Refrigerants, Naturally! for LIFE

Towards sustainable cooling in the European organic and small food retail sector

Status, technology needs and expectations

Public report

For the project RefNat4LIFE

Refrigerants, Naturally! for LIFE is an EU funded project to support the uptake of climate friendly cooling alternatives for food preservation, shop air conditioning and heating.

Lead authors:

Nina Masson, HEAT

Jascha Moie, HEAT

Britta Pätzold, HEAT

Contributors:

Aina Calafat, SEAE

Hans-Josef Brzukalla, BNN e.V.

Inês Efigénia, AGROBIO

Dr. Matthias Schmitt, BIV

Pauline Bruge, Ilana Koegelenberg, shecco

René van Gerwen, KNVvK

Wim den Boer, STEK

More information:

www.refnat4LIFE.eu

Info@refnat4life.eu

December 2020

Content

List of Figures

List of Tables

Glossary

Abbreviation	Description
AC	Air Conditioning
BAU	Business as usual
EE	Energy Efficiency
EEI	Energy Efficiency Index
GEF	Grid emission factor
GHG	Greenhouse gas
GWP	Global Warming Potential[1]
HC	Hydrocarbons
HCFC	Hydrochlorofluorocarbons
HFC	Hydrofluorocarbons
HFO	Hydrofluoroolefin
HP	Heat pump
LT	Low temperature
MEPS	Minimum Energy Efficiency Standards
MIT	Mitigation
MT	Medium temperature
MTOE	Million Tonnes of Oil Equivalent
MOOC	Massive open online course
OFR	Organic food retail
RAC(HP)	Refrigeration, Air conditioning (and Heat Pumps)
RefNat4LIFE Project	Refrigerants, Naturally! For LIFE project

[1] The following report adopts the GWP values provided in the IPCC Fifth Assessment Report (AR5). The term "low-GWP" is used for substances with a GWP <10. Wherever the term "low-GWP" is used throughout this report, for reasons of simplicity it also includes "zero-GWP" substances with a GWP = 0 (like ammonia R717, water R718, or air R729 as a refrigerant).

Executive Summary

Greenhouse gas emissions from refrigeration, air conditioning and heat pump (RACHP) systems in food retail demonstrate great mitigation potential. However, this potential is not fully exploited by the small food retail sector[2] which is ill-prepared for a change to a more sustainable technology and refrigerant choice.

As countries are trying to meet their Paris Agreement obligations by targeting net zero emissions by 2050 across all sectors, small food retailers increasingly aim to transit to zero greenhouse gas emissions associated with their cooling and heating appliances. Typical energy intensities in food retail are in a range of 500 to 1000 kWh/m² per year for total electricity consumption and an additional 80 to 250 kWh/m² per year for heating including domestic hot water. Typically, refrigeration equipment is responsible for about half of the total electricity consumption and air-conditioning for another 5 to 10 %. This demands appliances to be continuously upgraded for being as energy efficient as possible, as well as the deployment of near zero-emission refrigerants. In order to reduce the use of high Global Warming Potential (GWP) refrigerants, and to implement the F-Gas Regulation at EU-level, natural refrigerants have become an obvious choice in replacing synthetic substances like hydrochlorofluorocarbons (HCFCs) and hydrofluorocarbons (HFCs). With their very low or zero GWP, and no ozone depletion potential, hydrocarbons (HC), carbon dioxide (CO_2), ammonia (NH_3) and water (H_2O) are energy-efficient and cost-effective options for a wide range of applications. Natural refrigerants are proven to be environmentally benign, where fluorinated refrigerants (e.g. hydrofluoroolefins, HFOs) are suspect for potentially negative environmental impact on the short and long term (e.g. combustion by-products and formation of trifluoroacetic acid for which there is no known degradation mechanism)[3]. Around 200 manufacturers already offer natural refrigerant-based solutions in Europe (shecco, 2016), addressing a constantly increasing demand. The market is moving as policy pressure to reduce refrigerant emissions and energy consumption from RACHP in the European Union is gaining force.

When looking at European small food retail stores, the use of energy-efficient, natural refrigerant-based RACHP systems has remained relatively low for most store types due to various reasons. Small retailers often deprioritise an investment in new RACHP systems due to a lack of cashflow or financial support schemes. Even while from a lifecycle perspective energy-efficient equipment would make financial sense, they tend to opt for the extended maintenance of existing systems and often purchase second-hand equipment to compete with larger food retail chains that seize financial savings from blueprinting across their chain of stores. Moreover, there’s a lack of expert knowledge on the technical, environmental and commercial effects of inefficient RACHP systems and a lack of awareness in transiting to almost-zero-GHG solutions, making many small store owners reliant on the recommendations from local RACHP contractors and service companies. Contractors, servicing companies and their installers often lack the required know-how regarding the necessity of turning towards almost-zero-GHG solutions or are economically drawn to conventional solutions because they have to invest little time and money in these solutions. In other cases, they lack the technical knowledge in how to select and install appropriate zero-emission technical solutions. This results in stores running either old, inefficient and pre-owned RACHP systems or cheap new systems with refrigerants that will soon be banned from the EU due to their high GWP or low energy performance.

The first-ever stock model on the use of RACHP equipment in small food retail in five selected European countries indicates that if energy-efficient and climate-friendly RACHP equipment is adopted, about 11 % of GHG emissions can be avoided (emission mitigation,

[2] All food stores with a sales area below 1000 m² are considered small food retail

[3] Norwegian Environment Agency. 2017

MIT scenario). This adds to the expected decrease of around 30 % of RACHP-related emissions from 2020 to 2025 resulting from the implementation of the F-Gas Regulation and moderate improvements of energy efficiency (business-as-usual, BAU scenario). Scenarios for the selected five countries are based on a data set of 197,000 small food stores[4].

RefNat4LIFE closes gaps on RACHP awareness, training, communication, data collection and GHG emissions projections for Europe's small food retail stores

The EU-funded Refrigerants, Naturally! for LIFE (RefNat4LIFE) project specifically helps small food store owners to better understand their current challenges and support them in the uptake of more sustainable RACHP technologies and best practices. The project's main actions address the small food retail sector, with a focus on the organic food sector and the RACHP contracting and servicing sector. It thus reflects the expertise of the project consortium. The main actions are:

1. Create a Refrigerants, Naturally! sustainability platform for capacity-building, training, technology selection and outreach
2. Develop a strategy to measure, report and communicate RACHP sustainability efforts;
3. Establish online training courses and guidance documents for end-users and the supply chain on how to select and maintain environmentally-friendly RACHP equipment.

It is clear that RefNat4LIFE actions will only be effective if based on solid data about current and future RACHP use in the European small food retail sector. As such data had largely been missing, a market study was implemented to gather insights into a sector often disregarded in European and national statistics. This is essential to get a better understanding of i) the number of stores in the sector, ii) the structure of the small food retail sector, iii) its economic position and challenges, and iv) the potential for GHG emissions savings in this sector.

The result of the project's efforts to create such a solid data base is the present report. It brings together expertise from eight partners from Belgium, Germany, the Netherlands, Portugal and Spain representing organic food retail, the RACHP contracting and servicing sector, and the natural refrigerants industry perspective. Its findings are based on extensive research, online surveys carried out among end-users and RACHP contractors and qualitative interviews from October 2019 to April 2020. The collected information was fed into a comprehensive modelling exercise covering European food stores with up to 1,000 m^2 and their business-as-usual (BAU) and a mitigation (MIT) scenario of GHG emissions projected up until 2025. Despite its uncertainty (numbers of stores estimated at an accuracy margin of +/-30 %, and additional uncertainty on the future projection, which relies on data and indicators defined prior to the Covid-19 pandemic), the resulting data is unique, as it is the first-ever approximation on RACHP-related emissions from small food retail stores in Europe.

[4] Considered store categories: conventional supermarkets < 1000 m², conventional superettes ("mini supermarkets"), bakeries, butcher stores and other specialised food stores (e.g. cheese, deli, farm, fish, poultry shops). The number of bakeries and butcher stores in Portugal and Spain were estimated based on market indicators. Other specialised food stores were not included for Portugal and Spain and in Germany this category was filled with farm shops only.

Europe's small (organic) food retail: A sector with diverse growth prospects

Europe's food retail sector generated 1,128 billion EUR in sales in 2015 and is expected to grow to 2,289 billion EUR by 2022 (IGD, 2018)[5]. When looking specifically at the future of small food stores in Europe, however, the growth outlook is divided: On the one hand, convenience stores are among those types expected to thrive in urban settings. On the other hand, the existence of small traditional retail stores will be threatened by competition from retail chains expected to further a consolidation of the European food retail market. In summary, one can expect a move towards fewer small stores run by single owners and more local chains with a larger average sales area per store, co-existing next to convenience stores run by large food retail chains. Also, these large food retail chains tend to increase their share of organic food sales in several countries, particularly in the Netherlands, where few specialised organic food stores exist in comparison to the number of supermarkets. In 2015, it was estimated that 85 % of European[6] supermarket stores[7] had a maximum sales area of less than 1,000 m^2 and are hence covered under the RefNat4LIFE project, approximately 64 % of them being smaller than 400 m^2 (own estimate based on Nielsen, 2014 and market assumptions).

The share of the small food retail market in the overall food retail sector varies within European countries. In 2015, the Netherlands had the lowest share of small food retail stores in all supermarket stores including superettes with 67 %, followed by France and Germany in the range of 75 %. In contrast, Poland stood out with by far largest share with 99 %, followed by Austria, Czech Republic and Italy which all exceeded 90 %. Within the project partner countries, Spain, followed by Belgium and Portugal, had the greatest share in the range of 80 %.

Among the small store types included in the market analysis and stock model for selected countries[8] are small supermarkets, superettes (including traditional food retail shops), bakers, butcher stores, and other specialised food stores such as fish shops, poultry stores and farm shops, the first two of which were accounted separately for conventional formats and those specialised on organic food. Due to a lack of data clarity in distinguishing these store types from other formats such as small supermarkets, discount markets or convenience stores, the latter were included in the stock model when the sales area was below 1,000 m^2.

The organic food sector in particular is set to continue on a positive trajectory with more than one-third of the world's organic food sales occurring in the EU. Together, the five project countries make up over 40 % of all organic food sales in the EU (FiBL, 2020; AMI 2018). The picture becomes more blurred when looking at the store types selling organic food: while some countries such as Germany, Belgium or the Netherlands have a diverse mix of sales channels made up of conventional food retailers (52 to 58 %) and specialised organic food retail (OFR) channels (22 to 30 %); other countries like Spain and Portugal still

---

[5] Please note that for the entire report, all data analysed and used for stock modelling was available before January 2020. It can be expected that due to the Covid-19 pandemic affecting all countries in the world, the economic outlook especially for the small food retail sector, including the organic food retail sector, might significantly differ from original projections. This was not considered in this report as implications on national economies or individual market segments are still unknown. Forecasts of market growth rates for the entire food retail sector and its sub-categories need to therefore be handled with particular care.

[6] Included countries ("EU16+3"): Austria, Belgium, Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Netherlands, Poland, Portugal, Spain, Sweden; Norway, Switzerland, United Kingdom

[7] Considered store categories: hypermarkets (> 2500 m^2, large supermarkets (1000-2500 m^2), small supermarkets (400-999 m^2) and superettes (< 400 m^2, store numbers estimated from food retail market indicators).

[8] Selected countries: Belgium, Germany, Netherlands, Portugal, Spain

feature a dominance of the specialised OFR sector (44 to 53 %) (Agence BIO, 2017). A third country group including Austria, Denmark or Sweden is dominated by large food retail groups selling mostly organic food. Essentially, in those countries where organic products are well-established on the market with high per capita consumption, large shares are typically commercialised through conventional food retail. As visible in the stock model, market shares by store type vary largely from one country to another. By number, stores with a sales area < 400 m² are dominant in the OFR sector in Germany, Belgium and especially the Netherlands, Portugal and Spain. In terms of sales, large OFR stores (i.e. sales area 400 to 999 m²) dominate the German OFR market and continue to gain market shares.

Energy performance & GHG emissions: The small (organic) food retail sector lacks capacity to assess RACHP technology and shift to sustainable options

Key results from two online surveys and complementary personal interviews with small food retail end-users representing 1,061 stores in Europe showed the following: Whilst the energy efficiency performance of the appliance is a selection criteria when purchasing a new RACHP system, the application of wider system energy conservation features including doors on cooling cabinets, heat recovery or thermal insulation in existing small stores is rather low. Only very few small food store owners have assessed the energy performance of their installed RACHP equipment, suggesting that the data basis for replacing existing systems is lacking. Europe's traditional small food retail sector, including specialised organic food retailers, mostly does not have the financial capacity and expertise to opt for more energy-efficient, natural refrigerant-based RACHP equipment. Relying on mostly local contractors, shop owners usually do not apply a lifecycle perspective when selecting a new RACHP system, despite the fact that energy costs for running the equipment can take a share of up to 90 % from the total cost of (inefficient) models (Steinmaßl, 2014). The decision on an initial investment is often also tied to uncertain commercial prospects and the renewal of lease agreements for the shops. This often leads to an extension of the lifetime of RACHP systems to above the recommended periods or to a purchase of second-hand equipment with lower energy efficiency and possibly more harmful refrigerants. Particularly in the small food retail sector, the use of high GWP f-gases is still widespread and not in line with quickly increasing pressure from the EU F-gas Regulation demanding a ban of certain substances in a growing range of applications. In contrast, most food stores organised in larger chains, a format which is less present in the small food retail sector, are advanced in the technology uptake of low-GWP technology with higher energy efficiency, largely due to their robust solvency, more and better internal RACHP expertise, and better access to information.

Results also confirm that for the smallest food stores with < 400 m² sales area, the most popular RACHP systems are of a plug-in type (stand-alone systems), whereas stores between 400 and 1,000 m² sales area are more prone to using centralised refrigeration systems. The assumed average use of such centralised systems in OFR is an installed cooling capacity of around 25 kW per store with a sales area of 400 to 999 m², and 6 to 7 kW per store with sales areas below 400 m² among all store types. However, most small food retailers have limited knowledge about the key technical specifications of their RACHP systems, such as the refrigerants used, their energy consumption and running costs. They therefore lack an understanding of its cost and environmental impact.

RACHP-related greenhouse gas emissions from Europe's small food retail sector

The assessment carried out as part of the report, based on the stock model, underlines the relevance of the small food retail sector and its RACHP-related GHG emissions. According to these estimations, small supermarkets (400 to 999 m² sales area) contributed 40 % and superettes (<400 m² sales area) approximately 27 % to total RACHP emissions which exceeded 18 Mt CO_2eq in 2015 (accuracy margin +/- 30 %) for supermarkets of all sizes in an aggregated scenario for selected EU (16) and other (3) European countries[9]. Especially superettes offer a significant unexploited emission mitigation potential, due to the relatively delayed technological transformation and a lower level of organisation in this store type. Based on sales area specific assessments of GHG emissions in small food retail within the five project countries, RACHP-related carbon footprints of conventional supermarket stores were found typically in the range of 150 to 200 kg CO_2eq/m^2 per year for superettes and 80 to 150 kg CO_2eq/m^2 per year for small supermarkets. OFR and other small food retail stores (bakeries, butcher stores, other specialised stores) commonly showed RACHP carbon footprints in a range from 20 to 90 kg CO_2eq/m^2 per year, largely due to lower densities of installed RACHP equipment, and effectively less cooling demand, compared to conventional supermarket stores. In most OFR stores, reduction potentials of RACHP-related carbon footprints were projected in a range of 15 kg CO_2eq/m^2 per year by 2025. Projections did not consider the use of certified green electricity as data availability was limited across the project countries. As a result, indirect, energy-related emissions and related saving potentials might be lower for certain store categories, e.g. in the German OFR sector.

For all food store types considered in the five project countries, best practice energy efficiency improvements and an accelerated conversion of RACHP appliances to low-GWP, natural refrigerants, with special relevance to small store categories below 400 m² sales area, are expected to achieve additional emission reductions in the range of 0.4 Mt CO_2eq in 2025 compared to the baseline (BAU) scenario[10]. Cumulative RACHP-related emissions savings from 2021 to 2025 are projected to amount to 1.1 Mt CO_2eq. More than half of the total projected RACHP emission mitigation potential for the five project countries in 2025 is attributed to German small food retailers, followed by Spain.

Energy consumption and findings for different store categories

The survey in the five project countries showed that area-specific RACHP-related energy intensities in 2018 were typically between 150 to 200 kWh/m² per year both for conventional small supermarkets (sales area 400 to 999 m²) as well as for small OFR stores (sales area < 400 m²)[11]. Conventional superettes (sales area < 400 m²) stand out for the largest range of RACHP energy intensities in 2018, reaching from 150 to 400 kWh/m² per year. This is closely related to significant differences in the typical shop format in each country, coming along with great variations in the organisation level (large and financially strong chains vs. individual shop owners), variations of sales areas, installed RACHP equipment as well as the quality level and resulting energy performance of such appliances. RACHP energy intensities in 2018 in other small retail stores as e.g. bakeries, butcher stores, and also large OFR stores were estimated lower than 150 kWh/m² per year. Beside the installed cooled display area (refrigerated area) relative to total sales area, another important driver of high energy intensity is the widespread use of inefficient equipment and neglection of proper maintenance which is most relevant for the smallest store size categories (all considered small food retail stores except small supermarkets and large OFR stores). For those reasons, the greatest mitigation potentials are attributed to the smallest food retail stores.

[9] 16 EU member states according to Figure 4-8, plus Norway, Switzerland and United Kingdom (UK). Estimations are based on extrapolations from small food retail in the project countries Belgium, Germany, the Netherlands, Portugal and Spain.

