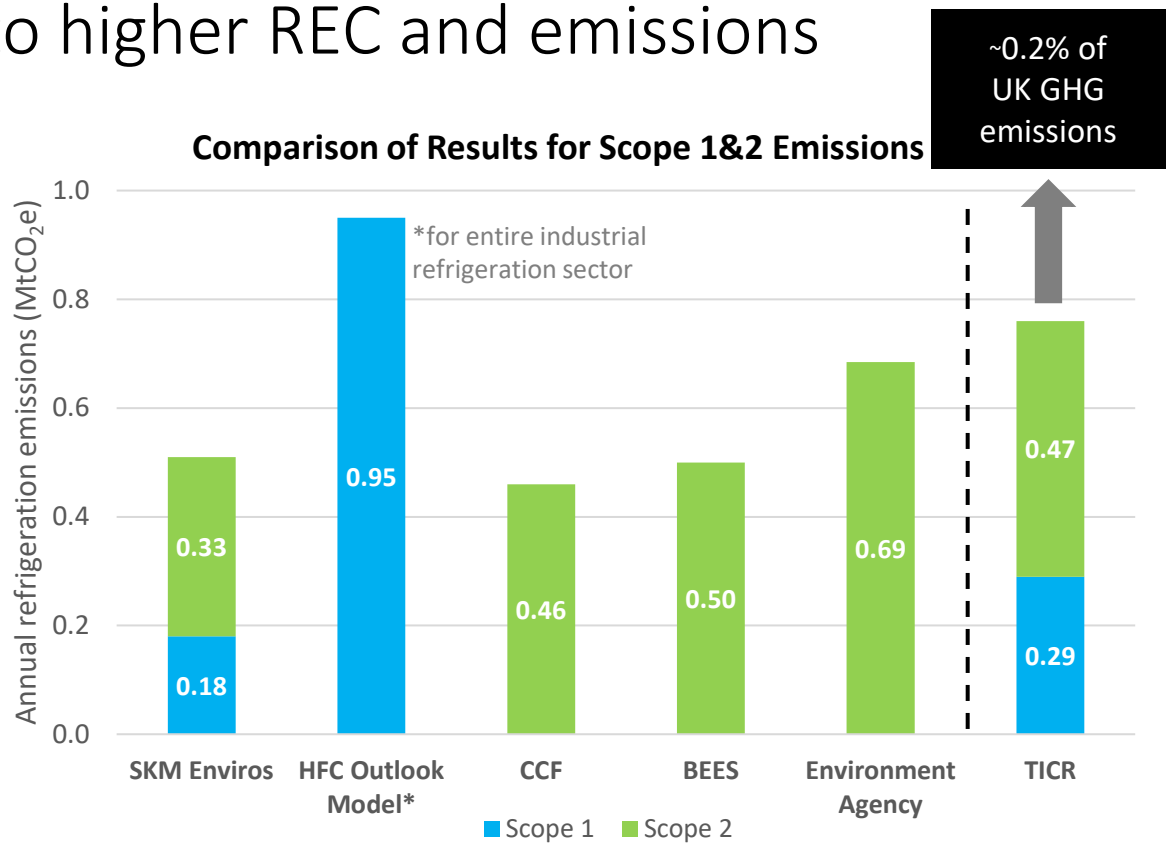


- Similar energy consumption figures when large stores (supermarkets) are compared
- Previous studies have highlighted risk of misclassification with VOA dataset for smaller stores
- Scope 1 suggest predominance of central systems, Scope 2 varies widely with carbon factors

