ENOUGH

EUROPEAN FOOD CHAIN SUPPLY
TO REDUCE GHG EMISSIONS BY 2050

PROJECT ACRONYM	ENOUGH
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D2.1:

Roadmap structure document - Development of model specification and structure

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[1]PU = Public

PP = Restricted to other program participants (including the Commission Services)

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CO = Confidential, only for members of the consortium (including the Commission Services)

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EXECUTIVE SUMMARY

Within WP2 work will be carried out to create technology roadmaps of state-of-the-art and future technologies/operational practises and to predict the GHG emission savings achievable when applying these technologies across products and sectors of the food chain.

This report covers the methodology that will be applied to generate the:

1. Technology reviews
2. Models that will be used to identify best technological and operational practices
3. Road maps

Deliverable 2.1

1. OBJECTIVES OF WP2

The objective of WP2 is to create technology roadmaps of best practice, state-of-the-art and future technologies/operational practises and to predict the GHG emission savings achievable when applying these technologies across products and sectors of the food chain. To this purpose, WP2 will:

1. Define roadmaps for each of the following links of the food supply chain, from harvest/slaughter to consumption:
    a. Food production/processing/packaging
    b. Food storage
    c. Food transport
    d. Food retail / food service
    e. Domestic
2. Develop models to predict the GHG emissions and assess the level of indirect and direct emissions savings, cost and payback and timescale for application of each individual technology.

Originally it was considered to assess emissions from product groups (meat, fish, dairy, fruit and vegetables, bakery and beverages) separately for processing (primary and secondary), storage and transport. However, it is not possible to differentiate foods sufficiently within the storage and transport sectors and so these will be considered across all food products in the way proposed for food service, retail and domestic. Each sector also cross-links into the demonstration activities in WP6 and will inform the selection of new projects within ENOUGH.

2. TASK 2.1: DEVELOPMENT OF MODEL SPECIFICATION AND STRUCTURE

Description of work to be carried out in T2.1:

LSBU will create a structure for the model which will link products and typical configurations found in each sector of the food chain. Inputs will be fed in from WP1 (and other WPs where appropriate) where information on types of facility will be identified.

It is anticipated that the structure shown in Figure 1 will be applied.

		Primary processing	Secondary processing	Storage	Transport (long/short)	Catering	Retail	Domestic
Meat		T2.7	T2.7	T2.4 (all food)	T2.5 (all food)	T2.3 (all food)	T2.2 (all food)	T2.6 (all food)
Dairy		T2.7	T2.7					
Fish		T2.7	T2.7					
Fruit and vegetables		T2.7	T2.7					
Bakery, confectionery		T2.7	T2.7					
Beverages		T2.7	T2.7					

Figure 1. Structure for road maps.

Methods to carry out the assessment will be created and methodologies to assess the financial paybacks and time to application for each technology will be developed. A structure for data collation and analysis will be provided that can be used by all partners involved in the WP. The work will assess each individual technical option (and non-technical options if these are quantifiable) individually. The overall impact of the options applied across the whole food chain and the additive impact of several options is part of WP4.

3. WP2 METHODOLOGY

WP2 covers the development of technology road maps covering the varied sectors of the food chain.

D2.1 describes the methodology for:

1. The reviews of available technologies that can save/reduce carbon emissions in the food chain.
2. The way that the outputs from the reviews can be used to generate road maps for each food chain sector.

3.1. Overview of WP2 methodology

The WP2 Teams folder will be used as a repository for information. This will be managed by the WP leader (LSBU).

The work for each sector of the food chain will be structured as follows (Figure 2):

1. The options (technical and non-technical) will be reviewed.
2. Case study/baseline examples within each sector will be obtained to identify where technologies have the most benefit.

3. The case studies will be modelled, and technologies applied to identify where there are the most benefit from the technologies available.
4. Using the case studies and the modelling, a road map for each sector will be generated. This will enable participants in each sector to identify where they are currently and identify the next step to reduce their carbon emissions.