[10] In the business-as-usual (BAU) scenario, moderate energy efficiency improvements and transformation of RACHP appliances towards the use of low-GWP refrigerants are assumed.

[11] An exception were conventional small supermarkets in the Netherlands with approximately 100 kWh/m² per year due to low relevance of centralised AC and of heat pumps.

Survey results also indicate that a number of stores operate centralised refrigeration systems without employing heat recovery. An optimisation of system configurations is expected to offer a significant energy saving potential for smaller food retail stores.

Harmonised data, information, and effective financial schemes are key to support Europe's small food retail sector in making more sustainable RACHP choices

Data collection and analysis performed under the RefNat4LIFE project took a deep dive into the current challenges which owners of small food stores face in Europe. The following central measures are recommended to support the uptake of more environmentally friendly RACHP equipment (see chapter 5 for the full recommendations):

Close identified data gaps and harmonise categorisation of small food retail

For a more reliable analysis and to ultimately better support small businesses, national statistical offices and other data collection bodies should work in unison to capture data on structure and developments in Europe's small food retail sector. A central European database with clear definitions, combined with national reporting obligations could be one possible tool to avoid data overlaps or omissions. As a relatively new sub-sector, especially Europe's OFR sector should create independent working groups inside umbrella food retail associations to collect more reliable data on store numbers, average sales area or sales channels, building on a standardised methodology to avoid the current variety of definitions. An easy-to-access online interface could complement data collection, allowing each individual store owner to enter data on a regular basis. Once having established such improved data collection and analysis, the uncertainties and inaccuracies in current study results could be reduced. However, this is not part of the current project.

Develop and disseminate basic information for smallest store formats

For stores with < 400 m^2 sales area, especially those run by independent shop owners or local chains, educational and communication campaigns should focus on the evaluation of installed RACHP units, the basics in choosing RACHP technology and the most important environmental, legal and economic impact associated with choosing the "wrong" system. The technology focus should be put on plug-in units. Non-technical information should focus on a comparison of capital cost vs. lifecycle cost, especially highlighting the relevance of energy efficiency as the decisive cost driver for any store owner regarding a piece of equipment's normal lifetime.

To effectively reach small shop owners with information and training materials developed under the RefNat4LIFE project, communication channels as specialised press, the respective OFR project partners and other associations and other actors as wholesalers in direct contact with the final client should be engaged.

If small business owners demand more energy-efficient, less harmful RACHP systems this would activate a pull strategy.

Contracting and servicing companies are key partners for best-practice maintenance, data collection, reporting and awareness-raising & chain stores enable fast replication of sustainable RACHP concepts and zero-carbon stores

As trusted partners of small store owners, RACHP contracting and servicing companies are best-placed to evaluate the energy performance and use of high-GWP refrigerants in existing RACHP equipment. Theoretically they could therefore play a key role in data collection for a central database to derive sector-specific and national data sets about the type and performance of installed RACHP units to monitor environmental impact from cooling and heating. However, such engagement would not only require regular access to and maintenance of the technical equipment, which is particularly not the typical case for small stores, but also the existence of a centralised data collection body managing this data. As required documentation would add to already significant administrative burdens for these small companies, strong incentives would need to be established.

Contracting and servicing companies are also key to raise awareness and to push sustainable technical solutions with a better lifecycle-cost-performance-ratio towards store owners. RefNat4LIFE actions therefore involve training and information for this stakeholder group. Priority educational topics are technology and refrigerant options available for cooling or heating needs, the advantages and challenges of natural refrigerants, legislative requirements regarding energy efficiency and a phase-out of fluorinated gases, as well as best practice maintenance and disposal of RACHP systems. Possible formats include MOOC training courses, short guidance documents and checklists – elements developed under the RefNat4LIFE project.

Given the strong impact of convenience stores and small supermarkets on overall GHG emissions, a first focus to reduce RACHP-related emissions should be put on local, regional or national chains operating multiple (OFR) stores, bakeries or butcher stores, as well as conventional chain stores. The adoption of renewable energies, using doors and remote controls on equipment, the selection of stand-alone and centralised refrigeration systems with natural refrigerants, or the utilisation of heat recovery especially in larger stores or those with bordering facilities (as e.g. processing areas or catering areas), are among those topics that should be discussed first. Under the RefNat4LIFE project, best practice criteria for small stores are developed to provide orientation.

Promote and set-up adequate financial models to alleviate financial pressure on small business owners

RACHP system suppliers and contracting companies are best suited to support innovative financing models tailored to the financial capabilities of small business owners. Such models might include financial or operational leasing schemes or ''Cooling as a Service'' (CaaS) to reduce the initial investment. Approaches that enable store owners to outsource their refrigeration needs to a third party would reduce their level of needed technical expertise and would also shift responsibility for efficiency and disposal of the appliances to the manufacturers. Special tax, credit schemes or loans for energy efficient RACHP do exist in some EU countries but should be reviewed in their effectiveness to support small food retailers.

In addition, RACHP system suppliers should demonstrate that an early investment in a more efficient system, even at a significant capital expenditure, offsets higher energy costs from a continued use of inefficient RACHP systems. This message should be emphasized by local contracting and servicing companies and energy auditors/advisors in direct contact with the final client (store owner) or operator.

1 Introduction, Climate Impact of Small Food Retail & Project Goals

1.1 Introduction

As countries are making a concerted effort to meet their Paris Agreement and Montreal Protocol obligations, greenhouse gas emission (GHG) and ozone-depleting substances (ODS) are being actively reduced. Natural refrigerants provide an important option for refrigeration, air conditioning, and heat-pump (RACHP) appliances. With very low or zero greenhouse warming potential (GWP) and no effect on ozone depletion, these substances can effectively replace current refrigerants (HCFCs, HFCs, HFOs) at a low cost.

Today, approx. 200 manufacturers are already using natural refrigerants in residential and (light)-commercial refrigeration and air conditioning units in Europe (shecco, 2016). Hence a growing supply base exists for a more accelerated uptake of non-fluorinated gases. In fact, the use of such gases in the European food retail sector is increasing. By June 2020, around 27,260 stores used CO_2 transcritical RAC systems in Europe, including 1,450 convenience stores of below 400 m^2 (shecco, 2020). Worldwide, 2.5 to 3 million HC-based commercial refrigeration units (excl. bottle coolers, vending machines) are in use. A growing number of large food retail chains have adopted natural refrigerants and energy efficiency measures as a blueprint for future stores.

However, by looking at smaller food retailers the situation was assumed to be significantly different: Small store owners, often independent, family-run businesses or local chains often struggle with the selection and maintenance of the best available RACHP equipment. Their reliance on mostly local RACHP installation and contracting firms with longer term ties based on trust makes them susceptible to misconceptions or a lack of expertise on the contracting side. It is often the case that small food retailers also deprioritise the investment in more energy efficient RACHP systems for financial reasons, shying away from the capital cost of new systems due to a lack of cashflow. Even while on a lifecycle perspective, the investment in new, more energy-efficient equipment could make financial sense, small business owners tend to opt for a prolonged maintenance of existing equipment. The main reason for deprioritising RACHP purchase, maintenance and replacement is the small shop owners' significant competitive disadvantage against large, efficient food retail chains who are able to seize financial savings from blueprinting across their various chain of stores, and a lack of inhouse knowledge on the environmental and commercial implications of inefficient RACHP systems.

In many cases, this results in stores running old, inefficient RACHP equipment that has been passed down from the predecessor or has been purchased as second hand equipment from specialised traders and is maintained until it finally reaches its end of life (= break-down). This has also led to a situation where units using high-GWP refrigerants such as R410A, R404A, or R134a in centralised and plug-in units are newly installed or serve as a replacement for end-of-life equipment in smaller stores. This is counterintuitive given the upcoming bans on their use under the F-gas Regulation. The result is a lock-in situation for store owners that will need to comply with those rules, starting in 2020.

Those assumptions formed the motivation for the Refrigerants, Naturally! For LIFE (RefNat4LIFE) project aimed specifically at small store owners, to better understand their current challenges and support them in the uptake of more sustainable RACHP technologies and best practices. However, since there is a pronounced lack of data on the small food retail sector, including the organic food retail sector, and their decision making factors for or against climate friendly RACHP equipment, the RefNat4LIFE project's Action 1 sets out to establish a more solid data base on a sector often disregarded in European and national statistics. This will be essential to gain a better understanding of i) the number of stores in the sector, ii) the structure of the small food retail sector, iii) the economic position and challenges, iv) and the awareness of and potential for GHG emissions savings in this sector.

1.2 Climate impact of (small) food retailers and relevant legislation

The problem arising from the current use of refrigeration, air-conditioning and heat pump (RACHP) units in Europe's Organic Food Retail and small food retail sector can be distinguished by a direct impact on GHG emissions through refrigerant leakage and an indirect impact on GHG emissions through energy use.

1.2.1 Direct and indirect GHG emissions from RACHP equipment

Direct greenhouse gas (GHG) emissions from refrigerant gases, foams or solvents, contribute to climate change when fluids with a Global Warming Potential (GWP) are released into the atmosphere. The higher the GWP (reference value is CO_2 = 1), the stronger the negative climate impact. A rising number of RACHP units and their direct GHG emissions from refrigerant leakage and illegal venting will endanger the EU's 2030 climate targets, and specifically those of the EU F-gas Regulation 517/2014. Hydrocarbons (R600a, R290 or R1270), with a Global Warming Potential (GWP) of 4; carbon dioxide (R744), with a GWP of 1; ammonia (R717), as well as water and air (all no GWP) are a direct solution to reduce refrigerant related GHG emissions, depending on their best application. However, they mostly face non-technical barriers, especially through non-favourable standards, lack of awareness and missing specific skill sets. This is especially true for small store owners that lack easy access to reliable information about the impact of RACHP units on the use of fluorinated gases, energy and financial resources.

Indirect emissions are produced when RACHP equipment consumes energy, resulting in the emission of greenhouse gases from power plants. As energy production is the primary factor in the emission of GHG in the atmosphere, energy use is a key consideration.

In fact, direct emissions only make up 10 to 40 per cent of total climate impact, while the remaining 60 to 90 per cent are indirect emissions relating to electricity consumption. Throughout the lifetime of RACHP equipment, both direct and indirect emissions occur during stages of production, operation, maintenance and end-of life treatment (see Figure 1-1). Therefore, the effectiveness of any strategy in the (small) food retail sector in driving down GHG emissions hinges on the ability to effectively address both direct and indirect emissions in RACHP technology adoption.

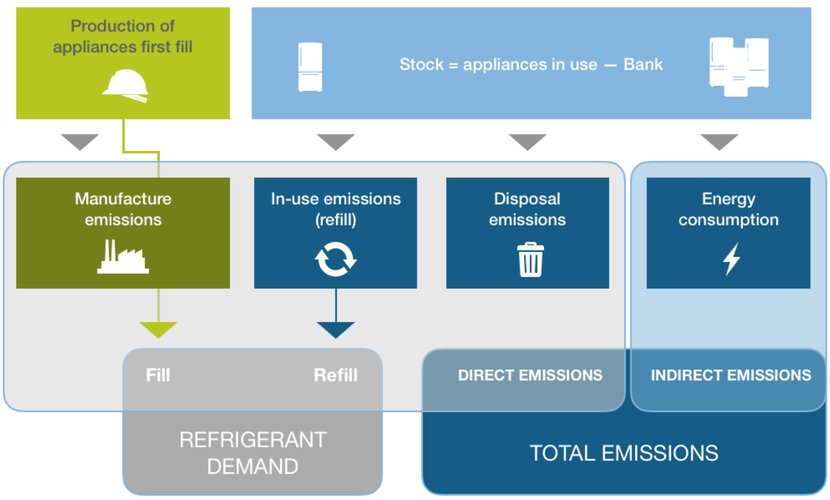

Figure 1-1: Direct and indirect emissions from RACHP equipment

Talking specifically about the problem arising from the non-sustainable use of RACHP equipment, one can look at GHG emissions from a hierarchical perspective: 1-2% of global GHG emissions stem from food retail; 3-4% of electricity use in Germany, France or Sweden is related to the sector. Stores selling food have a 50% higher energy usage than other commercial buildings. Refrigeration counts for 30-50% of the total energy used in a store, and therefore is the largest contributor to a food retailer's overall environmental impact. Commercial refrigeration is responsible for approx. 1/3 of HFC demand in the EU, with high-GWP refrigerants being responsible for 18-30% of the overall carbon emissions in EU stores. From a different perspective, heat islands around buildings are increasing, making the need for more air-conditioned spaces necessary (Tassou 2011, Enova 2007).

1.2.2 F-gas Regulation

The F-gas Regulation 517/2014 is the main legislative driver to phase down direct GHG emissions from RACHP equipment in the EU. For the individual equipment types addressed under RefNat4LIFE, the following rules apply:

Refrigeration (remote, plug-in)

The F-Gas Regulation 517/2014 targets the refrigeration sectors more than it does for the AC or heat pump (HP) sectors. From 2022 onwards in commercial refrigeration, all standalone and multipack systems with refrigerants with a GWP >150 will be banned. Centralised equipment will be regulated through the licencing system of the regulation and will not be allowed to use refrigerants with a GWP > 2500 as of 2020. In summary, the legislative pressure on the (light-)commercial refrigeration sector will continue to increase until 2022 and beyond.

Air-conditioners (AC)

There is a growing global market for air conditioning, with the market being valued at 135.2 billion USD in 2018, and an expected growth to 292.7 billion USD by 2025 (Zion Market Research, 2019). Room air conditioners alone made up 96.05 million units in 2017 and are expected to grow by 14% GACR during 2019-2024. Europe had a share of 5.83 million units room AC units in 2017 and has been showing a high growth rate (8.7%) from 2016 (Mordor Intelligence, 2020). Prior to 1990, the room air conditioning sector mostly used HCFC-22 as refrigerant and from the mid-1990s, the use of R407C started. Today, R410A, with a GWP of 2090, is the most commonly used HFC refrigerant in split A/C, as well as in portable units. The F-Gas Regulation 517/2014 has banned HFCs with a GWP higher 750 in split units that contain up to 3kg of refrigerant from 2025. From 2020 HFCs with a GWP above 150 will be banned in movable air-conditioning equipment. Air conditioning equipment is movable if the end-user can move it between rooms. In the future, manufacturers will have to either reduce the GWP of the refrigerant used or limit A/C production numbers. This means that R410A will have to be replaced by more climate-friendly alternatives quickly.

Heat pumps (HP)

Today, mostly high-GWP refrigerants R401A, R407c and R134a are used in HPs that are steadily growing in use. The EU F-Gas Regulation has not set any targets for the HP sector. However, via its contribution to the 2030 79% HFC reduction targets, the HP industry needs to support a reduction in average GWP values by 2030. Since HPs are less used in the small food retail sector which is mostly dependent on existing infrastructure, their use will be a rather secondary focus in the project.

1.2.3 EU Energy efficiency policy

The European Union is targeting an overall energy saving of 20% by 2020, and 32.5% by 2030 across Europe. The relevant policy tool is the amended Directive 2018/2002 (EU, 2018), as part of the **Clean Energy for All Europeans Package**, obliging EU countries to save on average 4.4% of their annual energy consumption between now and 2030.

To achieve this aim, the EU introduced a set of legislative mandatory measures for everyday energy-related products. With the introduction of a mandatory EU Energy Efficiency Label and other energy efficiency (EE) rules, it estimates a saving of 175 MTOE by 2020 and an average of € 500 per household / year. Measures are said to create € 55 billion in extra revenue for European companies. There are two main pieces of legislation affecting the use of energy-related products on the EU market:

- Ecodesign Directive (EU, 2009)
- Energy Labelling Regulation (EU, 2017b)

The **EU Ecodesign Directive** aims at minimizing GHG emissions from a life cycle perspective, from the development phase through the recycling / disposal phase. However, its main focus is often on the phase of the product's use by prescribing Minimum Energy Efficiency Standards (MEPS). MEPS follow a fixed time schedule and apply a special Regulation per product group. Producers can demonstrate compliance by using the approved EU harmonized standards and testing methods to achieve a minimum Energy Efficiency Index (EEI) (EU, 2017a).

Hence the framework Directive has a "push" function from the bottom, since it introduces MEPS for currently 24 product groups. It effectively bans low-efficiency products from the EU market, and directly addresses producers of models within those product groups.

As a complementary tool, the **EU Energy Label** has a "pull" function from the top, as it sets mandatory labelling requirements for currently 14 product groups. It therefore drives a move towards high efficiency products by rescaling the label in line with technological progress at regular intervals. Its main communication efforts address consumers that are encouraged to choose products in the highest range of the energy efficiency label. Table 1-1 shows an overview of the different application of the EU Ecodesign Directive and the EU Energy Efficiency Labeling Regulation for Refrigeration, Air Conditioning and Heat Pump (RACHP) appliances.

Table 1-1: Overview of the EU Ecodesign Directives and the EU Energy Efficiency Labelling Regulations of RACHP appliances.