COLD STORES

Larger number of stores obtained led to higher REC and emissions

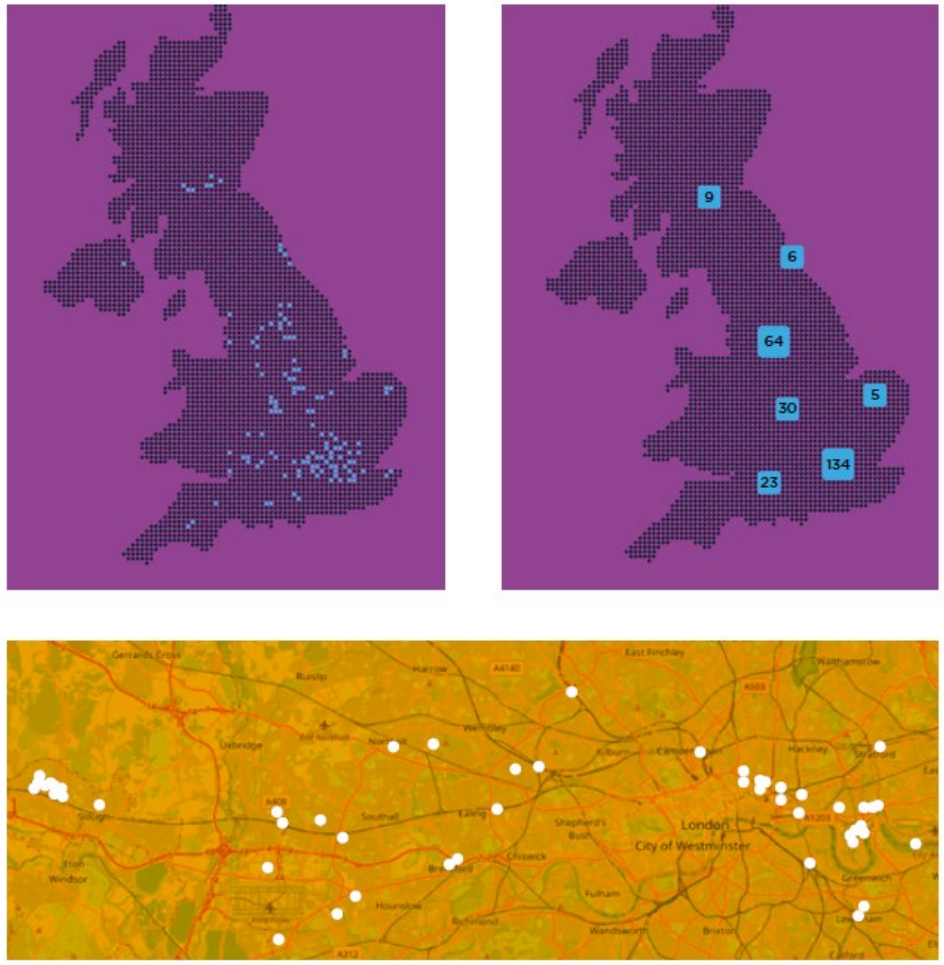




- Greater energy consumption could be explained by larger dataset and refrigerated volume ($58x10^6$ m^3)
- Higher uncertainty around Scope 1 emissions (equipment type), to be clarified during site surveys
- Scope 2 sensitive to carbon factors, if corrected leads to average of 0.16 $MtCO_2e$ across studies

INDUSTRIAL: DATA CENTRES

Data centres in the UK

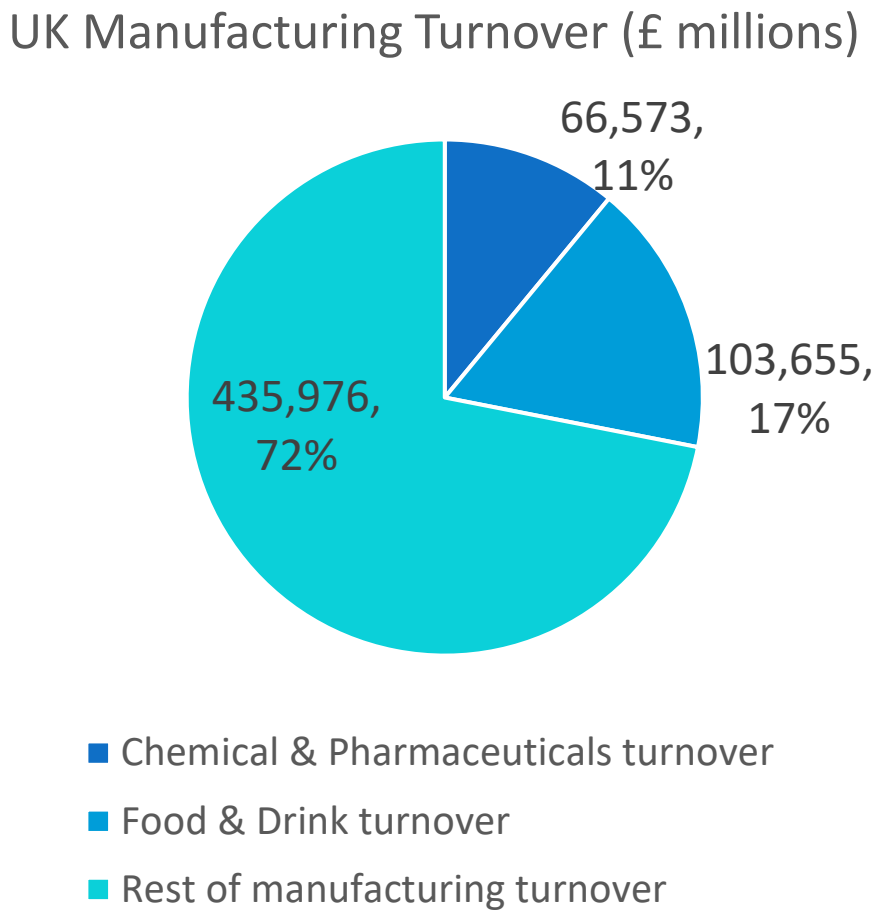


Distribution of UK TP4 CCA data centres [techUK, 2020].