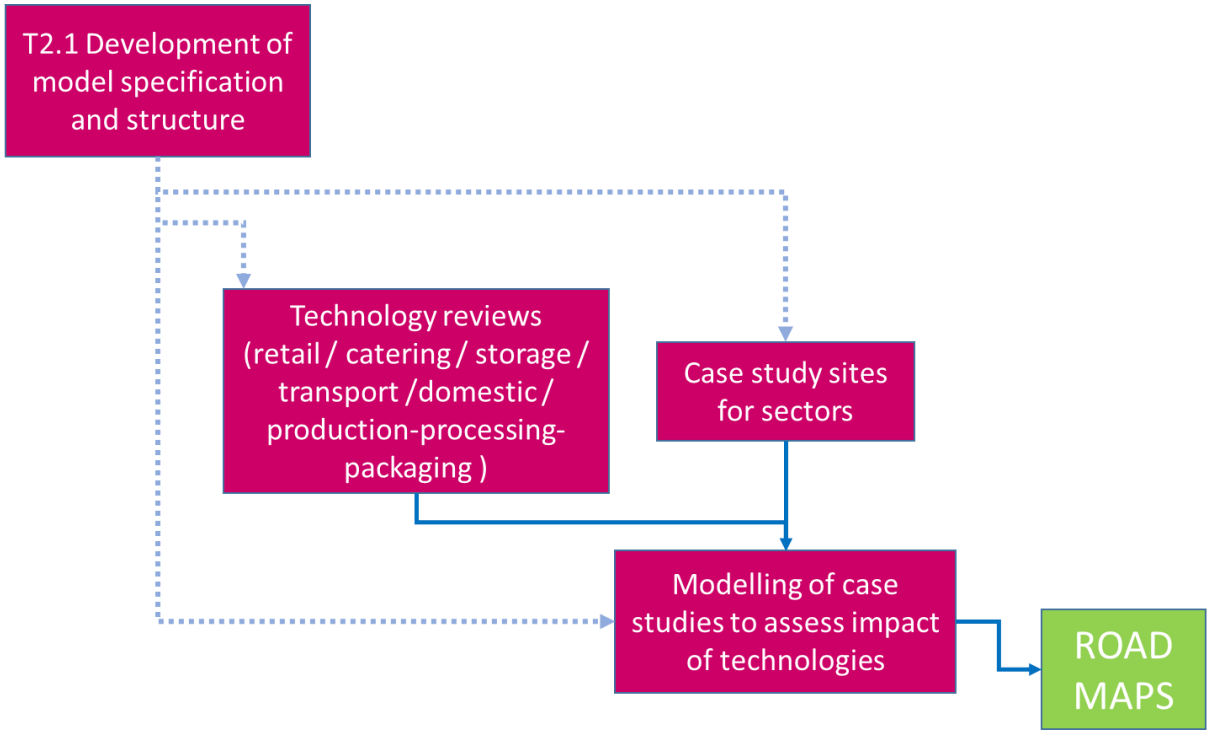


Figure 2. WP structure and links.

3.2. Technology reviews

A template for each technology review has been created (Appendix 1). All partners carrying out reviews will use the template to ensure a uniform methodology and reporting of the technologies.

At the start of each sector review, a list of potentially beneficial technologies will be created by the team involved (this can be added to during the review if additional technologies are identified). The boundaries for each sector review will be agreed. As it is intended to include cooling, heating, HVAC and any ancillaries it is vital that there are clear boundaries to define what will be covered in each review. For example, for the supermarket sector the boundaries/envelope are shown diagrammatically in Figure 3. The reviews will assess technologies related to the refrigeration (display cabinets), heating (hot cabinets), HVAC (for both the public and private areas of the store) and any ancillaries (e.g. non display cabinet lighting, door protection). The review will exclude any areas which overlap into other sectors (e.g. cafes and restaurants which are part of the food service sector and cold stores which are part of the cold storage sector).