Ecodesign Directive	Energy Labelling Regulation
Air conditioners and comfort fans	Air conditioners
Air heating and cooling products	
Local space heaters	Local space heaters
Heaters and water heaters	Heaters and water heaters
Professional refrigerated storage cabinets	Professional refrigerated storage cabinets
Refrigerators and freezers	Household refrigerating appliances
Solid fuel boilers	Solid fuel boilers
Ventilation units	Residential ventilation units

1.2.4 The Refrigerants, Naturally! for LIFE project and its focus on small food retail stores

The Refrigerants, Naturally! for LIFE (short: RefNat4LIFE) project aims to promote the uptake of climate-friendly cooling alternatives among end-users and servicing providers of refrigeration, air-conditioning and heat pump (RACHP) equipment. More specifically it addresses the organic food retail (OFR) sector, and other small food retail categories (including e.g. bakeries, butcher stores, corner stores and superettes – see chapter 3.4) that are challenged in finding more sustainable solutions to comply with requirements under the F-gas Regulation, climate and energy efficiency rules of the European Union and at national levels. The project's main targets are shown in Figure 1-2:

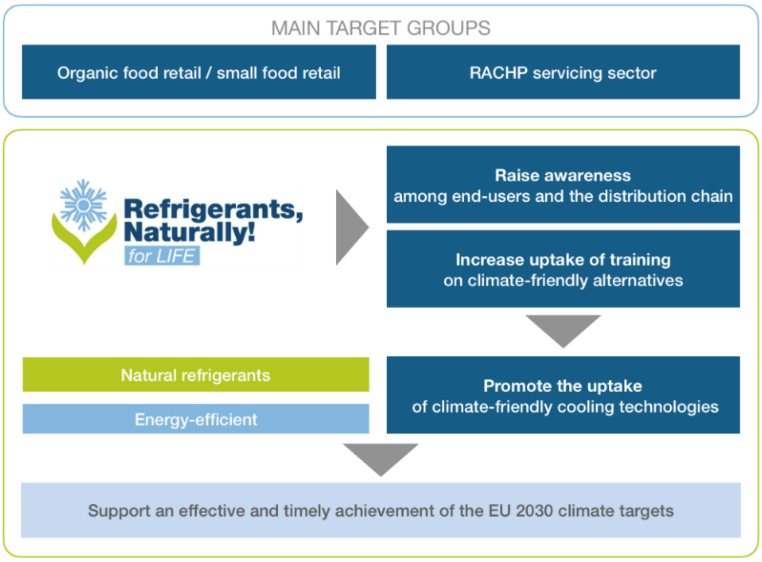

Figure 1-2: RefNat4LIFE project target groups, objectives and outcome

To achieve its objectives, the project engages in 5 main actions (Figure 1-3)[12]:

Figure 1-3: RefNat4LIFE project main actions

[12] For more detailed information on the project's objectives and main actions, please visit: https://www.refnat4life.eu/

1.3 About this report & methodology

This report is part of Action 1 “RACHP market assessment, stock modelling & technology user needs for the OFR sector” of the RefNat4LIFE project which lays the foundation for all the following project activities and deliverables. The aim of the report is to provide a first approximation of the GHG emissions related to RACHP-equipment from small food retail stores in Europe. To reach this goal the following sub-activities were performed to gather data on the target sector including its structure in different EU-countries, the number of stores and market trends, the RACHP-equipment used, and awareness and knowledge of store owners with regard to the environmental impact of the technologies and criteria for future purchase decisions:

- **Desk research:** A quantitative data collection to gather available statistics for small food retail stores on the market in general, and the OFR sector in particular, was carried out. As a first step, a definition of the research scope was set (see chapter 1.4) to limit the analysis for the size category and the type of food retail included. The initial focus of the analysis performed was on all stores with a sales area below 1,000 m^2. Chapter 2 and 3 of this report provide the results from this research and bring together scattered data on leading small food retail types, including independent OFR stores, bakeries, butcher stores and other small food retail formats.

- **Online surveys:** Several tailored versions of online surveys were drafted to reach the two main target groups of RefNat4LIFE: 1) the end-user sector, with a focus on the OFR sector and small food retailers; and 2) the RACHP contracting sector. The online surveys were carried out during the period from October 2019 to April 2020. 54 respondents completed the survey. Results of the surveys are compiled in chapter 4.2 of this report.

- **User interviews & store visits**: Based on the surveys, tailored interview guides were drafted to receive more in-depth information from the OFR and other small food retail sectors on the use and future adoption of sustainable RACHP technology. The interviews were planned to be carried out from October 2019 to April 2020. Several had to be cancelled due to the Covid-19 pandemic. Nevertheless, a number of interviews were carried out in the context of the online survey to gather the required data.

- **Stock modelling**: By condensing researched data, quantitative surveys and interviews with store owners/operators, a stock model was developed for the use of RACHP equipment in the OFR and small food retail sector. Based on research-based data revealing the numbers of stores by country and store category, the stock model develops a baseline, from here on denominated as a business-as-usual (BAU) scenario and a mitigation (MIT) scenario for the GHG emission modelling. To this end, the stock model considers refrigerant charges & types, cooling/heating capacity, energy efficiency, operating hours, and the number of RACHP appliances per store. The system boundaries in regard to the GHG emission accounting are defined in conformity with store operators’ immediate sphere of influence. The result aims to be the first approximation on the RACHP-related emissions from small food retail stores in Europe. The results of the stock model are compiled in sub-chapter 4.3.3.

1.4 Definition of Research Scope

This report focuses on the small food retail sector in the European Union, with a specific emphasis on the organic food retail (OFR) sector. For the LIFE project and the resulting public report to optimise results, a prior analysis of available store size categories and food retail types, and their compatibility with the project indicators and framework conditions for the project activities was carried out.

The following criteria were taken into consideration for a final definition of store formats and size categories included in the project (Table 1-2):

Table 1-2: Criteria for the definition of store formats and size categories of the RefNat4LIFE-Project.

Criteria	Explanation/Details
Focus on retail activities	Stores with a main focus on gastronomical or other non-retail activities are excluded from the scope of the project and this report, even if other factors could allow for their inclusion (like small sales area).
Focus on small retail chains and independent shop owners	As can be seen from recent years, larger conventional food retail chains have already made progress towards introducing low-GWP[13] or zero-GWP refrigerants, including natural refrigerants, in their stores. They are also more systematic in terms of rolling out energy efficiency measures and other sustainability elements across their stores. Therefore, the RefNat4LIFE project does not focus on that target group but instead aims at supporting independent shop owners and those local to national OFR chains to close the existing gaps in technology availability, awareness and access to tailored information. However, given the lack of data on individual organic food retail stores in many countries, and a lack of clarity on the size categories of different retail formats in available data sources, it was decided to include conventional supermarkets (convenience stores, superettes, etc.) and discount stores up to a size of 1,000 m^2 sales area in the stock model analysis (see chapter 4.3). Similarly, for the OFR sector, smaller national or local chains were included in the analysis, since in some countries like Germany they make up the biggest part of today's specialised OFR sector and hence they should not be excluded from further analysis and support measures. Where possible, the report provides more detailed quantitative or qualitative data about small independent food retailers in which they go beyond the stock model.
Focus on fresh food and perishable food sales	Stores with a focus on non-food related sales or the absence of any fresh or frozen food sections are mostly excluded from the project's scope.
Smaller average store size	The LIFE project aims at minimising the impact of RACHP specifically for smaller stores up to 1.000 m^2. As stated earlier, for reasons of data consistency, the stock model for that size category also includes conventional stores like supermarkets, convenience stores / superettes, or food discount stores.
Availability across the EU	The considered food retail store types and sectors should be represented in all or several European countries. Retail types with only a local presence are less important for reasons of offering a low overall positive environmental impact from RACHP technology change.
Significant impact from RACHP equipment	Their use of RACHP should constitute a significant part of the food retailer's energy consumption and energy costs. Sectors with no or only minor use of RACHP technology are no priority under this report.

[13] Please note that wherever the term "low-GWP" is used throughout this report, for reasons of simplicity it also includes "zero-GWP" substances with a GWP = 0 (like ammonia R717, water R718, or air R729 as a refrigerant).

1.4.1 Selection of store size categories

Table 1-3 shows an overview of the possible size categories into which different food retail store categories fall and the average store size in Germany. The latter serves as a reference of one European country, providing an indication for other national markets with a similar makeup. However, it cannot be representative of the European or all individual national markets. Please also note that the stock model explained in Chapter 4 assumes a categorisation based on Nielsen, 2017, to provide for data consistency given the variety of definitions and resulting overlaps in size categories.

Table 1-3: Overview of European store size categories within the RefNat4LIFE-Project.

Type	Impulse channel	Superette	Small / other food retail	Discount market ("Discounter")[14]	Supermarket
Size category [m²]	≤ 100	≤ 399	1 – 399	400 – 1.000	400 – 2.499
Ø size (DE) [m²]	n/a	n/a	291[15]	788	1.031
Definition	Bakeries + food retail stores + kiosks of max. 100 m²	Corner stores/ small food retail stores,often located in highly frequented urban locations	All food retail up to 399 m² (bakeries, butcher stores, fishmongers, other)	Limited range of products (2.000-3.000) as compared to supermarkets (12.000 articles on average)	Broader range of products as compared to discount markets
Challenge	Overlap with "small/other food retail channel" (EHI), and "superette" (Nielsen) in some statistics	Overlap with "impulse channel" and "small / other food retail" (e.g. EHI); commonly known also as "convenience store"	Overlap with "impulse channel" and "superette"	Overlap with "supermarket" categories in some statistics	Divided into "small supermarket" and "large supermarket" in data sources (e.g. Nielsen)
Data source	n/a	Nielsen	EHI	EHI	EHI

Based on the classification in Table 1-3, some further clarifications are provided as follows:

Supermarket: Especially for the organic food retail sector, supermarkets with organic products-only focus are becoming increasingly popular, taking away market shares from smaller, independent food retailers. As a challenge, and as this category is normally defined up to a size of 2,499 m², the project and this report only focuses on stores up to 1,000 m². Another complication is added by sub-categories of "small supermarkets" and "large supermarkets" with conflicting size limits by some data sources, making a conclusive analysis difficult.

Discount stores: Although the project and this report does not focus on this conventional food retail category, the stock model includes discount stores in the category of up to 1,000 m². This is due to a lack of consistent data across countries that would further distinguish smaller supermarkets from the discount market. Wherever possible the report will draw attention to the quantitative or qualitative difference between independent food stores, discount markets and supermarkets, in order to keep its original focus on the intended target group.

[14] Henrich, 2019

[15] HDE (2019)

Large supermarkets & hypermarkets: For reasons of simplicity, all categories comprising large supermarkets (2,500 – 4,000 m^2) and hypermarkets (2,500+ m^2; or 5,000+ m^2, depending on the data source) are not considered in the following report, the stock model analysis, or the RefNat4LIFE project.

1.4.2 Selection of food retail type categories

In addition to distinguishing store by size, the analysis performed looked at possible retail sectors in terms of the type of food sold. The combined result of the performed analysis, taking into account the criteria listed at the beginning of this sub-chapter and the store size categories, can be seen in Table 1-4:

Table 1-4: Final selection matrix for store size category and food retail type categories in the small food retail sector

Type of store	Retail focus	Fresh & perishable food focus	Small store size	Small chains & independen t	RACHP impact significant	Wide EU availability	Final selection for project focus
Specialised organic food retail (OFR)	+++	+++	+++	++	++	++	YES
Small food retail	+++	++	+++	+++	++	+++	YES
Bakeries	++	++	+++	+++	++	+++	YES
Butcher stores	+++	+++	+++	+++	+++	+++	YES
Farm shops	+++	+++	+++	+++	+++	++	YES
Confectionary	++	+++	+++	+++	+++	+	YES/NO (included in bakery category)
Ice cream parlour	+/++	+++	+++	+++	+++	++	NO**
Drugstores	+++	+	++	+	+	+++	NO
Discounter	+++	+++	++	+	+++	+++	NO
Convenience stores	+++	+++	+++	+	+++	+++	NO
Health shop	+++	+	+++	+++	+	+	NO
Petrol station	+++	+	+++	+	+	+++	NO

* From "+" = low; to "+++" high compatibility with criteria. *** While they comply with most of the relevant criteria, ice cream parlours are not included due to a lack of data available for individual countries and at the EU level. It is also assumed that the gastronomical character disqualifies a significant share of the stores in the criterion "Retail focus".

A definition for some of the preselected types is presented as follows:

Specialised organic food retail: The German Association of Organic Processors, Wholesalers and Retailers (Bundesverband Naturkost Naturwaren BNN e.V.) defines specialised OFR stores as those outlets with stationary sales offering a full assortment of dry and fresh foods, with a minimum of 95% of their food complying with Regulation (EU) 2018/848 on organic production and labelling of organic products. The stores need to be open for a minimum of five days per week. Organic farm shops are also required to purchase additional goods valued at 50,000 EUR per year (BNN, 2018). Other countries follow a similar definition, based on Reg. CE 178/2002, Reg. EU 1308/2013 and Reg. EU 1169/2011.

Farm shops: A farm shop is directly connected to a farm whose products are sold. Often farm shops also offer bought-in goods. There are farm shops that only offer a limited range of goods and others that sell products such as other foods, drinks and delicatessen products. Since "farm shop" is not a protected term, some shops which have no connection to a farm and sell only bought-in goods also call themselves farm shops. In the following report, the category of “other sales” in the marketing channels for the OFR sector could refer to farm shops as a way to market fresh products from the farm directly to the consumer without an intermediary.

Health shops / “Reformhaus®”: Reformhaus® is a cooperative. Shops are usually owner-managed, while others are organised as chains. Products sold in those types of stores are typically of organic origin, some being certified by a uniform “neuform” label across all stores. There is no central regulation, as may be the case with franchise companies. Certainly, there are some health stores that offer chilled goods, but generally this plays a subordinate role.

Confectionary: A confectionary is a business that typically offers a wide variety of pastries and typically also serves as a café. Confectionaries are found in different countries including Germany, Austria, Switzerland, France, Denmark, Sweden and the Czech Republic. However, the culture and function of the confectionary may vary based on locations.

Ice cream parlour: An ice cream parlour is a catering establishment where mainly ice cream is served, but also milkshakes, coffees and other beverages. They vary in terms of environment; some only have an order window and outside seating, while others have complete indoor facilities. Additionally, some parlours have drive-through windows. Some parlours remain open all year round (typically in warmer weather locations) and others in colder climates stay open only during warmer months, particularly from March to November.

Bakery: A bakery is a craft business that produces and sells baked goods such as bread, rolls, cookies, cakes, pastries and pies. Some retail bakeries are also categorised as cafés, serving drinks to customers who wish to consume the baked goods on the premises. For the purpose of this report, only the sales premises themselves, which are typically directly adjacent to the production rooms, shall be taken into account. Those “bakery shops” shall simply be called “bakeries” in the following.

Excluded from the scope of this report are 1) industrial bakeries for delivery of products to supermarkets; and 2) in-store baking units as part of some supermarkets and discounters. Hence the focus lies on “craft bakeries” or “artisan bakeries” with mostly smaller independent shops or regional chains that produce fresh food. Those can be found as shops in individual or multi-party buildings. The latter, however, are often cooled by the central air-conditioning and refrigeration system of the store, and hence they provide a less important category for the purpose of the project focusing on small RACHP units.

Butcher store: A butcher store is linked to an artisanal business that processes and sells the products of a slaughterhouse into meat and sausage products after slaughter. Increasingly, butcher shops also offer warm meals containing meat products. The focus, however, is on the sales of meat products and neither on their production nor on the gastronomical service.

Petrol station: A petrol station’s main purpose is to sell petrol, diesel, liquid gas, natural gas, hydrogen or electricity to users of motor vehicles. Many petrol stations are operated either independently or as franchise stations by large oil companies, such as Shell, BP, Total, ExxonMobil or Aral. Free, independent petrol stations operate under their own name. Today, many petrol stations offer more and more drive-in services and small supermarkets, partly offering warm food.

Drugstore: A drugstore is a specialist shop, generally offering products in the following five areas: Medicines (teas, essences and tinctures); Beauty care and wellness (body care products, perfumes, essential oils, cosmetics etc.); Organic reform products and wholesome food; Articles for the care of property in house and garden; Electronic aids (disposable cameras, batteries, USB cables etc.). The definition of drug store differs from country to country. Whereas in countries such as Germany or Austria large drugstore chains with a focus on beauty care and wellness dominate, other countries still have more of the owner-led independent drugstores to provide tailored advice to customers. Drugstore expert markets in countries such as Austria or Switzerland are allowed to sell medicines, similar to pharmacies, requiring drugstore operators to obtain special licenses.

Based on the performed analysis, the stock model collected data for the following size categories and food retail types (Table 1-5):

Table 1-5: Size categories and food retail types used for the stock model.

	Shop type
Conventional	**Total of small supermarkets, < 1000 m² sales area**[16]
	Small supermarkets, 400-999 m² sales area
	Superettes, < 400 m² sales area
	Bakeries (independent stores incl. subsidiaries)
	Butcher stores (independent stores incl. subsidiaries)
	Other specialised food shops (incl. farm shops)
OFR	**Total of OFR stores, < 1000 m² sales area**
	OFR shops 400-999 m² sales area
	OFR shops < 400 m² sales area, incl. organic farm shops

[16] The term “supermarket” is here adopted from Nielsen, 2017. It is used as a synonym for small independent stores, discount markets and other food retail types below a sales area of 1,000 m^2.

2 The European Small Food Retail Sector

This chapter begins by providing a short introduction to the overall European food retail sector in order to examine Europe's small food retail sector in relation to the bigger picture. Its structure as well as recent and future trends are described firstly at EU level, then for each of the countries covered under the RefNat4LIFE project. This information is essential for the development of Business-As-Usual (BAU) and Mitigation (MIT) scenarios for GHG emissions from this sector, provided in chapter 4 of this report.

2.1 Europe (European Union & other)

2.1.1 Context: Small food retail sales & growth trends as part of the overall food retail sector

Europe's food retail companies and stores (specialised and non-specialised) generated 1,128 billion EUR in 2015. 904,000 companies were involved in this sector with 7.4 million employees working in food retail (Food & Drinks, 2018). Together, France, Germany, Italy, Spain and the UK accounted for more than half of the value of the European food retail market in 2013. By 2022, the European food retail market is estimated to reach 2,289 billion EUR in sales, translating to a 3.7% GAGR in the period 2017-2022. Saturated markets such as Germany or France will experience a slower pace of expansion; while Central and Eastern Europe will experience higher growth rates (IGD, 2018). Table 2-1 provides an overview of European countries' food retail sales in 2017, and their expected sales by 2022.