- Running business processes, Government services, telecommunications, transport infrastructures, social networks, and more
- Over 16% of domestic output, 10% of employment and 24% of total UK exports, growing fastest in the G-20
- DCD data suggests 450 colocations and 11,500 enterprise facilities in 2018
- ~70% of the colocation market is located around the M25
- Whole market revenue forecasted at over £280bn in 2023

INDUSTRIAL REFRIGERATION

Food & Drink and **Chemicals & Pharmaceutical** sectors were reviewed



10	**Manufacture of food products**
10.1	Processing and preserving of meat and production of meat products
10.2	Processing and preserving of fish, crustaceans and molluscs
10.3	Processing and preserving of fruit and vegetables
10.4	Manufacture of vegetable and animal oils and fats
10.5	Manufacture of dairy products
10.6	Manufacture of grain mill products, starches and starch products
10.7	Manufacture of bakery and farinaceous products
10.8	Manufacture of other food products
10.9	Manufacture of prepared animal feeds

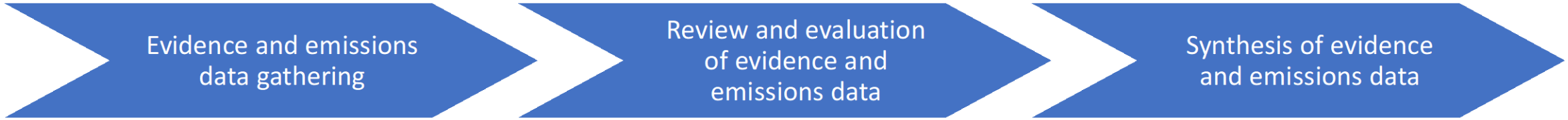
11	**Manufacture of beverages**
11.0	Manufacture of beverages

20	**Chemical three-level SIC codes**
20.1	Manufacture of basic chemicals, fertilisers and nitrogen compounds, plastics and synthetic rubber in primary forms
20.2	Manufacture of pesticides and other agrochemical products
20.3	Manufacture of paints, varnishes and similar coatings, printing ink and mastics
20.4	Manufacture of soap and detergents, cleaning and polishing preparations, perfumes and toilet preparations
20.5	Manufacture of other chemical products
20.6	Manufacture of man-made fibres

21	**Pharmaceuticals three-level SIC codes**
21.1	Manufacture of basic pharmaceutical products
21.2	Manufacture of pharmaceutical preparations

INDUSTRIAL REFRIGERATION

Research methodology to estimate emissions



- Grey literature
- Academic literature
- Datasets

- Consulting style literature review to evaluate relevance of evidence and data sources
- Review of best practises to estimate refrigeration emissions
- Identification of suitable benchmarks

- Detailed review of the relevant documentation to identify key content and synthesis of the emissions data from the sources
- Compare and contrast emissions data from the different data sources