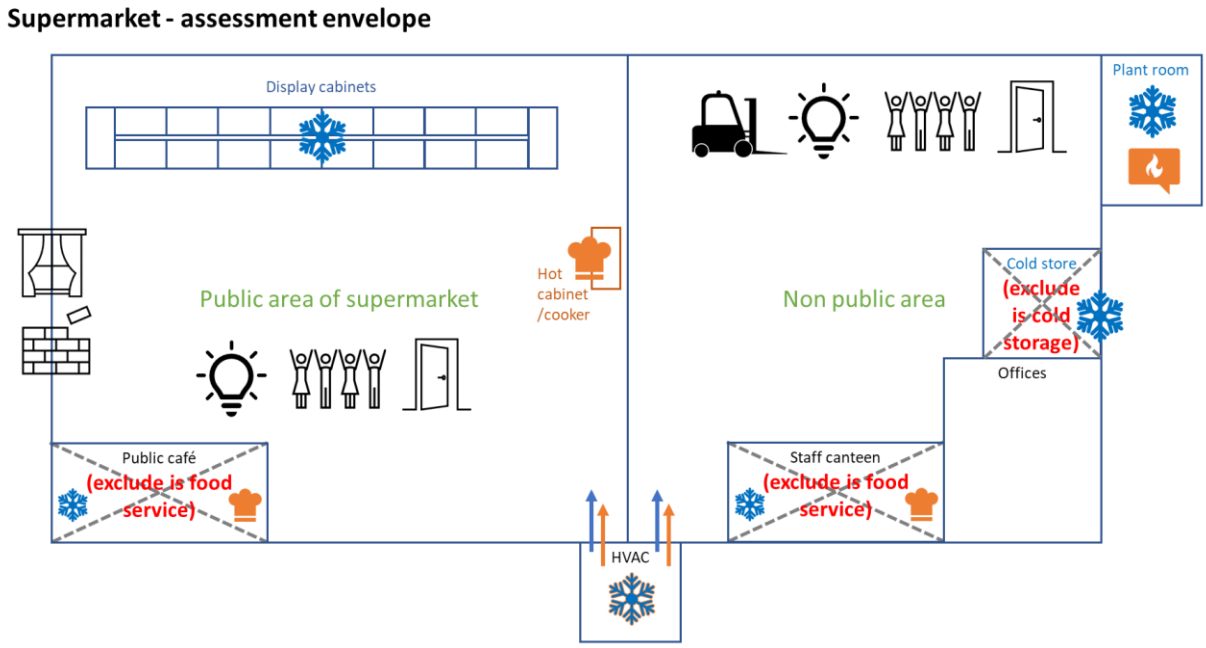


Figure 3. Assessment envelope for supermarkets.

The technologies for review will be divided amongst the team. An example of part of the spreadsheet for use with the supermarket sector is shown In Appendix 2.

Individual reviews will be collated into a document by the leader of Tasks 2.2-2.7. Technologies will be collated alphabetically under each of the following headings:

1. Refrigeration
2. Cooking/hot food
3. HVAC
4. Ancillaries

3.3. Case studies

To enable the benefits of the technologies to be assessed, a set of case studies will be identified for each sector. Ideally each of the main partners involved in the sector assessment should provide 1-3 case study sites where there is detailed information on the operation that can be modelled to identify the optimal technologies that can be applied. These will enable retrofitting options to be assessed. New sites can be assessed by applying the best technical options to similar functionality sites (i.e. same number of display cabinets, hot food etc).

The case studies will provide:

1. A baseline that can be used for applying alternative technologies.
2. Information on the state of each sector in different European countries and whether the level of development within a sector varies across Europe.
3. Whether different technologies tend to be applied in different countries.

A data collection template will be created for each sector at the start of the work on that sector. An example of the information that is required for supermarkets is shown in Appendix 3.