Table 2-1: European food retail markets in 2017 and 2022 (est.) IGD (2018) [17]

Country	2017 (€bn)	2022 (€bn)	CAGR
Germany	239.06	264.37	2.0%
France	224.74	249.70	2.1%
United Kingdom	216.33	249.56	2.9%
Italy	174.94	192.82	2.0%
Spain	110.98	124.39	2.3%
Poland	62.94	73.22	3.1%
Netherlands	48.82	58.41	3.7%
Belgium	40.76	47.19	3.0%
Switzerland	40.44	44.52	1.9%
Sweden	29.60	33.14	2.3%
Austria	25.13	28.79	2.8%
Portugal	18.97	21.15	2.2%

[17] IGD defines the grocery retail market as all food, drink and non-food products (e.g. health and beauty, pet care, clothing, DIY) sold through all retail outlets selling predominantly food in a given country. This definition includes modern retail formats, such as supermarkets and hypermarkets, and traditional retail formats such as open-air markets and traditional food stores such as bakers. It excludes wholesale and foodservice formats and drugstores/pharmacies.

Regarding market shares in 2015, 39% of all European supermarket stores including superettes fell into the category covered under the RefNat4LIFE project: 10% into the category of 1-400 m^2 sales area, and 29% into the size category of 400-1,000 m^2 sales area. Large supermarkets with 1,000-2,500 m^2 of sales area made up 26%, and hypermarkets 36% (Nielsen, 2017).

Precise data on the contribution from small traditional specialised stores is largely unavailable, with one reason being the varying definition of food retail store types and sales area classification. Although traditional food retail stores still have a significant market share especially in central or southern Europe, modern food retail formats have experienced the strongest growth in the sector in recent years. From 2004 to 2012, those formats including discount markets, supermarkets and hypermarkets, increased by 24 Member States, evident in new shop openings and increased floor space. Discount stores had been the most successful, increasing their sales areas by 81% between 2000 and 2011, followed by hypermarkets (46%) and supermarkets (26%). In parallel, large retail groups expanded their market share continuously (30% of the entire food retail market in 2012), leading to a consolidation of Europe's food retail market. In 2012, discount stores accounted for 54% of the total edible grocery sales in the EU (EY et al., 2014). However, in the last five years the rate of new store openings has been in decline globally, especially in developed markets like Europe.

With regard to average sales areas, some research organisations predict that from 2017-2022, supermarkets & neighbourhood stores with a smaller average sales area size would show higher growth rates (3.7% CAGR) than hypermarkets and superstores, even exceeded by expected growth rates for convenience stores (4.8%) and discount stores (5.8%) (Planet Retail RNG, 2017), both categories with an average sales area below 1,000 m^2. Other grocery stores could therefore make up 49% of the sales of modern grocery retailers by 2022, as compared to traditional hypermarkets ("big-box store").

The following trends affecting the future development of the small food retail sector globally and in the EU can be noted:

- **High growth rates for convenience stores, small supermarkets and discount stores** with 75% of shoppers living in urban areas. In Central and Eastern Europe, nearly 70% of the population will live in urban areas by 2022; in Western Europe it will be nearly 80% (Planet Retail RNG, 2017)
- **More demand for customised food and individual shopping experience for physical stores,** including more frequent "top-up shopping", shop-in-shop experience, social shopping (restaurants, workshops), click & collect schemes without the need for a check-out, use of digital services, mobile payment or augmented reality
- **Rise of online and delegated shopping** including click-to-buy, auto-replenishment or direct-to-consumer services through voice and mobile ordering services
- **Demographic changes** that have led to a decrease in average household size from 2.6 in 2012 to an estimated 2.4 in 2022 in developed countries has increased the elderly's need for corner stores and home delivery
- **Focus on convenience, fresh and regional products**, **organic food** including "made in store" products, smaller portions of fresh food, ready-to-eat products; high demand for ethnic, organic and special diets (allergies, diabetes, obesity) food, and vertical farming
- **Higher awareness for environmental and social performance** of food production, distribution, and consumption

The above trends have already had an impact and will continue to influence the set-up of typical food retail stores in Europe, including its demand for more flexible RACHP units. For example, the trend towards more sustainable consumption in food and non-food products is also spreading towards the supply of RACHP units. While those are normally not in the focus of the consumer's attention, more shop owners are starting to shift their focus towards solutions with a lower total environmental impact, namely by saving energy, material resources, and producing less waste.

2.1.2 Small food retail stores: number, sales area & trends

From 2000 to 2011, the total sales area per food retail store category showed the following evolution: The only relevant category for the RefNat4LIFE project, small supermarkets of up to 1,000 m^2, is contained in the supermarket category of 400-2,499 m^2. This category grew by 26% to 44,177 m^2, distributed among 58,858 outlets, in 2011. Hypermarkets grew by more than 46% to 23,146 m^2 in 6,372 outlets and discount markets by 81% to 29,068 m^2 in 39,887 outlets in 2011. (EY et al., 2014).

In the following, bakeries are described in more detail as they represent a significant share of small food retail stores and also relatively sound data has been made available across different EU-countries that enabled comparison of results under this project.

Bakeries as one important representative of small food retail

The European bakery industry is the food sector with the highest value added. In 2012, 154,803 companies were active in this sector, which also represents the highest number of companies out of all food sectors (53.7%). 99.7% of companies in the industry are Small and Medium Entities (SMEs), with less than 9 employees per company.

In 2006, 34% of all bakery products in the EU were produced in artisan bakeries. Another 5% was produced at in-store baking units in some supermarkets or at some restaurants. The remaining 61% was produced by industrial bakeries (EC, 2014). The latter two types are excluded from the scope of this report.

Bakery companies are not distributed evenly across Europe, as shown in Figure 2-1, with almost half of them being located in only two countries, France and Italy, and 85% in nine countries. Among the leading countries are project countries Germany (14,761 companies), Spain (10,295), Portugal (6,524) and Belgium (4,021). In terms of per capita distribution, Portugal takes 2nd rank Europe-wide with 6.19 bakery companies per 10,000 inhabitants. The Netherlands on the other side of the spectrum of the considered project countries only has 1.51 companies per 10,000 inhabitants.

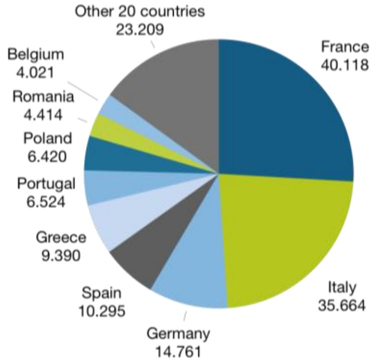

Figure 2-1: Distribution of bakery companies in Europe in 2012 (EC, 2014).

EU countries greatly differ in terms of the share of artisan supply versus industrial supply. This distinction is of relevance since in countries with a higher share of artisan supply the number of individual bakery stores is higher than in countries where industrial bakeries dominate. Out of the project countries, the Netherlands had the lowest share of artisan bakery supply (10%) versus industrial supply in 2006, followed by Germany with approximately 25%, and Spain with 35%. Portugal is the project country with the highest share of artisanal bakery supply (40%).

As regards the supply of fresh bakery, one can see a split between artisan bakeries and modern retail (supermarkets). Figure 2-2 provides an overview, where in 2011, 32% of all fresh bakery was distributed by artisan bakeries, with another 32% by supermarkets. Artisan bakeries and bakery chains – a total of 42% of fresh bakeries supply - are covered in this report. However, as a major trend in the bakery retail sector, modern retail is growing much more quickly in terms of market share, confirmed by a decline in the number of artisan bakeries in most countries.

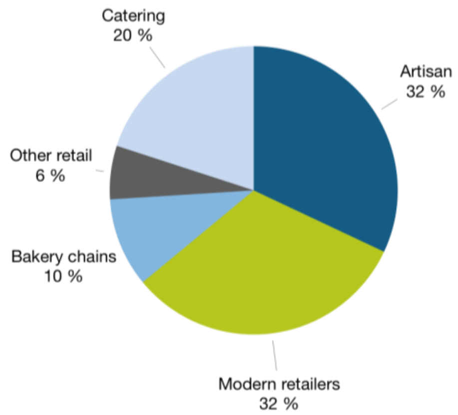

Figure 2-2: Market share of supply channels of fresh bakery 2011 (EC, 2014).

2.2 Project countries

2.2.1 Small food retail Germany – Overview

Short Profile Indicator	Year	Data
Sales total food retail	2017	239.06 €bn[18]
Sales total food retail	2022 (est)	264.37 €bn[19]
Number of all supermarket stores < 1,000 m² (1+2)	2015	23,435
Number of supermarket stores 400-999 m² (1)	2015	19,848[20]
Number of superette stores < 400 m² (2)	2015	3,587[21]
Number of bakeries	2018	46,000[22]
Number of butcher stores	2018	19,667[23]

2.2.1.1 Small food retail sales & growth trends

According to the EHI Retail Institute, the German food retail sector generated 162.10 billion EUR sales in 2018, an increase from the year before (158.3 billion EUR). Out of this 73.9

[18] https://www.igd.com/articles/article-viewer/t/european-grocery-retail-market-to-be-worth-2289-billion-by-2022/i/18614
[19] https://www.igd.com/articles/article-viewer/t/european-grocery-retail-market-to-be-worth-2289-billion-by-2022/i/18614
[20] https://einzelhandel.de/index.php?option=com_attachments&task=download&id=10310
[21] https://www.nielsen.com/de/de/insights/report/2016/booklet-retail-consumers-advertising/
[22] https://www.baeckerhandwerk.de/baeckerhandwerk/zahlen-fakten/
[23] https://www.fleischerhandwerk.de/presse/jahrbuch-zahlen-und-fakten.html

billion EUR or 47% was generated by discount markets (mostly up to 1,000 m^2) (EHI Retail Institute, 2018b). Supermarkets (400 to 2,500 m^2 sales area) represented 48.7 billion EUR in 2017 or approximately 30% from the total food retail market shares, a significant increase from 35.1 billion EUR in 2008 (Bulwiengesa, 2017).

The small / other food retail sector (including e.g. bakeries, butcher stores) held a market share of 3.1% from the total food retail sector in 2016 (Figure 2-3).

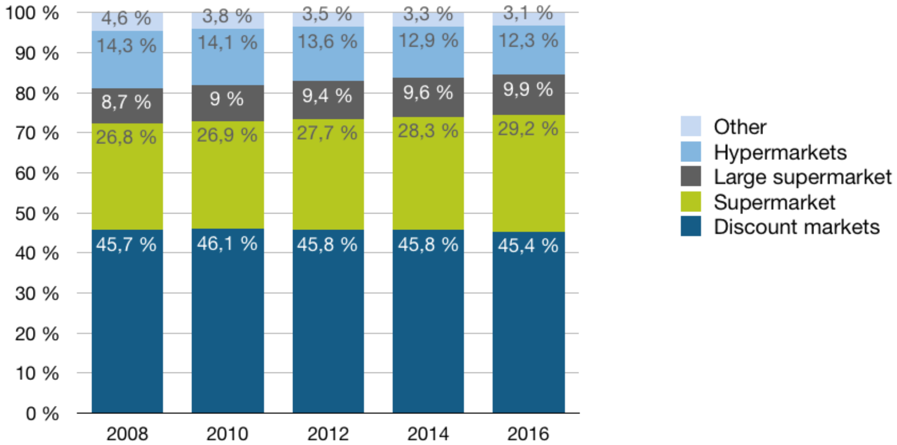

Figure 2-3: Germany: market share per food retail store type 2008-2016 (Bulwiengesa, 2017)

2.2.1.2 Small food retail stores: number, sales area & trends

In 2018, Germany had a total of 37,551 food retail outlets. This was a decline of -4.4% from the 39,288 stores in 2010. Looking at the number of stores, the dominant food retail type was represented by discount markets with 15,990 stores in 2018 (see Figure 2-4).

Small food retail stores made up 8,600 outlets and 22.9% of all stores in Germany in 2018. It is important to note that while small food retail stores decreased by 42.3% from 14,900 stores in 2007, the category of "supermarkets" and "large supermarkets" increased over the same period of time. Overall, and despite food retail chains experimenting more and more with small urban formats, the trend towards a further consolidation of the German food retail market away from small food retail outlets towards medium-sized and larger formats continues.

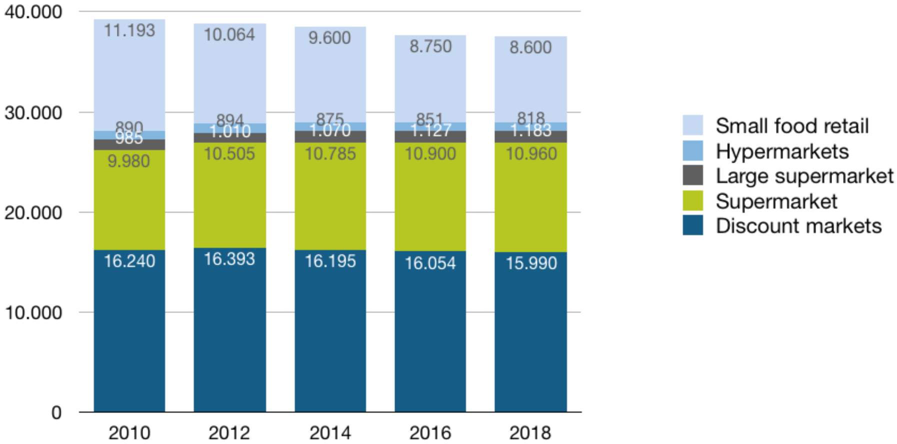

Figure 2-4: Germany: number of food retail stores by type, 2010-2018 (HDE, 2019)

Figure 2-5 provides an overview of the development of the small food retail sector for stores below 400 m^2 sales area from 2008 to 2016. While the area output has increased over the years, all other indicators such as turnover, number of stores and total sales area have decreased.

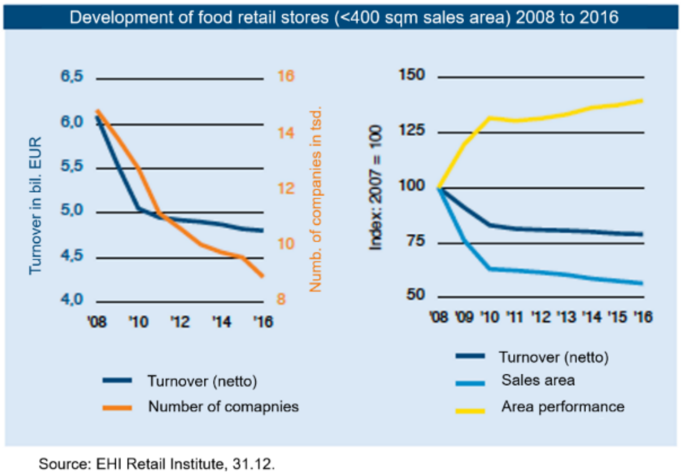

Figure 2-5: Overview on the development of small food retail stores with a sales are below 400 m² from 2008 to 2016. (Bulwiengesa, 2017).

Looking at the total sales area occupied by the different food retail channels in Germany, discount markets are once again dominant with 12.6 million m^2 in 2018, followed by supermarkets (see Table 2-2). Overall, Germany had 36.2 million m^2 of total sales area for all food retail formats.

Table 2-2: Total sales area [million m²] of different store types in Germany from 2010 to 2018. Modified after HDE, 2019).

Store type	Sales area [mio. m²]								
	2010	2011	2012	2013	2014	2015	2016	2017	2018
Small food retail stores	11.7	11.9	12.1	12.1	12.2	12.5	12.5	12.6	12.6
Discounter	9.6	9.7	10	10.2	10.4	10.6	10.7	11.2	11.3
Supermarket	6.3	6.3	6.3	6.3	6.1	6.1	6.0	5.9	5.8
Big Supermarket	3.4	3.5	3.5	3.6	3.7	3.7	3.9	3.4	4.0
Hypermarket	2.9	2.8	2.8	2.8	2.7	2.6	2.6	2.5	2.5

The average sales area per type of food retailers is shown in Table 2-3.

Table 2-3: Average sales area [m²] per type of food retailer. Modified after HDE, 2019).

Type	Small / other food retail	Discount market (“Discounter”)	Supermarket	Large supermarket	Hypermarket
Size category [m²]	1 – 399	400 – 1,000	400 – 2,499	2,500 -4,999	5,000+
Average size (DE) [m²]	291	788	1,031	3,381	7,090

2.2.1.3 Bakeries, butcher stores & specialised small food retail

Bakeries: Germany is among those European countries with a still relatively high total number of bakery companies, but takes a medium rank in terms of its share of artisan (approx. 25%) vs. industrial bakeries. However, with 1.84 bakeries per 10,000 inhabitants in 2012, Germany has a relatively low per capita concentration as compared to countries like Greece, Portugal, France or Italy (all above 6 bakeries per 10,000 inhabitants) (EC, 2014).

The total sales generated within the German bakery trade rose to 14.67 billion EUR, or 1,276,000 EUR per company, in 2018. However, the number of artisan bakeries has significantly reduced over the last decades (Figure 2-7). Below 100 m^2 part of the "impulse channel" category, the number of bakery stores was at approximately 46,000 sales outlets in 2017, out of which 35,000 were representing local or national bakery chains (Figure 2-6). The artisan bakery trade, however, is still fragmented with 11,347 different companies active in this food retail trade (EHI Retail Institute, 2019a).