To be completed by January 2024

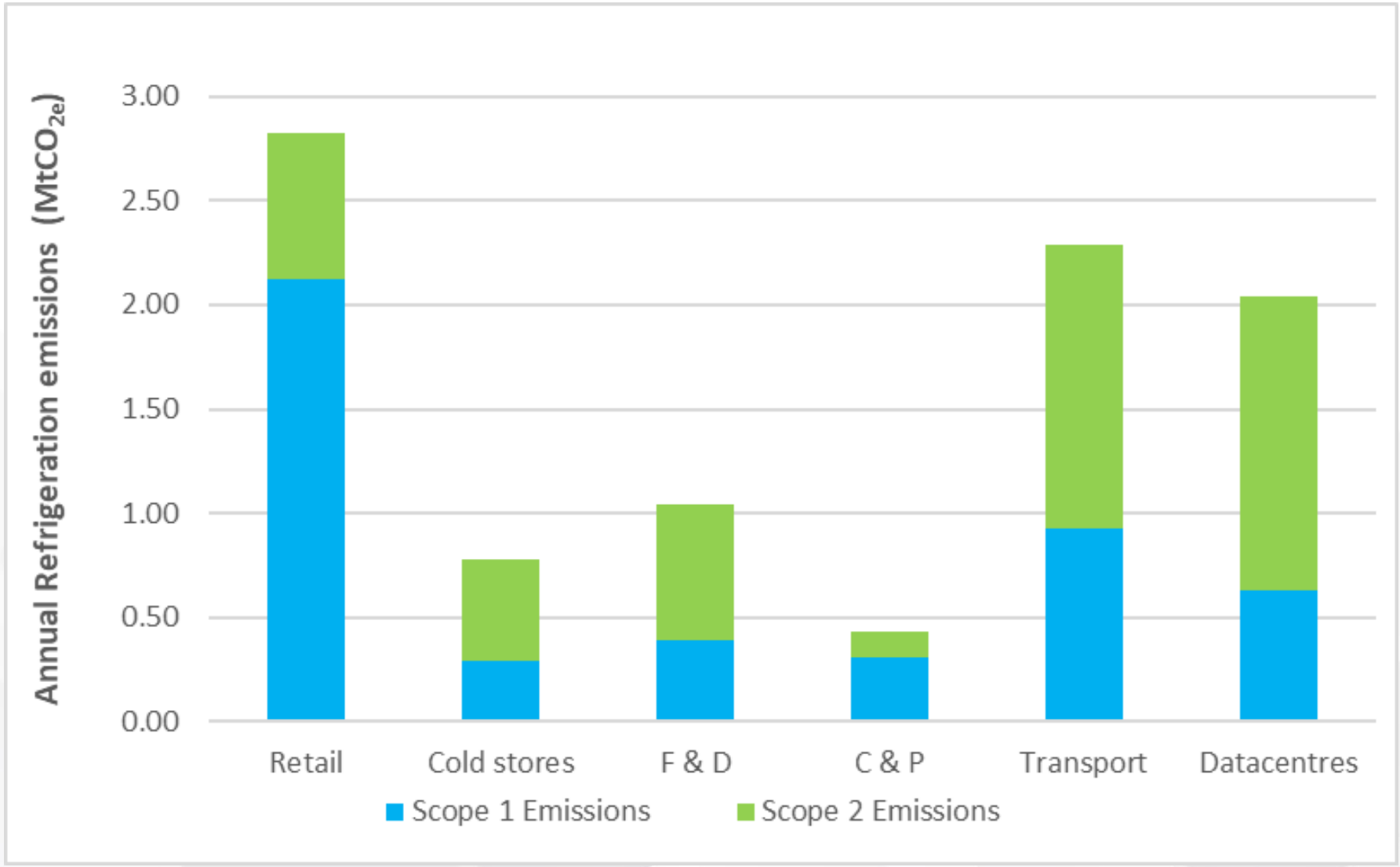
- Site surveys gathering refrigeration emissions data

- Analysis of the site survey data

- Benchmarking and extrapolation of site survey data to sector level emissions calculations where possible

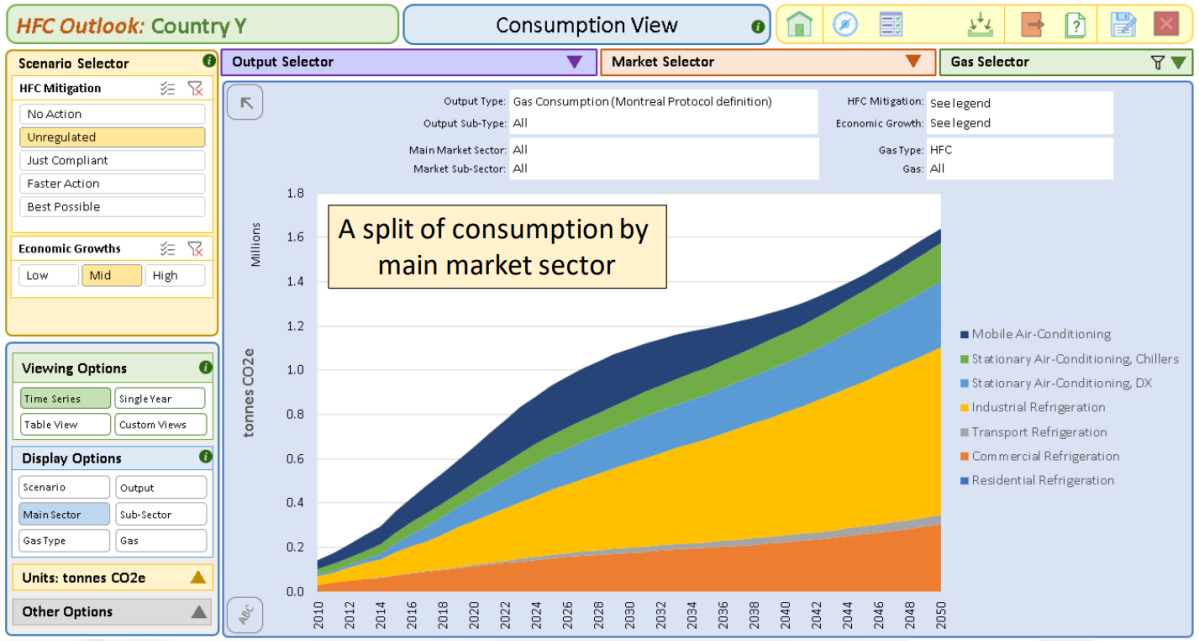
Note: The main two main databases identified through the literature review was the National Atmospheric Emission Inventory for Scope 1 and Climate Change Agreements and DUKES for Scope 2