3.4. Mathematical modelling and identification of technologies to be applied

For each sector a model or set of models will be developed to identify the benefits of each technology (in terms of carbon saving and energy reduction). The models will enable the impact of technologies on the whole envelope of assessment to be identified. This includes interactions between technologies where technologies may have benefits in one area but may have a negative impact in anther. Such an example is doors on retail display cabinets where the doors have significant benefits on the energy used by the refrigerated display cabinets but may in certain environments increase the need for cooling in the store envelope. Impacts such as this may have varied effects in different European locations (for example doors may have fewer overall benefits in Sothern Europe than Northern Europe due to the ambient condition in each location).

Using the models developed, the order in which technologies should be applied, the level of benefit and the impact of interactions between separate technologies and the store environment can be identified. This will provide information on:

1. The impact of retrofitting a technology versus applying it to a new facility.
2. Whether the same technologies should be applied in the same order across Europe.
3. Whether there are fundamental differences between European countries.
4. The cost-benefit of the application of each technology and whether it is currently viable or may be in the future.

From this a set of road maps can be generated. Overall the road maps will present to end users the technologies that can be applied, in general terms the optimal order in which they should be applied (each user of the Roadmap will be different and therefore the Roadmaps can only ever be general guidance) and the benefits in terms of carbon and energy savings and the related costs/paybacks.

The road map may vary according to location and country and so more than one road map may be generated within a sector. Different road maps for retrofitting and new facilities may also be the most optimal method to present the results.

3.4.1. Models to be applied

The models to be applied for each sector of the food chain will be reviewed at the start of each sector assessment. For example for the retail sector EnergyPlus will be used as it is a buildings simulation model suitable for assessing the whole supermarket envelope. It has also been used previously for similar applications in supermarkets and so is capable of assessing the integration of technologies across cooling heating, HVAC and any additional ancillaries.

EnergyPlus will be used wherever possible in other sectors. It is anticipated that it will be suitable for food service as the model concept is quite similar to that for retail. For other sectors models developed internally by the WP2 team may be more suitable (such as that developed for cold stores by LSBU).

Appendices

APPENDIX 1. TEMPLATE FOR TECHNOLOGY ASSESSMENTS

We are only looking to review technologies that can save greenhouse gas emissions.

A review of each technology should be carried out and any references listed below the review. The review should include all available published information, or any information obtained directly from manufacturers of the equipment. The review should compare and contrast available information (peer reviewed papers, conference papers, grey literature, manufacturers data, personal experience) and provide a critical assessment of the validity of the information. Overall we need to know the proportion of greenhouse gas emissions that a technology could save and any constraints around the use/application of the technology. We also need to know the cost for application of the technology and the TRL level of the technology. If the technology is not currently available we need to know the approximate time until it could be deployed.

Reviews of each technology can be of variable length (depending on availability of information) but should rarely be more than 2-3 pages long.

To be able to quickly compare information please complete the following table (in addition to the review).

Please complete for each technology (details on how to complete are below):

Direct emissions savings (% or another quantifiable metric)	
Quality of direct emissions information	
Indirect emissions savings (% or another quantifiable metric)	
Quality of indirect emissions information	
Availability barriers	
TRL level	
Maintainability issues	
Legislative concerns	
Payback time (years)	