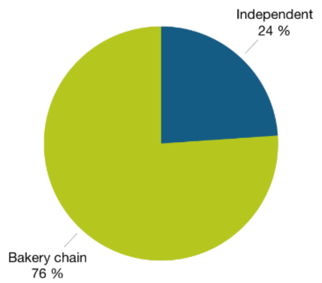

Figure 2-6: Germany: share of bakery chains vs. independent stores

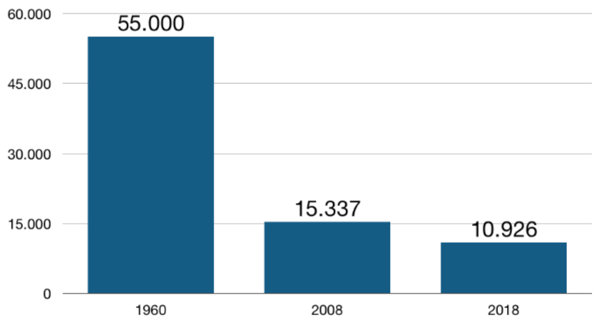

Figure 2-7: Germany: number of artisan bakeries 1960-2018

The largest conventional bakery chain in Germany (K&U) operated 810 stores, out of which 99 were self-service bakeries and 654 shop-in-shop formats (EHI Retail Institute, 2018c). The largest organic bakery chain in Germany (Ludwig Stock Hofpfisterei) operated 156 sales outlets in 2011. All other organic chains had significantly fewer stores (EHI Retail Institute, 2011). It is estimated that only 3% of all German bakeries are organic-only stores.

The average sales area of a German artisan bakery shop is 70 m^2. Most shops are located in the inner city where rent is expensive, so sales area is limited with only a small back office space. The trend is however towards larger sales areas, as in the other food retail categories (German Artisan Bakery Association, personal communication,).

Butcher stores: In 2018, Germany had 19,667 butcher shops, out of which 11,917 were independent stores and 7,750 were branch stores of mostly regional chains (Figure 2-8). 25.2% of all active companies in the sector had at least one branch store in addition to the main sales outlet. The total number of stores declined from 21,319 sales outlets two years earlier (-8%), sharing the trend of the overall small food retail sector of declining sales outlets. A major reason for increased commercial shutdowns is the lack of successors in the butchery trade (EHI Retail Institute, 2019b). As a major trend, one can note a move towards higher income and better performing butchers.

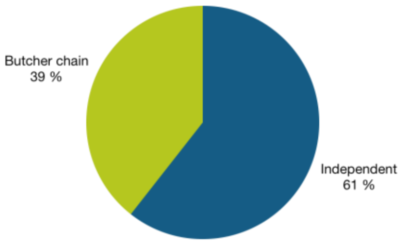

Figure 2-8: Germany: share of butcher store chains vs. independent stores in 2018

Farm shops: In Germany there are around 30,000 to 40,000 farm shops in which farmers directly sell their products to consumers (BMEL, 2013).

2.2.2 Small food retail of the Netherlands - Overview

Short Profile		
Indicator	**Year**	**Data**
Sales total food retail	2017	48.82 €bn[24]
Sales total food retail	2022 (est.)	58.41 €bn[25]
Number of all supermarket stores < 1,000 m² (1+2)		3,562
Number of supermarket stores 400-999 m² (1)	2015	2,873[26]
Number of superette stores below 400 m² (2)	2015	689[27]
Number of bakeries	2017	3,873[28]
Number of butcher stores	2017	1,757[29]

2.2.2.1 Small food retail sales & growth trends

In 2017, the sales of the small food retail sector were distributed as follows: butcher stores 975 million EUR; bakeries 747 million EUR; cheese and deli shops 222 million EUR; fish shops 362 million EUR; and poulter shops 99 million EUR. This amounts to a total of 2.4 billion EUR.

2.2.2.2 Small food retail stores: number, sales area & trends

The number of small food retail stores makes up 69% of all food retail stores in the Netherlands (9,192 out of a total of 13,286 stores).

The small food retail market was made up of the following mix of businesses in 2017: 28% bakeries, 13% butcher stores, 5% cheese and deli shops, 7% fish shops, 2% and poulter shops; and 46% small supermarkets (Figure 2-9). While the number of cheese and deli

[24] https://www.igd.com/articles/article-viewer/t/european-grocery-retail-market-to-be-worth-2289-billion-by-2022/i/18614
[25] https://www.igd.com/articles/article-viewer/t/european-grocery-retail-market-to-be-worth-2289-billion-by-2022/i/18614
[26] https://www.nielsen.com/be/en/insights/report/2017/nielsen-grocery-universe-2017/
[27] Assumed from market shares by store size and assumed averages sales areas in other European countries, based on: https://www.nielsen.com/be/en/insights/report/2017/nielsen-grocery-universe-2017/
[28] https://www.retailinsiders.nl/branches/foodspeciaalzaken/brood-en-banketzaken/
[29] https://www.retailinsiders.nl/branches/foodspeciaalzaken/slagerijen/

shops (+2.1%) increased in the period 2017-2019, both fish shops (-2.1%) and poulter shops (-1.0%) showed a decrease in number of shops.

2.2.2.3 Bakeries, butcher stores & specialised small food retail

Bakeries: In 2017, 3,873 bakeries were operating in the Netherlands. Their number declined by 1.8% in the period from 2017 to 2019. Besides the relatively low total number of bakery companies as compared to other EU countries, the Netherlands is also among the country with the highest share of industrial bakeries as compared to artisan bakeries (approx. 10% in 2012) in Europe, confirming that there is a relatively low number of small artisan bakery shops available in the country. With 1.51 bakery companies per 10,000 inhabitants in 2012, the Netherland ranks at the lower end of the European spectrum (from 0.29 in Switzerland to 8.44 in Greece).

Butcher stores: In 2017, 1,757 butcher stores were operating in the Netherlands. The number of butcher stores increased in the period 2017-2019 by 2.7%.

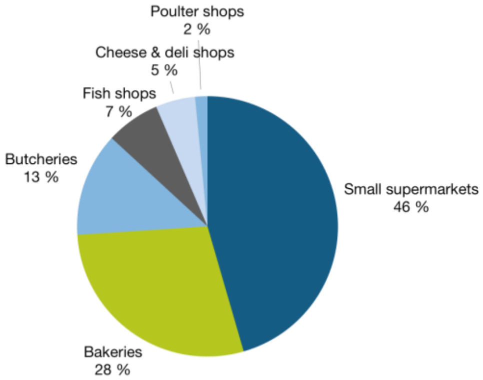

Figure 2-9: Netherlands: share of store types in the small food retail sector (Bionext, 2019)

2.2.3 Small food retail Spain - Overview

Short Profile		
Indicator	**Year**	**Data**
Sales total food retail	2017	110.98 €bn[30]
Sales total food retail	2022 (est.)	124.39 €bn[31]
Number of all supermarket stores < 1,000 m² (1+2)	2015	17,443
Number of supermarket stores 400-999 m² (1)	2015	6,114[32]
Number of superette stores below 400 m² (2)	2015	11,329[33]
Number of bakeries	2012	10,295[34]
Number of butcher stores	2013	10,518[35]

2.2.3.1 Small food retail sales & growth trends

According to the data from the Spanish Central Business Directory (DIRCE) from the National Institute of Statistics (INE), 20% of the total number of retailers are establishments specialising in food and beverages. This translates to around 115,900 stores. The rate of stores per population is 2.5 food and drink stores for every 1,000 inhabitants. Self-service establishments have increased their market share in recent years, as has also the number of stores and the average sales area. In 2015, 21,641 self-service establishments were registered (478 hypermarkets and 21,163 supermarkets) with a total sales area of 12,898,455 m^2.

Retail trade of food products decreased by -0.2% in 2015. There is no official data calculated for subsequent years, but the evolution of retail sales is quite similar to the Food Index, and this had positive rates during most of the year in 2016 and in 2017 (around 0.8% on average).

2.2.3.2 Small food retail stores: number, sales area & trends

In Spain, discount markets are one of the dominating food retail categories in terms of number of stores. Small supermarkets and discounters together represent 17,443 stores. This is a total of 6.1 million m^2 of sales area, out of which 4.8 million m^2 are dedicated to the sales of food. Fresh food is sold on 1.9 million m^2 in these two smaller food retail categories (see Table 2-4) (Kantar, 2018). The percentage of fresh food sales in traditional stores decreased by 5.4% from 2017 to 2018, while sales increased by 2.8% in discount stores, and by 2.8% in supermarkets.

[30] https://www.igd.com/articles/article-viewer/t/european-grocery-retail-market-to-be-worth-2289-billion-by-2022/i/18614
[31] https://www.igd.com/articles/article-viewer/t/european-grocery-retail-market-to-be-worth-2289-billion-by-2022/i/18614
[32] Mercasa (2016); 2015 data
[33] Mercasa (2016); 2015 data
[34] https://issuu.com/fp7leo/docs/bakery_and_bakeoff_market_study/27
[35] Estimation based on number of butcher stores per habitant in other project countries

Table 2-4: Number of stores and sales areas [m²] of different types of food retail stores of Spain (Kantar, 2018).

Type	Sales area [m²]	Number of stores	Total sales area [m²]	Total sales area for food [m²]	Total sales area for fresh food [m²]
Hypermarkets	>2,500	478	1,818,337	909,169	359121,755
Supermarkets	1,000-2,500	3,720	5,024,825	4,019,860	1,587,845
Small-size Supermarkets	400-999	6,114	3,896,171	3,116,937	1,231,190
Discounter	100-399	11,329	2,159,122	1,727,298	682,283
Self-service supermarkets	40-99				
Traditional food shops	<40				
Cooperative shops Frozen food stores Fish shops Butcher shops Dairy shops Bakeries	<100				
Drug stores Online sales Street markets Farm shops					

Figure 2-10 provides an overview of the total sales of fresh food per food retail type. The percentage of fresh food sales in traditional stores decreased by 5.4% from 2017 to 2018, while sales increased by 2.8% in discount stores and by 2.8% in supermarkets.

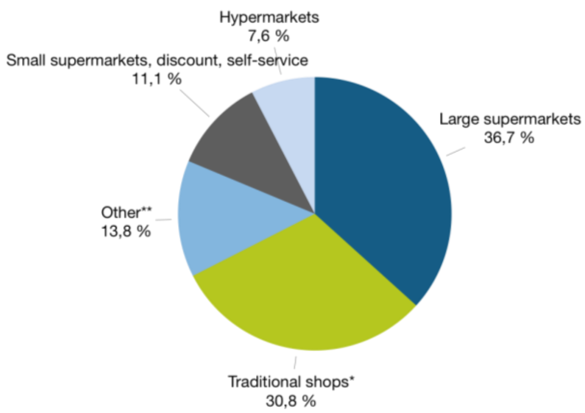

Figure 2-10: Spain: share of fresh food sales, by marketing channel, 2018 (Kantar, 2018)[36]

[36] * Traditional shops include cooperative shops, frozen food stores, fish shops, butcher shops, dairy shops, and bakeries; ** Other stores include drug stores, online sales, street markets, and farm shops.

2.2.3.3 Bakeries, butcher stores & specialised small food retail

Bakeries: Spain belongs to those countries with a high total number of bakery companies (10,295 in 2012). With 2.2 bakery companies per 10,000 inhabitants in 2012, Spain takes a middle rank, similar to Germany, on a spectrum from 0.29 in Switzerland to 8.44 in Greece. As a confirmation, the share of artisan (approx. 25%) bakeries as compared to industrial bakeries in 2006 was also comparable with Germany and therefore takes a middle rank among all EU countries.

Butcher stores: In 2013, Spain had 10,518 butcher shops.

2.2.4 Small food retail Belgium - Overview

Short Profile Indicator	Year	Data
Sales total food retail	2017	40.76 €bn[37]
Sales total food retail	2022 (est.)	47.19 €bn[38]
Number of all supermarkets stores < 1,000 m² (1+2)	2015	3,547
Number of supermarket stores 400-999 m² (1)	2015	2,079[39]
Number of superette stores < 400 m² (2)	2015	1,468[40]
Number of bakeries	2017	4,311[41]
Number of butcher stores	2018	3,432[42]

2.2.4.1 Small food retail sales & growth trends

Large retailers, namely hypermarkets, took a market share of 49.5% in Belgium, while medium-sized food retailers above 400 m^2 had a share of 30.4% and discount markets a share of 15.4% in 2016. Small food retailers and traditional food retailers took a share of 4.7% of the total market. Figure 2-11 provides an overview of the situation in 1995, 2001 and 2016. While middle size food retailers, including smaller supermarkets, have increased their market share continuously, the small food retail sector, including convenience and corner stores but also traditional shops such as night shops, has reduced in importance over the years (Gondola, 2017).

[37] https://www.igd.com/articles/article-viewer/t/european-grocery-retail-market-to-be-worth-2289-billion-by-2022/i/18614
[38] https://www.igd.com/articles/article-viewer/t/european-grocery-retail-market-to-be-worth-2289-billion-by-2022/i/18614
[39] https://www.nielsen.com/be/en/insights/report/2017/nielsen-grocery-universe-2017
[40] https://www.nielsen.com/be/en/insights/report/2017/nielsen-grocery-universe-2017
[41] https://www.dhnet.be/actu/belgique/le-nombre-de-boulangeries-wallonnes-en-recul-constant-5d11f3e59978e215c700bd7f
[42] https://www.sninet.be/fr/archives-de-presse/detail/chaque-semaine-une-boucherie-ferme-en-belgique

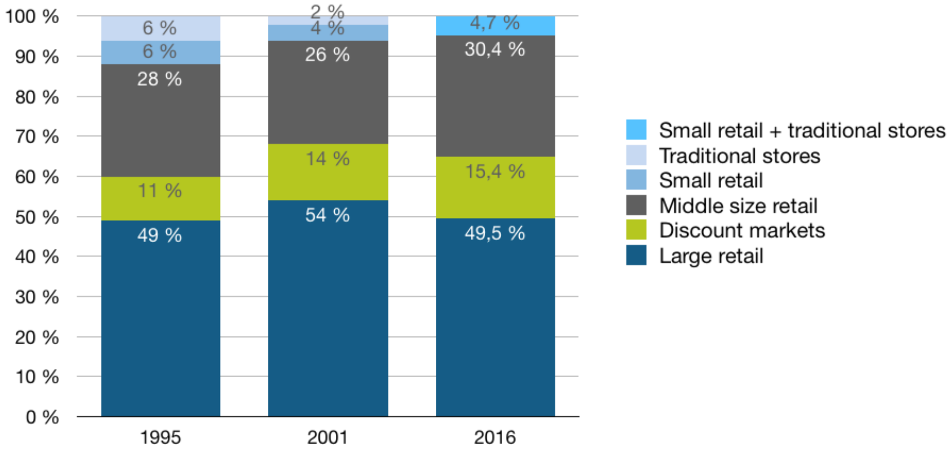

Figure 2-11: Belgium: market share of food retail store types in 1995, 2001 and 2016 (Gondola, 2017).

2.2.4.2 Small food retail stores: number, sales area & trends

The number of small supermarkets in Belgium below 400 m^2 was at 1,468 in 2015, while stores of between 400 – 999 m^2 made up 2,079 stores, including discount markets (2015 data by Nielsen, 2017). The average sales area for the smallest category was 167 m^2, while for the category of 400-999 m^2 the national average was 861 m^2.

Small retail and traditional stores made up a total of 4,477 stores in 2016, (Gondola, 2017), down from 10,325 stores twenty years ago. In total, Belgium had 7,163 food retail stores in 2016. Figure 2-12 provides an overview of the different store types by size category in 1995, 2006 and 2016.[43]

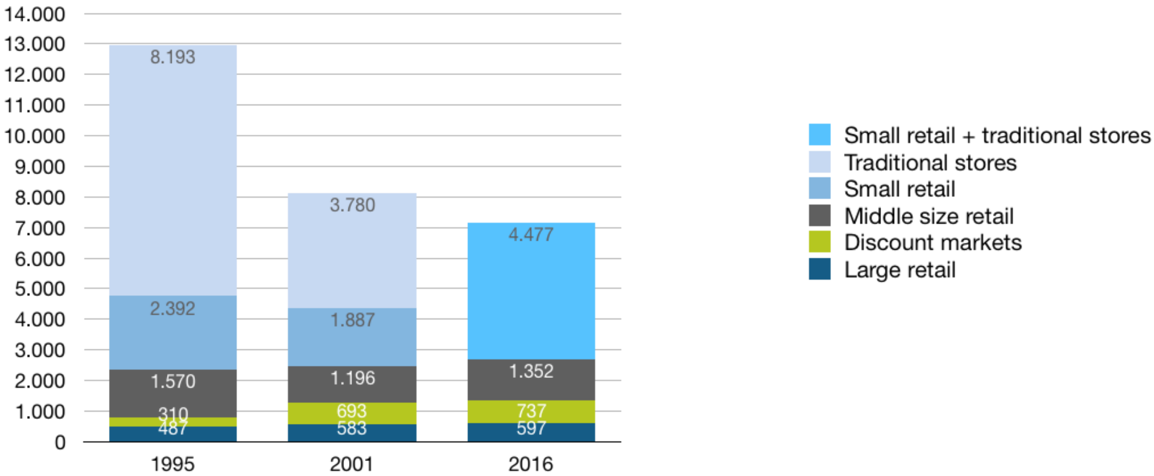

Figure 2-12: Belgium: number of food retail store types in 1995, 2006 and 2016 (Gondola, 2017)

As a general trend, small food retailers are on the decline due to a lack of profitability and rising competition from a growing number of supermarkets.

As regards the total sales area taken by all food retail stores in Belgium, this amounts to 3.8 million m^2. While large and medium-sized food retail formats both have strong shares in the

[43] National average sales area: Large retail = 2,119 m^2; Discount market = 884 m^2; Middle size retail = 821 m^2; Small size retail = 167 m^2.

total sales area (both around 1.2 million m²), small food retailers and traditional stores occupy 749,000 m² (Table 2-5).