REFRIGERATION SECTOR EMISSIONS

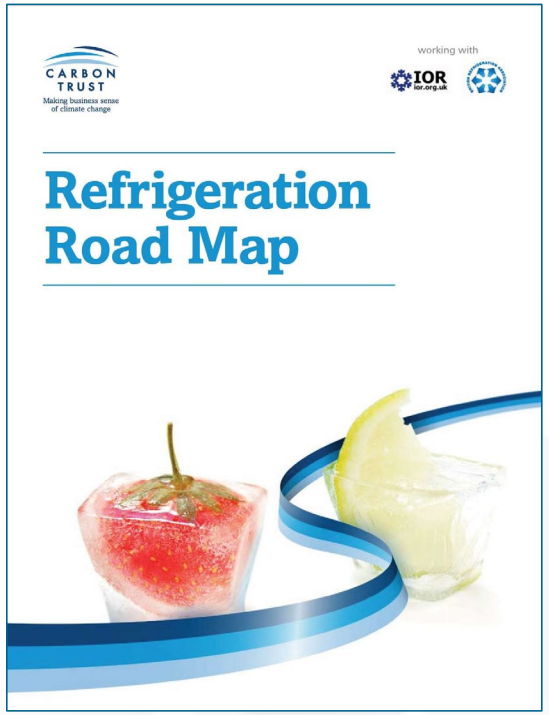


- Refrigeration scope 1 and 2 emissions represent 2.4 % of the UK's total GHG emissions and nearly 7% of the UK electricity consumption

ROADMAPS FOR INDUSTRY



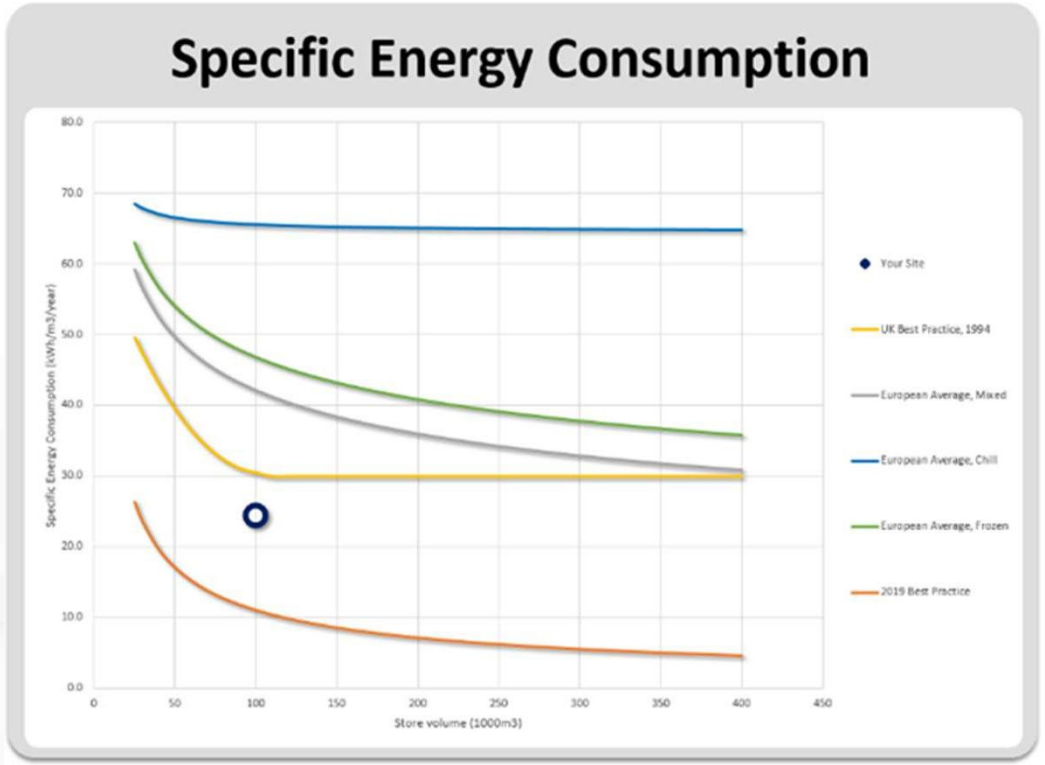
Model emissions to 2050 for different scenarios