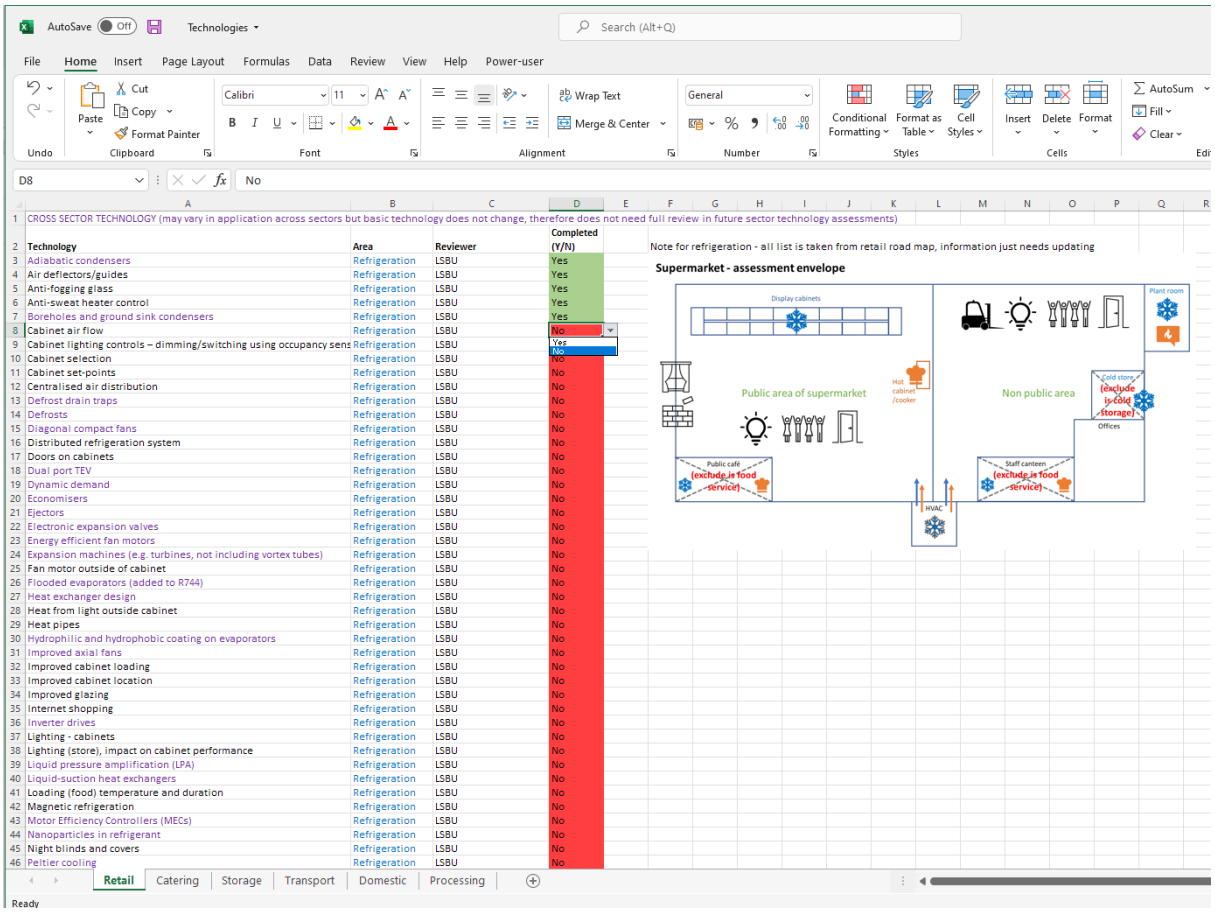
References:

If possible use the MSWord citation function. If you do not wish to use this then please use Chicago (Sixteenth edition) notation.

Technology summary table information:

Direct emissions savings (% or another quantifiable metric)	Overall savings that the review indicated. This could be a range if the information is not clear, or results vary according to the situation that the technology is applied in. Please be specific about any savings, e.g. savings of X% if applied to an R404A system but only Y% if applied to an R744 system. Please be clear on what the % value applies to – the cabinet, the supermarket refrigeration system, the whole store. Please be clear on how the carbon emission savings were calculated.
Quality of direct emissions information	How robust is the available information? Is it unequivocal or open to debate?
Indirect emissions savings (% or another quantifiable metric)	Overall savings that the review indicated. This could be a range if the information is not clear, or results vary according to the situation that the technology is applied in. Please be clear on what the % value applies to – the cabinet, the supermarket refrigeration system, the whole store. Please be clear on how the carbon emission savings were calculated (carbon conversion factor applied).
Quality of indirect emissions information	How robust is the available information? Is it unequivocal or open to debate?
Availability barriers	H=prototype/demonstrator only M=limited availability L=available
TRL level	Mark as: TRL1-4 TRL5-7 TRL8-9 TRL 1 – basic principles observed TRL 2 – technology concept formulated TRL 3 – experimental proof of concept TRL 4 – technology validated in lab TRL 5 – technology validated in relevant environment TRL 6 – technology demonstrated in relevant environment TRL 7 – system prototype demonstration in operational environment TRL 8 – system complete and qualified TRL 9 – actual system proven in operational environment
Maintainability issues	List any relevant issues
Legislative concerns	List any relevant issues
Payback time (years)	Time to recover cost of technology. This is equal to the saving in electrical energy per year divided by the cost of the technology. It does not include other ongoing costs, e.g. maintenance, cost of finance etc.