Table 2-5: Sales surface area [m2] by store type in Belgium in 2016 (Gondola, 2017).

Store type	Sales area [m²] 2016
Large retail	1,265,310
Hard discounter	605,059
Middle size retail	1,194,548
Small retail and traditional stores (< 400 m²)	748,848
TOTAL	3,813,765

2.2.4.3 Bakeries, butcher stores & specialised small food retail

Bakeries: Belgium, despite its relatively small surface area, featured among Europe's nine leading countries in 2012 with the highest number of bakery companies (4,021). In 2017, 4,311 bakeries were counted (Figure 2-13) (DH, 2019). The country also had a higher-than-average share of artisan bakeries (approx. 35%) as compared to large industrial bakery companies in 2006. As for the per capita concentration of bakery companies, Belgium ranks high, with 3.62 per 10,000 inhabitants.

Butcher stores: In 2018, Belgium had 3,432 butcher stores, down from 4,270 ten years ago (Figure 2-13)

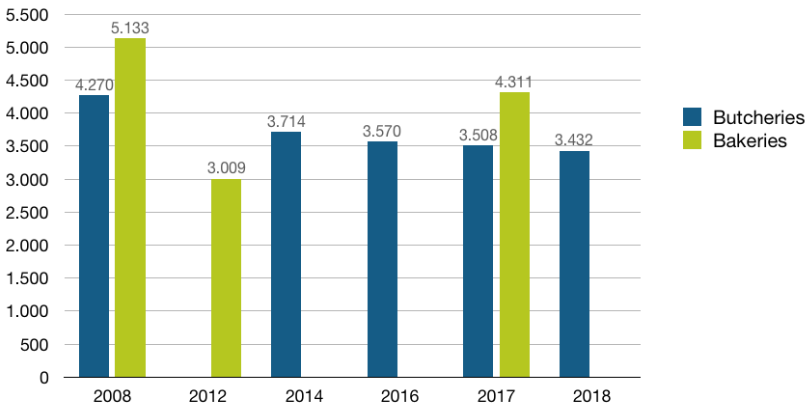

Figure 2-13: Belgium: number of bakeries and butcher stores, 2008-2018 (SNINET, 2019)

2.2.5 Small food retail Portugal - Overview

Short Profile		
Indicator	**Year**	**Data**
Sales total food retail	2017	18.97 €bn[44]
Sales total food retail	2022 (est.)	21.15 €bn[45]
Number of all supermarket stores < 1,000 m² (1+2)	2017	2,265
Number of supermarket stores 400-999 m² (1)	2017	1,100[46]
Number of superette stores < 400 m² (2)	2017	1,165[47]
Number of bakeries	2012	6,524[48]
Number of butcher stores	2013	2,358[49]

2.2.5.1 Small food retail sales & growth trends

Portugal has more general small stores with a higher share of fresh products than large markets like France. In 2018, there were a total of 3,558 retail stores in Portugal of which 1,725 focused mainly on the food trade (48.5%). Out of these, 1,659 are on the main continent (95.2%) and 170 have their activity on the islands (Madeira with 87 stores and Azores with 83 stores, equivalent to 2.3% and 2.6% respectively). Regarding the type of activity this can be estimated by the goods each business sells, where 70.1% (2.1 billion EUR) are focused on first-need supplies (Figure 2-14).

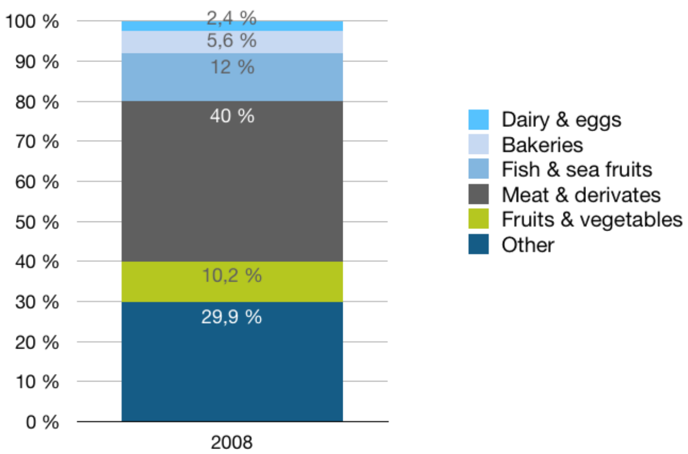

Figure 2-14: Portugal: share of food retail by food type sold, 2018

Small food retail stores below 1,000 m² occupied a share of 64.2% from the total Portuguese food retail sector in 2018, down from 64.8% one year before.

[44] https://www.igd.com/articles/article-viewer/t/european-grocery-retail-market-to-be-worth-2289-billion-by-2022/i/18614
[45] https://www.igd.com/articles/article-viewer/t/european-grocery-retail-market-to-be-worth-2289-billion-by-2022/i/18614
[46] Estimation by Agrobio (personal communication)
[47] Estimation by Agrobio (personal communication)
[48] https://issuu.com/fp7leo/docs/bakery_and_bakeoff_market_study/27
[49] Estimation based on number of butcher stores per habitant in other project countries

2.2.5.2 Small food retail stores: number, sales area & trends

For the small food retail sector, in 2018, a total of 2,284 stores were operating in Portugal. Out of those, 1,201 had a size of below 400 m^2; and 1,083 were in the category 400 to 999 m^2. This can further be distinguished into the specialised small food retail sector that occupied 55.7% of the small food retail market, with 348 stores below 400 m^2, and another 612 stores in the larger size category up to 999 m^2.

From 2017 to 2018, the Portuguese food retail market only increased marginally, from 3,496 stores to 3,558 stores. However, the small food retail market decreased in the same period, with stores in the category below 400 m^2 showing a negative growth of -2%, and larger size stores up to 999 m^2 by -3.4%.

As regards the percentage share of cooled fresh food sold in small food retail stores, the following can be estimated for 2018: in stores below 400 m^2, the share was 42.5%; while larger stores up to 999 m^2 had a share of 45.5% of fresh food.

2.2.5.3 Bakeries, butcher stores & specialised small food retail

Bakeries: Portugal was among the leading countries in terms of number of bakery companies in 2016, with 10,260 companies generating 585,197 EUR or 5.6% of the country's food retail sector (INE, 2016). In terms of per capita distribution, Portugal took 2nd rank Europe-wide in 2012, with 6.19 bakery companies per 10,000 inhabitants, with only Greece having more bakery companies per inhabitant. The share of artisan bakeries (40%) as compared to industrial bakeries is also among the highest across Europe, suggesting that Portugal's bakery sector is a highly diverse one with many small players.

Butcher stores: In 2013, Portugal had 2,358 butcher shops.

3 The European Organic Food Retail Sector

The RefNat4LIFE project puts a focus on the organic food retail sector as a special part of the total food retail sector. This focus was put as in the OFR sector retail stores with relatively small sales area (< 1,000 m^2) dominate. The OFR sector showed a positive development in recent years and further growth is expected. In addition, in several EU-countries the sector is to a certain degree well defined and organised (e.g. in associations) and can therefore be approached in a targeted way through respective OFR associations (including the RefNat4LIFE project partners). This chapter provides specific information on the OFR sector complementing the scene presented in chapter 2.

3.1 Europe (EU + other)

3.1.1 Sales & growth trends in the organic food retail sector

In the European Union, the market for organic products is constantly growing. From 2014, when total sales in the organic food retail sector reached 23.96 billion EUR for the EU28, this number rose to 37.4 billion EUR in 2018 (FiBL, 2020). In 2014, the EU28 hence held a share of 38% of all organic food retail sales worldwide (global: 62.63 billion EUR). Average growth rates for sales in organic food have been at around 10% over the last six years. From 2012 to 2017, the increase in organic food retail sales was 66.5%. The annual per capita purchase of organic food rose from 47.4 EUR to 73.0 EUR for the EU28 from 2014-2018.

In 2015, 68% of all organic food was consumed in just four EU countries: 30% in Germany, 20% in France, 9% in Italy, and 9% in the UK. In 2018, this amounted to sales of 10.9 billion EUR in Germany, 7.9 - 9.1 billion EUR in France, and 3.1 - 3.5 billion EUR in Italy (FiBL, 2020). This makes those markets by far the dominating ones in the EU. The other RefNat4LIFE project countries Spain (1.9 billion EUR in 2018), the Netherlands (1.3 billion EUR in 2018), Belgium (698 million EUR in 2018), and Portugal (21 million EUR in 2011) in total contributed around 3.9 billion EUR to the organic food retail sales, together providing a share of more than 10% from the EU28 (FiBL, 2020; AMI 2018).

Table 3-1 provides an overview of sales for the OFR sector per EU and EFTA country, including annual growth rates. It also shows the per capita consumption for most of the European countries in the years 2011, 2012, 2016, 2017 and/or 2018, depending on data availability.

Table 3-1: per capita consumption of organic food per European country, OFR sales, annual sales growth rates in %, and share of organic food sales from total, for 2011 - 2018. Source: FiBL 2020

Country	Year	Per capita organic consumption [€]	Organic retail sales [Million €]	Organic retail sales growth (1 year) [%]	Organic retail sales [%]
Austria	2012	127	1,064.7		
	2018	205	1,810.0	6.7	8.9
Belgium	2012	35	391.0		
	2018	61	698.0	5	3
Bulgaria	2012	1	7.0		
	2017	4	29.2	6,5	
Croatia	2012	24	104.0		
	2018	24	99.3		2.2
Cyprus	2016	2	1.5		

Country	Year	Per capita organic consumption [€]	Organic retail sales [Million €]	Organic retail sales growth (1 year) [%]	Organic retail sales [%]
	2018	2	1.5		
Czech Republic	2012	7	70.0		
	2018	12	126.5		1.2
Denmark	2012	159	887.0		
	2018	278	1,807.0	12.9	11.5
Estonia	2018	32	41.8		2.7
Finland	2012	37	202.0		
	2018	56 (2017)	336.0	8.7	2.4
France	2012	62	4,020.0		
	2018	136	9,139.0	15.4	4.8
Germany	2012	87	6,970.0		
	2018	132	10,910.0	5.5	5.3
Greece	2012	6	68.7		
	2018	6	66.0		
Hungary	2012	3	25.0		
	2018	3	30.0		0.3
Ireland	2012	23	103.9		
	2018	43	206.4	10.5	0.7
Italy	2012	32	1,885.0		
	2018	58	3,483.0	5.3	3.2
Latvia	2016	2	4.0		
	2018	6	51.0		1.5
Lithuania	2016	2	6.0		
	2018	18	50.5		1.0
Luxembourg	2012	143	75.0		
	2018	221	135.0	10.7	8.0
Netherlands	2012	47	791.4		
	2018	75	1,287.2	6.8	4.7
Norway	2012	40	201.5		
	2018	79	422.8	3.9	1.7
Poland	2012	3	120.0		
	2018	7	250.0		0.2
Portugal	2011	2	21.0		0.2
Romania	2012	1	11.7		
	2018	2	40.7		0.7
Slovakia	2012	1	4.0		
	2018	1	4.0		0.2
Slovenia	2012	21	44.1		
	2018	27	48.6		1.8
Spain	2012	21	998.0		
	2018	42	1,903.0	16.4	2.8

Country	Year	Per capita organic consumption [€]	Organic retail sales [Million €]	Organic retail sales growth (1 year) [%]	Organic retail sales [%]
Sweden	2012	95	905.0		
	2018	230	2,366.0	4.0	9.6
Switzerland	2012	193	1,519.9		
	2018	312	2,654.5	13.3	9.9
United Kingdom	2012	33	2,072.0		
	2018	38	2,536.9	5.3	1.5
EU	2012		20,852.0		
	2018		37,412.3		

An alternative data source (Bionext, 2018) summarises the total sales of the OFR sector in 2017 and 2018, the growth rate, current market share from the total food retail sector, as well as the expected total sales and market share by 2025, as summarized in Figure 3-1 and Figure 3-2.

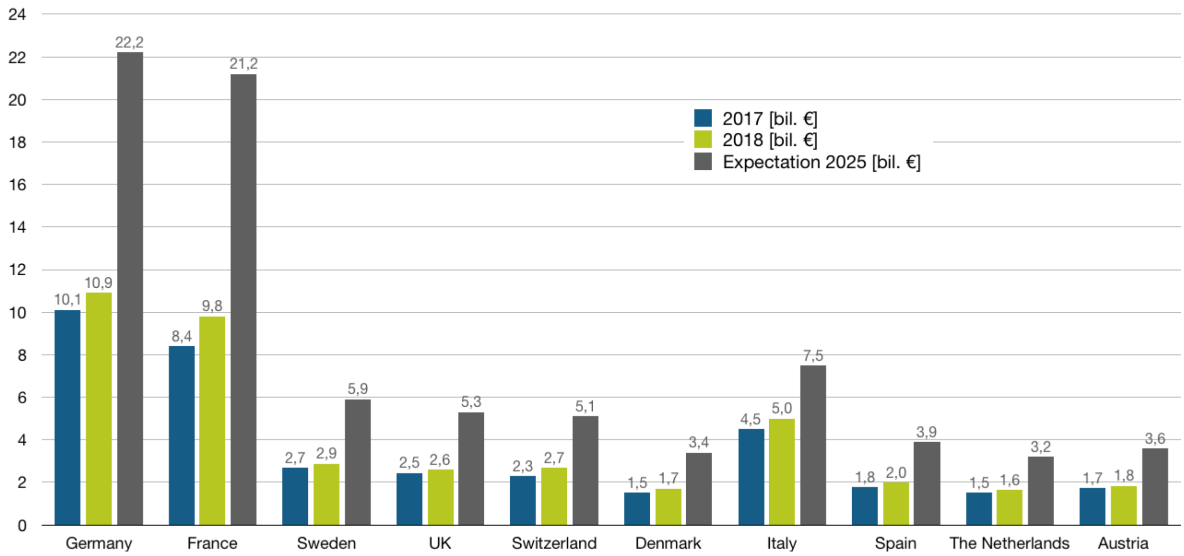

Figure 3-1: Total sales of the OFR Sector for selected European countries in 2017, 2018 and 2025 (estimated) (Bionext, 2018)

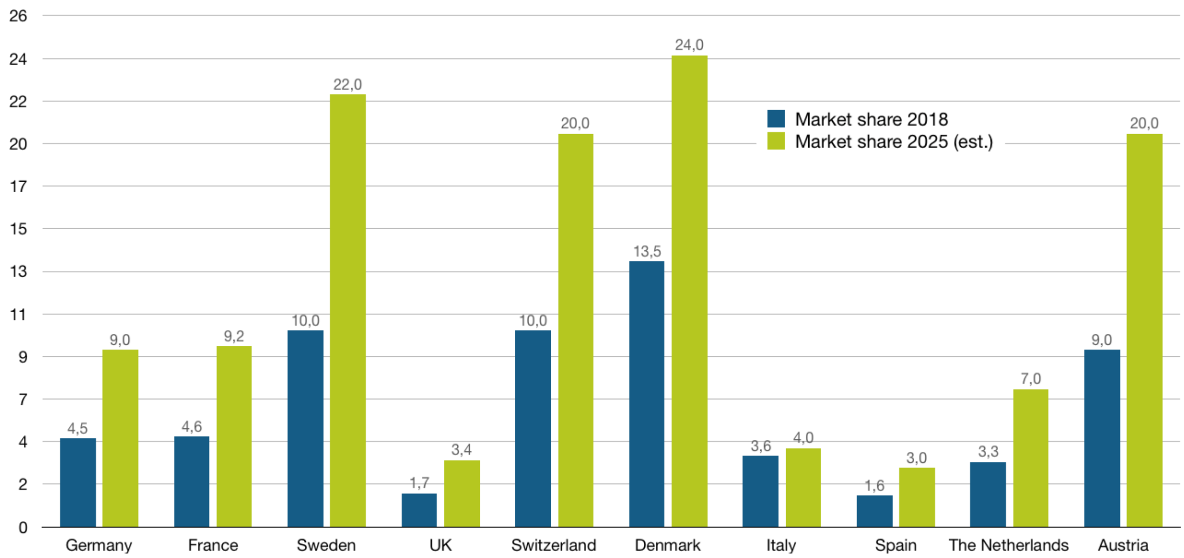

Figure 3-2: Market share of the OFR sector for selected European countries in 2018 and 2025 (estimated) (Bionext, 2018)

If ranked according to the capita consumption, the European countries with the highest consumption of organic food in Europe are all located in Northern or Western Europe (FiBL-Ami 2020 showing data for 2018, see also figures per country for 2018 in Table 3-1):

- Switzerland: 312 EUR
- Denmark: 312 EUR
- Sweden: 230 EUR
- Luxembourg: 221 EUR
- Austria: 205 EUR
- France: 136 EUR
- Germany: 132 EUR (FiBL, 2020)

3.1.2 Sales per marketing channel

The availability of specialised OFR stores in each country and an estimation on RACHP appliances used and their resulting GHG emissions in the sector can be calculated. For the purpose of this report and the RefNat4LIFE project, this is of even higher importance than the sales' numbers. Distinct differences between EU countries can be noted as regards the type of sales channel used for the distribution of organic food:

- **Diverse sales channels:** In Belgium, the Czech Republic, Finland, France, Germany, Hungary, Italy and the Netherlands, distribution channels are quite diverse with both specialised retailers and large distribution chains playing a significant role.
- **Large food retailers dominate:** In Austria, Bulgaria, Croatia, Denmark, Luxemburg, Sweden, the UK, large distributors dominate the market for organic food sales.
- **Specialised organic food retail dominates**: In Greece, Portugal and Spain, specialised OFR distributors are dominant.