Roadmaps tailored to each sector

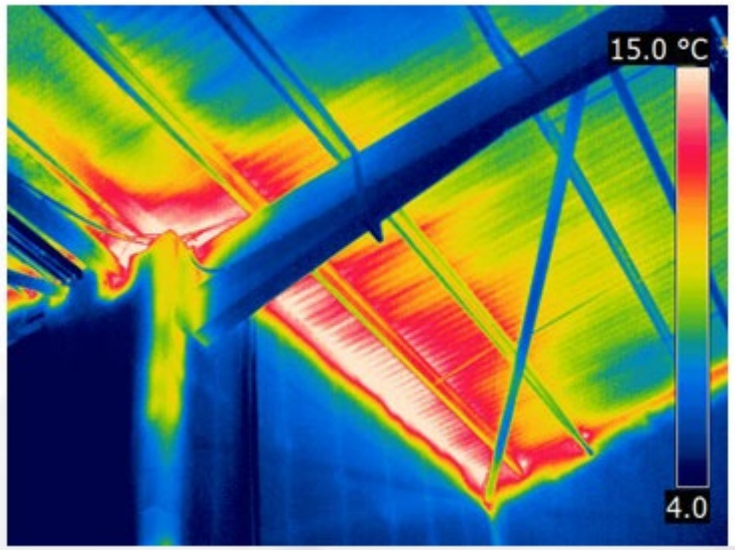
Industry engagement

BENCHMARKS



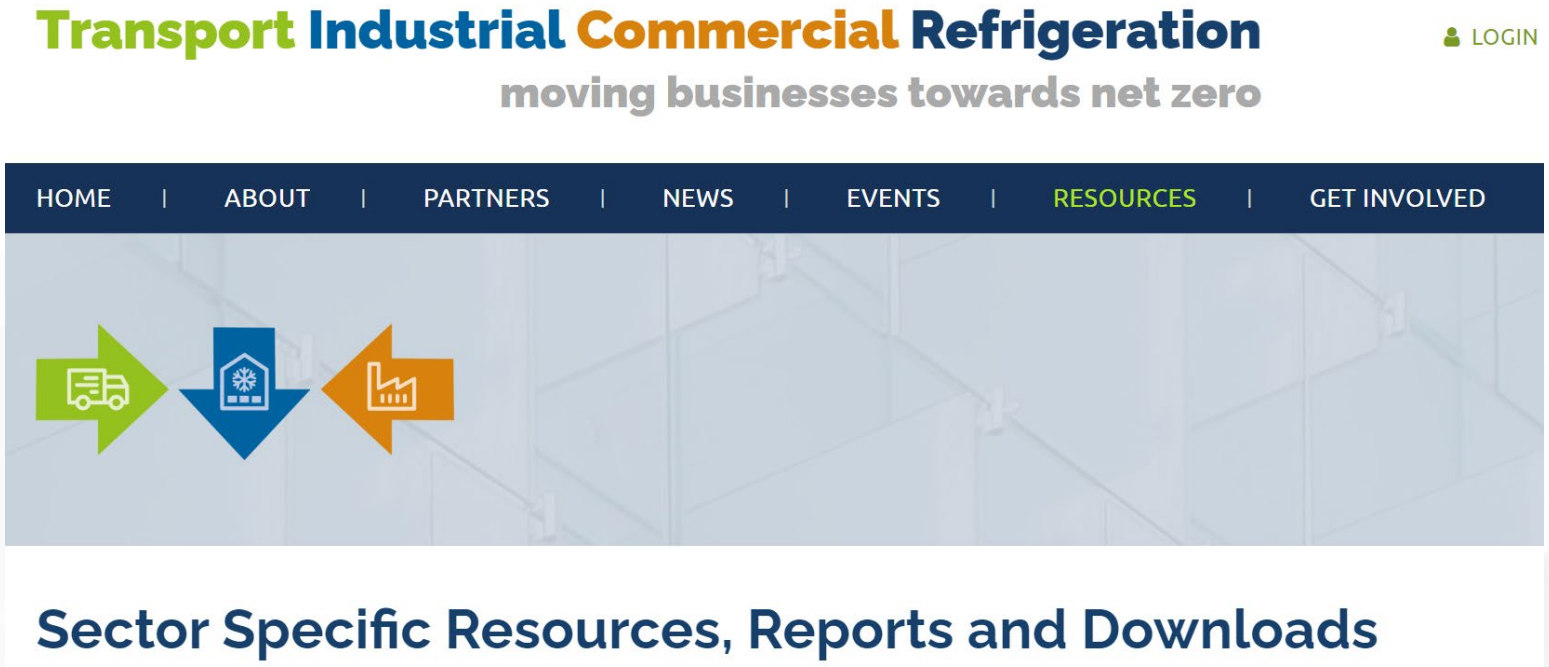
https://www.star-ref.co.uk/news/star-refrigeration-launches-new-energy-consumption-benchmarking-app-for-the-tcsd-industry/