APPENDIX 2. TECHNOLOGY LIST



	A	B	C	D
1	CROSS SECTOR TECHNOLOGY (may vary in application across sectors but basic technology does not change, therefore does not need full review in future sector technology assessments)			
2	**Technology**	**Area**	**Reviewer**	**Completed (Y/N)**
3	Adiabatic condensers	Refrigeration	LSBU	Yes
4	Air deflectors/guides	Refrigeration	LSBU	Yes
5	Anti-fogging glass	Refrigeration	LSBU	Yes
6	Anti-sweat heater control	Refrigeration	LSBU	Yes
7	Boreholes and ground sink condensers	Refrigeration	LSBU	Yes
8	Cabinet air flow	Refrigeration	LSBU	No
9	Cabinet lighting controls – dimming/switching using occupancy sens	Refrigeration	LSBU	No
10	Cabinet selection	Refrigeration	LSBU	No
11	Cabinet set-points	Refrigeration	LSBU	No
12	Centralised air distribution	Refrigeration	LSBU	No
13	Defrost drain traps	Refrigeration	LSBU	No
14	Defrosts	Refrigeration	LSBU	No
15	Diagonal compact fans	Refrigeration	LSBU	No
16	Distributed refrigeration system	Refrigeration	LSBU	No
17	Doors on cabinets	Refrigeration	LSBU	No
18	Dual port TEV	Refrigeration	LSBU	No
19	Dynamic demand	Refrigeration	LSBU	No
20	Economisers	Refrigeration	LSBU	No
21	Ejectors	Refrigeration	LSBU	No
22	Electronic expansion valves	Refrigeration	LSBU	No
23	Energy efficient fan motors	Refrigeration	LSBU	No
24	Expansion machines (e.g. turbines, not including vortex tubes)	Refrigeration	LSBU	No
25	Fan motor outside of cabinet	Refrigeration	LSBU	No
26	Flooded evaporators (added to R744)	Refrigeration	LSBU	No
27	Heat exchanger design	Refrigeration	LSBU	No
28	Heat from light outside cabinet	Refrigeration	LSBU	No
29	Heat pipes	Refrigeration	LSBU	No
30	Hydrophilic and hydrophobic coating on evaporators	Refrigeration	LSBU	No
31	Improved axial fans	Refrigeration	LSBU	No
32	Improved cabinet loading	Refrigeration	LSBU	No
33	Improved cabinet location	Refrigeration	LSBU	No
34	Improved glazing	Refrigeration	LSBU	No
35	Internet shopping	Refrigeration	LSBU	No
36	Inverter drives	Refrigeration	LSBU	No
37	Lighting - cabinets	Refrigeration	LSBU	No
38	Lighting (store), impact on cabinet performance	Refrigeration	LSBU	No
39	Liquid pressure amplification (LPA)	Refrigeration	LSBU	No
40	Liquid-suction heat exchangers	Refrigeration	LSBU	No
41	Loading (food) temperature and duration	Refrigeration	LSBU	No
42	Magnetic refrigeration	Refrigeration	LSBU	No
43	Motor Efficiency Controllers (MECs)	Refrigeration	LSBU	No
44	Nanoparticles in refrigerant	Refrigeration	LSBU	No
45	Night blinds and covers	Refrigeration	LSBU	No
46	Peltier cooling	Refrigeration	LSBU	No

Note for refrigeration - all list is taken from retail road map, information just needs updating

Supermarket - assessment envelope

Column A: Technologies are listed.