Figure 3-3 provides an overview of the different types of sales channels by EU country.

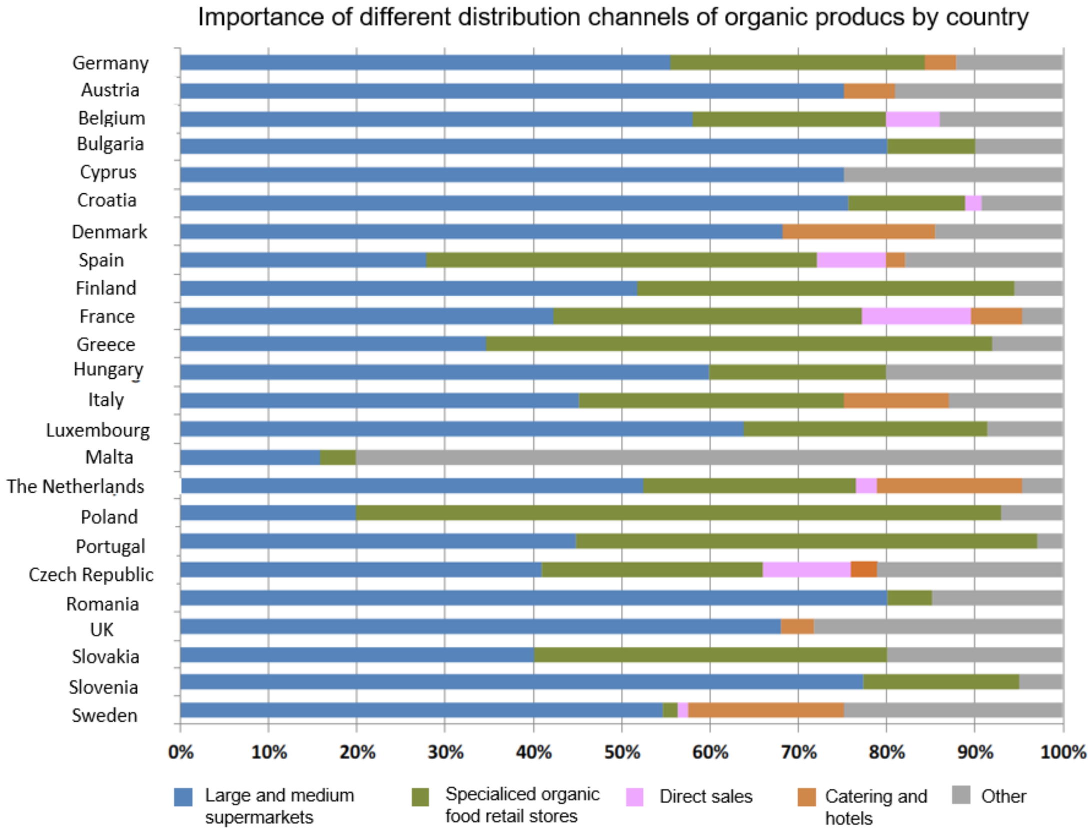

Figure 3-3: Overview on different distribution channels of organic products of European countries (Agence BIO, 2017).

For the RefNat4LIFE project countries the approximate situation for the year 2014 is shown in Table 3-2.

Table 3-2: Overview on the main distribution channels of organic products within the RefNat4LIFE-project countries in 2014 (Agence BIO, 2017).

Country	Food retail (mostly chains)	Specialised OFR stores	Direct sales	Other (incl. gastronomical services)
Belgium	58%	22%	6%	14%
Germany	55%[50]	30%	-	15%[51]
Netherlands	52%	24%	2%	22%
Portugal	44%	53%	-	3%
Spain	28%	44%	8%	20%

[50] For Germany, the category of “food retail” also includes drug stores.
[51] For Germany, the category of “other” refers mostly to small food retail formats like bakeries, butcher stores, weekly markets and farm shops. Therefore, some unknown share would also need to fall into the category of “direct sales”.

Where more detailed or updated numbers are available per country, those are presented in the following individual country chapters.

Information from a reliable source on the total number of OFR stores in the European Union, their total sales area by retail category, is currently not available. Specific data submitted by statistical offices of the individual EU Member States are limited, usually not making a distinction between conventional and organic food trade. Several national OFR associations confirmed that compiling such data would require carrying out specific research, which is beyond the scope of the RefNat4LIFE project and this particular stock taking exercise (see also chapter 6 on the limitations in the stock model).

3.1.3 Share of cooled goods of total turnover

To get a better understanding of the required cooling equipment in the respective OFR marketing channels, an approximation was attempted via an analysis of the share of cooled goods from the total turnover in the OFR sector. As a general fact, the organic market is dominated by perishable fresh produce compared to conventional markets.

Dairy products: As a general rule, one can note that the share of organic dairy consumption is high in the countries producing them. In Denmark, Sweden and the UK, organic dairy products thus take a share of 30% of the entire organic food market; in Belgium 20%, and in Italy and the Netherlands 13%, whereas France has a share of 12%.

Meat products: Meat products constitute around 10% of the organic market in Belgium and the Netherlands.

Fruits & vegetables: Organic fruits and vegetables continue to be highly popular purchases among European organic consumers, presenting around one fifth of many national organic markets. Organic vegetables have the highest market share after eggs, representing between 9-15% of the sales value of all vegetables sold in Switzerland, Austria and Germany.

3.2 Project countries

3.2.1 Germany

Short profile		
	Year	**Data**
Sales organic food retail	2019	11.97 €bn[52]
Sales organic food retail	2025 (est.)	22.2 €bn[53]
Number of OFR stores	2019	2,426
Number of OFR stores 400-999 m^2	2019	679[54]
Number of OFR stores below 400 m^2	2019	1,730[55]

3.2.1.1 OFR sales & growth trends

Germany is Europe's dominant market for organic food products, with sales of 11.97 billion EUR in 2019. In 2016, the OFR market share from the total food retail sales increased to

[52] BÖLW, 2020
[53] Bionext, 2018
[54] Estimation BNN, based on Biohandel, 2020
[55] Estimation BNN, based on Biohandel, 2020

4.8%. Since 2012 (7 billion EUR), the German OFR sector has increased by 48.4% (Figure 3-4).

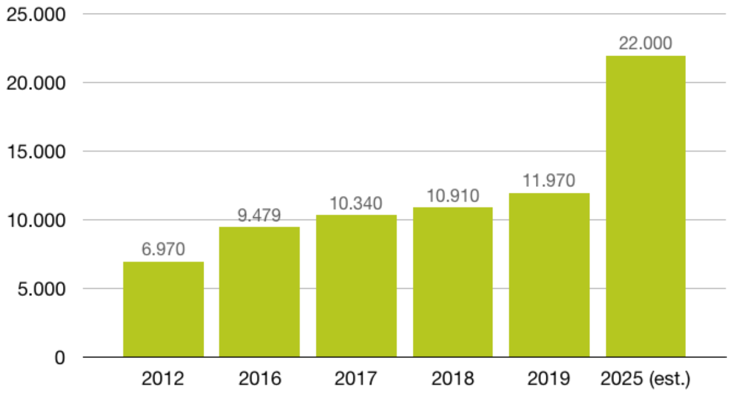

Figure 3-4: Germany: OFR sales in 2012-2019 [€bn], and estimated sales in 2025. Source: own analysis, based on FiBL 2020 and Bionext 2018

3.2.1.2 OFR sales channels

In 2019, 59.6% (7.13 billion EUR) from the total organic food sales, were made in conventional discount markets and full-range supermarkets. 3.18 billion EUR, (26.6%) were generated in specialised OFR shops. Another 1.66 billion EUR or 13.9% via bakeries, butcher stores, farm shops, online sales, as well as farmer's and weekly markets (Figure 3-5). Whereas direct sales and other sales channels have remained relatively stable over the years (2.7% average growth 2017-2019), the share of conventional food retail stores offering organic food is increasing faster (9.3% average growth 2017-2019) than that of specialised OFR stores (3.8% average growth 2017-2019). While the number of smaller OFR stores is decreasing, larger specialised OFR chains are increasing their market share.

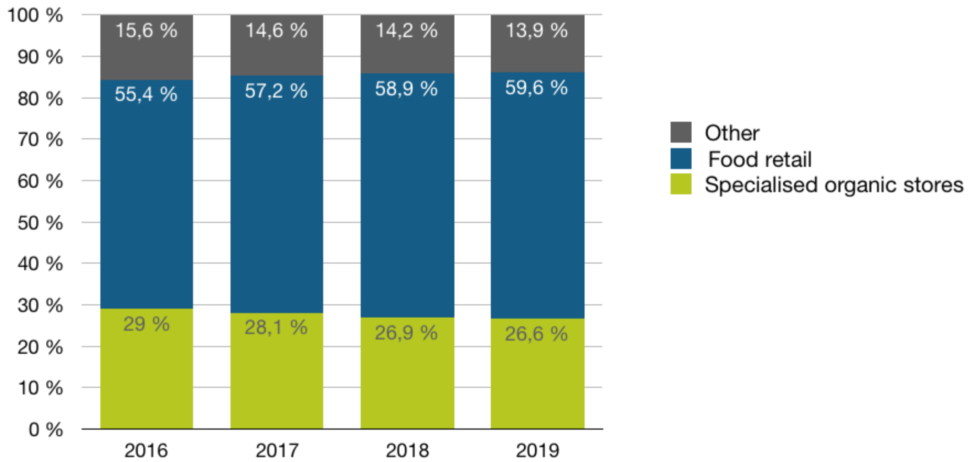

Figure 3-5: Germany: share of ORF sales per marketing channel in 2016-2019 (BÖLW, 2019; BÖLW, 2020)

The turnover of specialised stores selling organic products (Naturkostfachhandel), including non-food, increased from 2.3 billion EUR in 2012 to 3.76 billion EUR in 2019 (BÖLW, 2020).

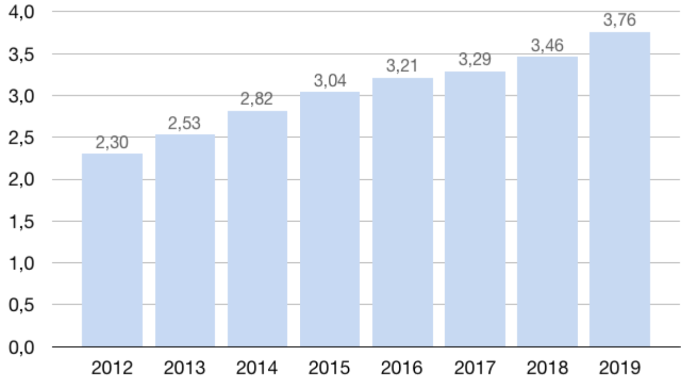

Figure 3-6: Germany: turnover [€bn] of specialised organic product stores (including non-food) in 2012 to 2019 (BÖLW, 2020)

3.2.1.3 OFR stores: types, number, sales area & trends

Germany had 2,426 specialised OFR stores at the end of 2019. As a further breakdown of this number, the German OFR sector was made up of 54% specialised organic stores (Bio-Fachgeschäft), 30% of organic supermarkets (Bio-Supermarkt), and 16% of organic farm shops (Bio-Hofläden) (BNN, 2020; Figure 3-7). As another sub-category in the OFR sector, the largest organic bakery chain in Germany operated 156 sales outlets in 2011. All other organic chains had significantly less stores (EHI Retail Institute, 2011). It is estimated that only 3% of all German bakeries are organic-only stores.

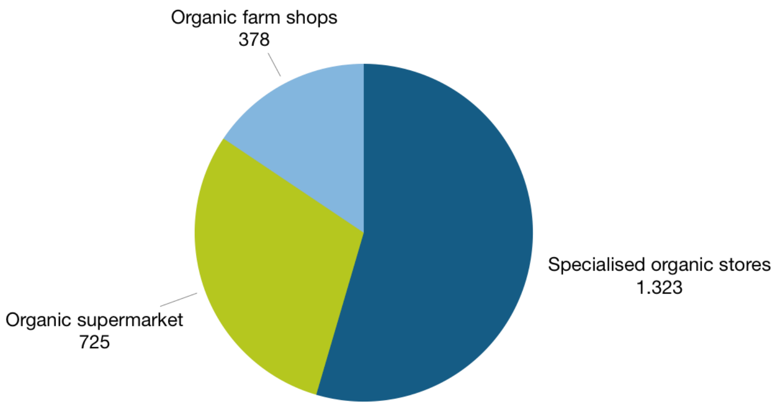

Figure 3-7: Germany: number of specialised OFR stores, by retail type, 2019 (BNN, 2020)

While the total number of OFR stores remained relatively stable the year before, a negative trend in the category of shops below 100 m^2 was noticeable with 36 shops being closed and only 10 new shops opening in 2017. Above 400 m^2, however, a reverse trend was visible, with 50 new shops opening and only 6 closing. As a confirmation of the ongoing consolidation in the OFR sector, most shops were opened by OFR chains with 49 of the 78 new stores being opened in 2017. This trend also continued in 2018 as 66% of new larger stores were opened by OFR chains.

In 2016, the total sales area of the entire German specialised OFR sector was 590,000 m^2. It grew to 655,000 m^2 in 2017, and by another 1.4% in 2018. Two-thirds of this total sales area is occupied by branch operators like regional OFR chains (BÖLW, 2020). The average sales area increased from 227 m^2 in 2016, to 259-265 m^2[56] in 2017 and 274 m^2 in 2019 (BNN, 2020). The average sales area was:

- 159 m^2 for specialised organic stores;
- 592 m^2 for organic supermarkets;
- 97 m^2 for organic farm shops

Figure 3-8 shows the distribution for 2019 in which the sales area is further broken down into categories of size. The smallest specialised organic food retail store in Germany has a sales area of 10 m^2, while the largest covers 3,000 m^2. At least 98% of OFR stores in Germany have a sales area of maximum 800 m^2 and thus fall below the selected limit of 1,000 m^2 within the LIFE project.

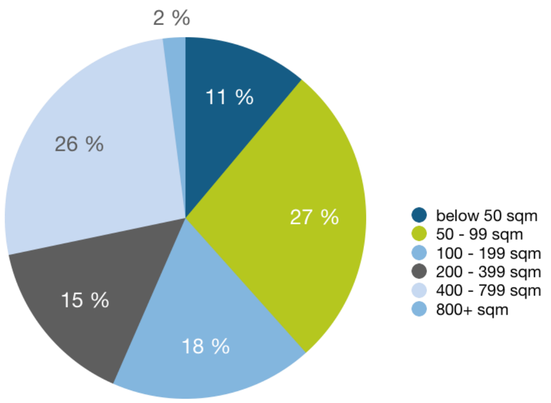

Figure 3-8: Germany: sales area by size category in the specialised OFR sector, 2019 (BNN, 2020)

3.2.2 The Netherlands

Short profile	Year	Data
Sales organic food retail	2018	1.3 €bn[57]
Sales organic food retail	2025 (est.)	3.2 €bn[58]
Number of OFR stores	2018	413
Number of OFR stores 400-999 m^2	2018	0
Number of OFR stores below 400 m^2	2018	413[59]

3.2.2.1 OFR sales & growth trends

The market for organic food in the Netherlands is constantly evolving. While the total market share of organic products from national food sales was still low at 3.3-4.7% in 2018 (FiBL, 2020), its growth rates are significant: the OFR sector shows a plus of 8.4% in 2018 in comparison to 2017. Since 2012, when OFR retail sales were at 791,4 million EUR, the OFR sector has grown by 52.3% to 1.2-1.5 billion EUR in 2017, and 1.3-1.6 billion EUR in

[56] Different average sales area due to conflicting data sources. 259 m^2 by BNN; 265 m^2 calculated from total sales area for the entire sector in 2017.
[57] FiBL, 2020
[58] Bionext, 2018
[59] Bionext, 2018

2018, depending on the data source (see Figure 3-9). In 2018, consumption of organic food per capita was 75 EUR in the Netherlands (FiBL, 2020). It is estimated that the share of organic food sales from all food sales will increase to 7% by 2025, with total sales of 3.2 billion EUR.

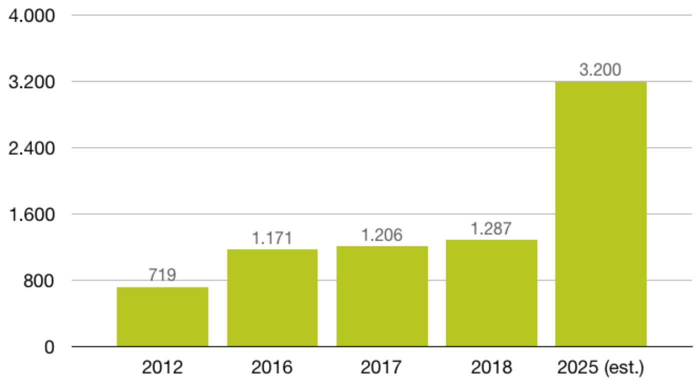

Figure 3-9: Netherlands: OFR sales [€million] in 2012-2087 and estimated sales in 2025. Source: own analysis, based on FiBL 2020 and Bionext 2018

3.2.2.2 OFR marketing channels

In 2018, specialised OFR stores contributed 321.6 million EUR, or 19.6% to the organic food retail sales in the Netherlands. This is a 0.9% decrease as compared to 2017. Most sales were generated through conventional supermarkets (842.6 million EUR, or +8.2% from 2017) that held a share of 51.4% from all sales; followed by the foodservice sector with 350.8 million EUR or 21% (Table 3-3).

Another source for 2014 provides the following overview of the Netherlands organic food retail market in terms of stores: 52% conventional food retail, 24% specialised OFR stores, 2% direct sales, and 22% other sources.