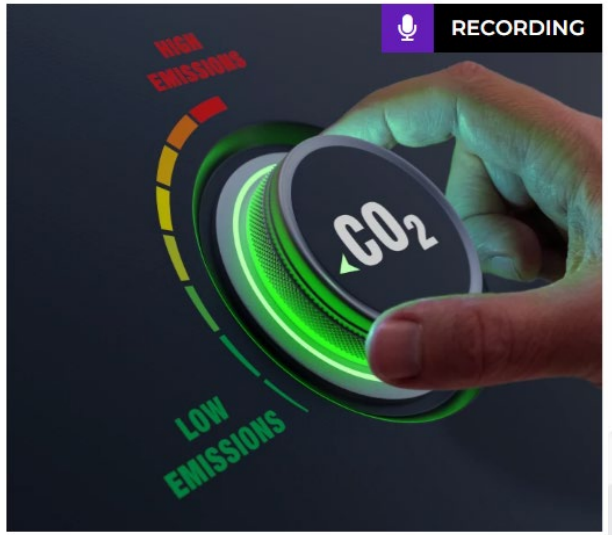
- Enable comparison between sites
- Identify poor, average and good performance



TRAINING

https://netzerorefrigeration.uk/





Maintenance or Design?

"Is money best spent on energy efficient design or maintenance?" Rob Unsworth and Lisa Pogson explore the issues

NET ZERO REFRIGERATION BY 2050

Skills

Energy

Innovation

Legislation

THE ROUTE TO NET ZERO REFRIGERATION

2050

INTO THE FUTURE

Circular economy

Urban farming

Whole system understanding

Integration of heating and cooling

Increased demand

More efficient refrigerants and systems

Benchmarks

Heat sharing

Transport emissions increase

Data centres

Demand-side response

More domestic produced food

Equality

What could the Transport, Industrial and Commercial Refrigeration look like in 2050 if are to meet our net zero targets?

Better monitoring, measuring & reporting

Green cities

Cooling becomes priority

Importance of skills & training

New policy standards & incentives

Carbon pricing?

Local generation

Digital heat

Natural refrigerants

Decarbonising the grid

Efficient appliances

End of F-gas

Optimisation of industrial processes

Changing behaviours and expectations

Less supermarkets, more cold stores

Affordable technology innovation

High temperature heat pumps

Innovation

Systems free of F gases

Big data, AI, Internet of Things

Increase understanding of planning

Training – penalty based and incentive based

Behaviours of drivers

Skills

Lack of data

Focus on the bigger players

Better marketing for innovation

Lack of training and knowledge – need to incentivize management

What would it take to get there? What are the barriers, opportunities and enablers? Could we get there by 2030?

Yes but start now!

Safety

Voluntary agreements

F-gas log (online?) made public

Legislation

Carrot and stick approach

End of life

Ban for new equipments

Data transparency

EU policy

Air quality regulation

Importance of system responsibility & ownership

Challenge of electrification for long distance transport

Heating & cooling as a service

Hydrogen

Energy

Refrigeration wide performance standards

Waste heat recovery

Need for optimal energy modelling

Integrate heating and cooling in supermarkets

Real time monitoring

TRANSPORT REFRIGERATION

Barriers

- Multiple challenges beyond GHG emissions such as air quality i.e., particulates and NOX exposure

- Lack of regulations in the transport refrigeration sector / associated political and financial costs of introducing regulation

- The UK is influenced by EU policies, in particularly HGVs imported from the EU

- Electrification is challenging for long-distance logistics due to weight restrictions on vehicles
- Considerations relating to switching to natural refrigerants.

- Incorrect driver behaviour

- Small independent companies (man and a van) have a small profit margin and generally use second hand vehicles and have limited resources

Vs.

Opportunities

- Improving air quality, enabled by regulation similar to clean air zone

- Adopting a carrot and stick approach to regulation Focus on big market players to maximise impact.

- Potential for servitization-based business models & rental options to alleviate the capital investment
- Creating more affordable technologies and funding for transport innovation in the UK

-- Driver's behaviour: Providing better training and automated systems to optimize engine operation

- Hydrogen for long haul vehicles – not as heavy as added batteries and can power refrigeration systems.