Column B: Sector is identified (pull down selection list).

Column C: Reviewer is identified.

Column D: Whether review is completed (pull down selection list).

APPENDIX 3. CASE STUDY DATA COLLECTION

Case study data collection - retail

Store general	
Location (address or location according to degrees, minutes, and seconds (DMS) format, degrees and decimal minutes (DMM) format, or decimal degrees (DD) format)	
Opening hours	
Total size (m^2) Sales area (m^2) Store height (m)	
Store lighting type (e.g. fluorescent, LED)	
Typical no of customers per day	
Store set point temperature (°C), RH (%), does this vary (daily, over year)?	
Does the store generate its own energy, e.g. from solar panels (if so please describe)	
Store energy consumption per year (kWh/y), if multiple fuel sources split between them	
Do you apply DSR (demand side response)? Is so, please describe	
Refrigerated display cabinets	
Length of chilled cabinets (m)	Produce (% open/with doors) Dairy (% open/with doors) Meat (% open/with doors)
Length of frozen cabinets (m)	Frozen (% open/with doors) Ice cream (% open/with doors)
Are cabinet remotely operated or integrals (if both, provide % of frozen and chilled based on cabinet length)	
Are any integral cabinets attached to a water loop condenser system?	
Cabinet set points	Produce Dairy Meat Frozen Ice cream

If available list the manufacturer and models of cabinets. If there is information on TEC/TDA (total energy consumption/total display area) for any cabinets please provide	
If cabinets have doors, what type of door is applied? (e.g. single/double/triple glazing) Have doors been retrofitted?	
Type of cabinet lighting (e.g. LED)	
Controls for cabinet lighting (e.g. turn off or dim between specific hours)	
Type of cabinet fan motors (e.g. shaded pole, EC)	
Are air deflectors applied on open fronted cabinets?	
How is condensate on any cabinet doors controlled? (e.g. humidity controlled electrical heaters)	
Type of expansion valves applied	
Defrosts - type	
Do open fronted cabinets have night blinds, if so, when are they applied (times)	
Any special cabinet energy saving features applied? (e.g. strip curtains)	
Refrigeration plants (remotely operated cabinets)	
Type (e.g. central remote DX system, distributed DX systems, secondary system)	
Describe any special features such as heat reclaim, ground source condensers	
Condensers – type (e.g. air cooled, evaporative, adiabatic)	
Condenser fan motor type (e.g. shaded pole, EC)	
Do you have suction-liquid heat exchangers (where are they located)	
Do you have floating head pressure control, if so please provide details	
Do you use liquid pressure amplification?	

What refrigerant(s) or secondary fluid are applied	
Refrigerant charge(s) (kg)	
Refrigerant leakage (%/year)	
Service and maintenance	
Describe your service and maintenance routine	
Cooking	
Type of oven(s)	
Time operated/day (h)	
Number of ovens	
What fuel(s) is(are) used?	
Total power input according to fuel type (kW)	
If you have information on energy used for cooking per year, please supply according to fuel type (kWh/y)	
Hot display cabinets	
Type of cabinet/store	
Time operated/day (h)	
Number of cabinets	
What fuel(s) is(are) used?	
Total power input according to fuel type (kW)	
If you have information on energy used for cooking per year, please supply according to fuel type (kWh/y)	
HVAC	
Energy source for heating	
Is cooling provided by direct expansion refrigeration? If another system is applied, please provide information (e.g. heat based refrigeration such as absorption)	
Type of system	
% of time/year when heating	
% of time/year when cooling	
Energy consumption/year (kWh) in terms of gas and electrical	
Air exchange rate (per hour)	
Is humidity in the store controlled?	

Ancillaries	
List any additional energy using equipment associated with the supermarket (e.g. cold stores, forklifts, offices, vending cabinets, lights)	