- Switch to natural refrigerants

COMMERCIAL REFRIGERATION

Barriers

- Safety concerns
- Lack of training and knowledge
- Competition between retailers
- Cost driven market with low margins
- Behaviour related to COVID-19 and touching chiller doors in supermarkets
- Information sensitivity
- Lack of data
- Prevalence of less efficient equipment in convenience stores and small independent businesses
- More difficult to communicate with smaller retailers
- Lack of incentives to change
- Other priorities
- Cyber security

Vs.

Opportunities

- Solve cost of living crisis – delivering an essential service
- Visibility of the industry
- Integration of heating and cooling in supermarkets
- Increasing priority of cooling globally (COP 28)
- Transitioning to low-carbon business models through online operations
- Leveraging big data
- Adopting IoT and AI
- Embracing flexibility and local energy generation
- Facilitating EV charging at supermarkets
- Learning from neighbouring industries and adopting best practices can contribute to sustainable development

INDUSTRIAL REFRIGERATION

Barriers

- Lack of skills and understanding within the industry
- Absence of responsibility and ownership of refrigeration systems performance, leading to different parties having different incentives
- Over-specification of refrigeration requirements due to long supply chains
- Inadequate energy modelling programs that don't prioritize optimal efficiency during the initial design phase
- Lack of monitoring and a tick-box mentality toward maintenance and continuous improvements
- Insufficient incentives for day-to-day improvements and addressing emissions

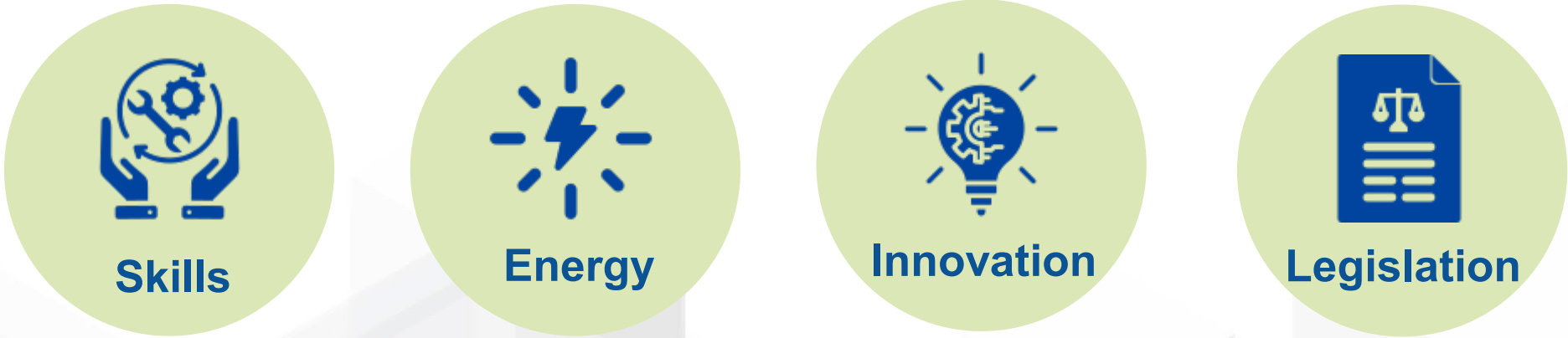
Vs.

Opportunities

- Training programs to enhance knowledge in designing, specifying, maintaining, and operating industrial refrigeration sites
- Establishing a culture of responsibility and ownership within the industry, drawing parallels with the transformation seen in health and safety practices
- Energy efficiency measures can save money, improve processes, and reduce emissions
- Improved energy modelling software for more accurate and efficient design

ENABLERS TO NET ZERO REFRIGERATION

THE ROUTE TO NET ZERO REFRIGERATION → **2050**



Skills

- Training decision-makers, policymakers, & engineers

Energy

- Monitoring and real-time data of energy can enable instantaneous pricing, demand-side response, grid management, and variable pricing

Innovation

- Marketing strategies can help promote both existing & new technologies
- Cooling and heating as a service business models
- Digital twin technology for maintenance and performance monitoring

Legislation

- Penalty-based and incentive-based:
  - More stringent energy performance targets, labelling & air quality
  - Supporting affordable technology and innovation through incentives / rewarding proportional progress rather than minimum thresholds
- Data availability and transparency
- F-gases: recovering and accounting

TICR PARTNERS

EST 1892 LSBU

CARBON TRUST

Carbon³IT

CLT CARBON LIMITING TECHNOLOGIES

IOR.org.uk
REFRIGERATION AIR CONDITIONING HEAT PUMPS

STAR TECHNICAL SOLUTIONS

UNIVERSITY OF BIRMINGHAM

Reducing carbon emissions in Transport, Industrial and Commercial Refrigeration

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