Table 3-3: Netherlands: sales per OFR marketing channel 2017– 2018 (Bionext, 2018)

	2017 sales [€bn]	2018 sales [€bn]	Development 2017-2018 [%]
Conventional food retail	778.9	842.6	8.2
Specialised OFR	324.6	321.6	-0.9
Food service	305.0	350.8	15.0
Direct Sales			
Other	102.0	123.0	20.6
Total	1,510.5	1,638.0	8.4

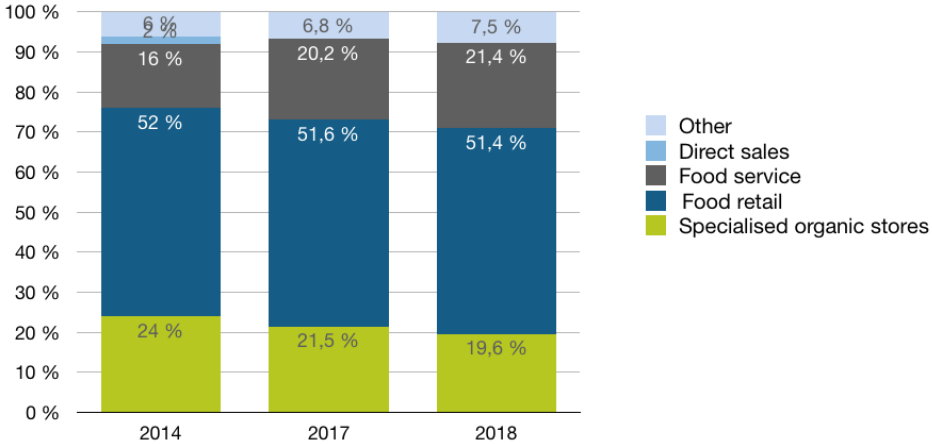

Figure 3-10: Netherlands: share of OFR sales per marketing channel in 2014-2018 (Bionext, 2018)

3.2.2.3 OFR stores: types, number, sales area & trends

In 2018, 5,622 stores (31%) selling organic food belonged to the conventional food retail sector. Only 2% of those stores selling organic food belonged to the specialised OFR sector, and another 3% were farm shops. 11,500, or 64% stores belonged to other categories (Figure 3-11). This makes the Netherlands a European country with diverse OFR sales channels, similar to Germany, France and Italy.

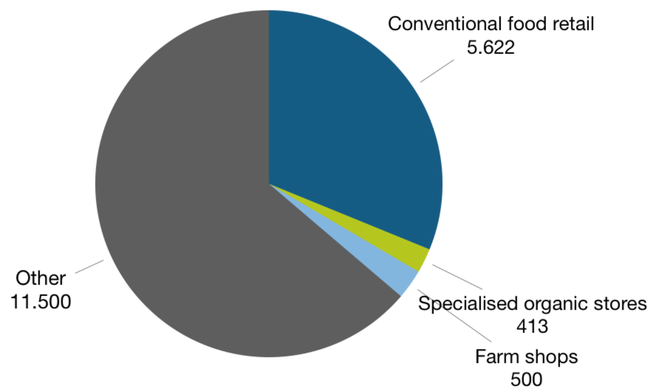

Figure 3-11: Netherlands: number of OFR stores, by marketing channel, 2018 (Bionext, 2018)

3.2.3 Spain

Short profile		
Indicator	**Year**	**Data**
Sales organic food retail	2017	1.9 €bn[60]
Sales organic food retail	2025 (est.)	3.9 €bn[61]
Number of OFR stores	2019	1,500[62]
Number of OFR stores 400-999 m^2	2019	0[63]
Number of OFR stores below 400 m^2	2019	1,500[64]

3.2.3.1 OFR sales & growth trends

Organic food retail sales in Spain have increased significantly over recent years. While in 2012 they were at 998 million EUR, they then increased by 90.7% until 2017 which nearly equated double the amount of sales in just five years (Figure 3-12). Hence 2017 saw 1.78 - 1.9 billion EUR of sales generated for this market segment, depending on the source (Bionext, 2018; FiBL, 2020). Bionext estimates that in 2018, the Spanish OFR sector generated 2.0 billion EUR.

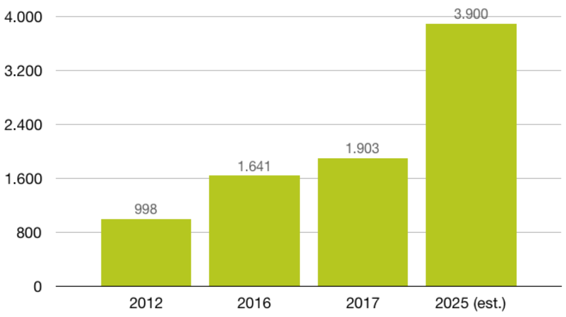

Figure 3-12: Spain: OFR sales [€million] in 2012-2017 and estimated sales in 2025. Source: own analysis, based on FiBL 2020 and Bionext 2018

Organic food sales in Spain today have a market share of 1.6% to 2% (depending on the source) from the total food retail market. Per capita consumption of organic products stood at 42 EUR in Spain in 2017, whereas the EU average was at 67 EUR per person (FiBL, 2020).

By 2025, it is estimated that the OFR sector will grow to 3.9 billion EUR, with a 3% market share of the total food retail market.

According to the official data of the Spanish Ministry of Agriculture, Fisheries and Food (MAPA) (Ministerio de Agricultura, 2019), 361 companies were involved in the retail of organic food, and 1,424 as wholesalers in 2018 (Ecological, 2018).

[60] FiBL, 2020
[61] Bionext, 2018
[62] Estimation by SEAE, 2020 (personal communication)
[63] Estimation by SEAE, 2020 (personal communication)
[64] Estimation by SEAE, 2020 (personal communication)

3.2.3.2 OFR marketing channels

In Spain, 28% of all OFR sales are generated in conventional food retail stores. The majority (44%) is generated in specialised OFR stores (Figure 3-13).

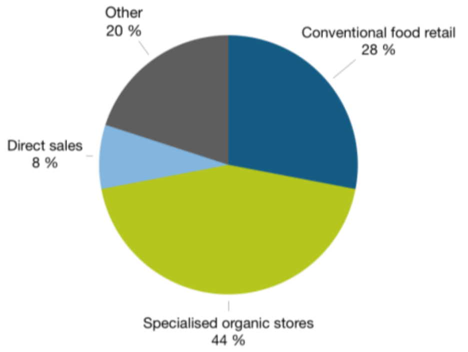

Figure 3-13: Spain: share of OFR sales, by marketing channel (Agence Bio, 2017)

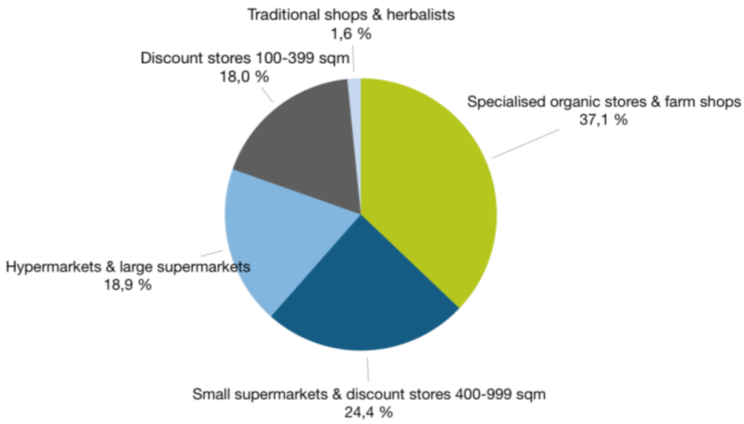

Figure 3-14: Spain: share of OFR sales, by marketing channel (MAPA, 2018a, MAPA, 2018b, Ecological, 2018)

Other sources assume a 37.1% of OFR sales to have been made through specialised stores and farm shops in the size category 40-399 m^2, followed by 24.4% in smaller supermarkets and discount stores of between 400-99 m^2, 18.9% in hypermarkets and large supermarkets, 18% in discount stores of 100-399 m^2 and 1.6% through traditional small shops and herbalists (Figure 3-14).

As a general trend that can also be seen in other countries, specialised OFR stores declined in importance for organic food sales in the period 2015-2017, while the largest increase can be seen for smaller supermarkets (up from 4-7%) and discount stores (up from 7-8%).

3.2.3.3 OFR stores: types, number, sales area & trends

11,329 stores or 45.8% of all stores selling organic food belong to the discount store category, followed by 24.7% belonging to small supermarkets, and 15% to large supermarkets of up to 2,500 m^2. Specialised organic stores are relatively low in number (6.1%), similar to traditional food shops (6.5%) and hypermarkets (1.9%) (Figure 3-15).

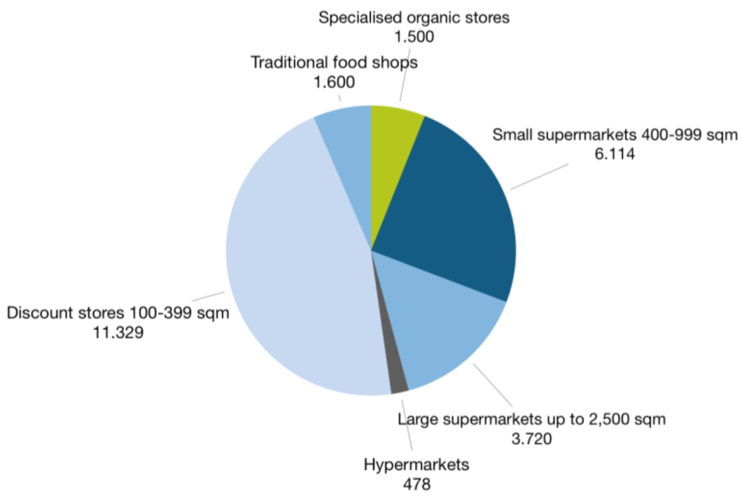

Figure 3-15: Spain: number of stores selling organic food, by marketing channel (MAPA, 2018a, MAPA, 2018b, Ecological, 2018)

In Spain, the eco-friendly supermarket Veritas had the highest number of supermarkets with organic produce with its nearly 70 stores. Second on the list, the Alicante-based SuperSano ranked as one of the leaders with 14 stores in Spain in 2019 (Forte, 2019).

3.2.4 Belgium

Short Profile		
Indicator	**Year**	**Data**
Sales organic food retail	2019	760 €million[65]
Sales organic food retail	2025 (est.)	1.8 €bn[66]
Number of OFR stores	2020	675[67]
Number of OFR stores 400-999 m^2	2020	50[68]
Number of OFR stores below 400 m^2	2020	625[69]

3.2.4.1 OFR sales & growth trends

In Belgium, 2,201 companies are active in the organic food sector. Sales in the organic food retail sector increased from 391 million EUR in 2012 to 760 million EUR in 2019 (Figure 3-16). This equalled an increase of 61.6% in just five years. Another source indicates that in 2019 Belgian consumers spent 760 million EUR on organic products, a 15% increase compared to 2017 (RTBF, 2019b; Retail Detail, 2019). In 2018, each Belgian spent 61 EUR on organic food (FiBL, 2020).

[65] FiBl, 2020
[66] Bionext, 2018
[67] Estimation by shecco, 2020 (personal communication)
[68] Estimation based on survey/interviews
[69] Estimation based on Natex Bio (2016)

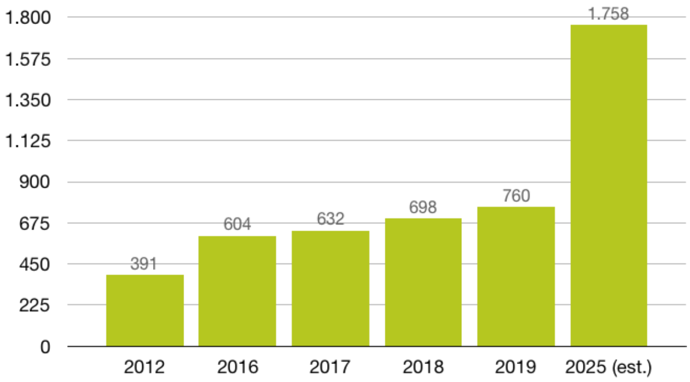

Figure 3-16: Belgium: OFR sales [€million] in 2012-2019 and estimated sales in 2025. Source: own analysis, based on FiBL 2020

The market share of organic food from all food sales in Belgium is 3.2%, with the southern region of Wallonia (4.8-6%) taking a stronger share as compared to the northern region of Flanders (2.5%) (2018) (Biowallonie, 2019; Retail Detail, 2019; Beaudelot & Mailleux, 2019). Indeed, Flanders accounts for only a small part of the overall expenditure for organic food: only 38% of the expenditure (289 million EUR) comes from the Flemish Dutch-speaking part of the country. Flanders lags behind Wallonia in both relative and absolute figures. The sector is also growing faster in the French-speaking part of the country.

As regards future sales trends, a 15% growth per annum is assumed for the OFR sector in Belgium.

3.2.4.2 OFR marketing channels

In Belgium, 58% of all OFR sales are generated in conventional food retail stores, and 22% are made through specialised OFR stores (Figure 3-17).

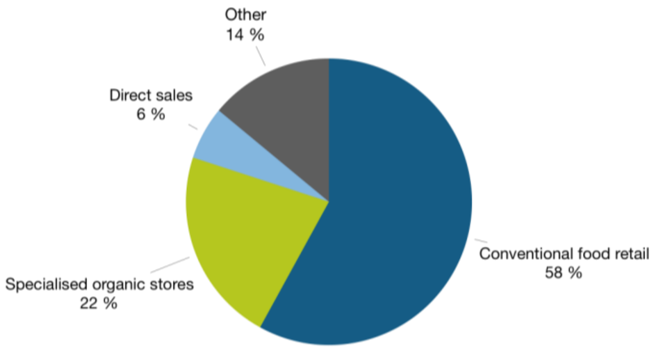

Figure 3-17: Belgium: share of OFR sales, by marketing channel (Agence Bio, 2017)

For the Wallonia region of Belgium, 36.1% of organic food was distributed via general supermarkets, 30.4% in specialised stores, 7.0% in hard discount stores, 5.2% in hypermarkets, 3.9% from bakers and pastry cooks, 2.9% from farms and breeders, 2.1% in markets, 1.4% from butcher stores and 10.9% in other types of shops (health, diet stores, etc.) in 2018.

The brands' market shares changed little between 2008 and 2013. Between 2013 and 2018, "organic" specialist stores experienced significant growth (+98%), mainly to the detriment of generalist supermarkets, whose market share for the purchase of "organic" products fell sharply (-36%). Similarly to other countries, the share of organic food sold through discount stores in Wallonia has increased significantly, up from 1.2% in 2008 to 7.0% in 2018.

However, in this region of Belgium the specialised OFR stores have increased their market share over the years, up from 17.4% in 2008. 3.9% of organic food is sold through bakeries and 1.4% through butcher stores (Table 3-4).

Table 3-4: Wallonia (Belgium): share of OFR sales, by marketing channel (SPW, 2019)

	2008 [%]	2009 [%]	2010 [%]	2011 [%]	2012 [%]	2013 [%]	2014 [%]	2015 [%]	2016 [%]	2017 [%]	2018 [%]
Hypermarkets	4.4	4.7	5.3	5.0	5.6	5.1	4.7	4.6	5.4	4.9	5.2
Supermarkets (excl. OFR stores)	54.9	56.9	54.4	54.7	54.3	56.2	51.7	47.6	43.2	44.7	36.1
Discount stores	1.2	1.7	2.8	3.0	3.4	3.3	3.4	6.1	8.7	9.2	7.0
OFR stores	17.4	14.1	15.9	16.0	15.8	15.4	21.4	22.7	24.4	23.3	30.4
Farm shops	5.4	5.2	4.5	4.4	2.9	2.7	3.6	3.2	3.3	2.0	2.9
Butcher stores	2.3	1.5	2.3	2.7	2.6	2.9	2.2	2.3	1.7	1.1	1.4
Bakeries	1.8	1.4	1.7	1.8	1.4	1.4	1.2	1.1	0.7	1.1	3.9
Other	12.6	14.5	13.1	12.4	14.1	13.0	11.8	12.4	12.7	13.7	13.0

3.2.4.3 OFR stores: types, number, sales area & trends

No official national data is available regarding the total number of organic stores. In Brussels alone 70 organic food stores can be found (2019) (RTBF, 2019a). Independent research carried out within the project estimates the total number of specialised OFR stores across the country to be at 675, including 625 in the smaller category below 400 m^2, and the remaining 50 in the larger category.

3.2.5 Portugal

Short profile		
Indicator	**Year**	**Data**
Sales organic food retail	2011	21 €million[70]
Number of OFR stores (all below 400 m^2)	2019	47[71]

3.2.5.1 OFR sales & growth trends

According to FiBL, Portugal generated 21.0 million EUR sales from the organic retail sector in 2011, the latest year of data collection available. The share of the total food retail sales was at 0.2%. Hence it belongs to the smallest European countries in terms of total market size and share of organic food from the total food sales per country. Per capita consumption was at 2.0 EUR per year in 2011. For the last nine years, no new data has become available in publicly accessible databases (FiBL, 2020).

[70] FiBL, 2020
[71] Estimation by Agrobio (personal communication)

3.2.5.2 OFR marketing channels

In Portugal 53% of stores selling organic food belong to the specialised OFR category. Portugal thus belongs to the smaller group of EU countries with a dominance of specialised organic food retailers, similar to Greece, Poland and Spain. However, since 2011 the specialised OFR sector has shown slower growth rates than the large distributors which have a share of 44% of all OFR sales in Portugal (Agence Bio, 2017). Only 3% of OFR sales are generated through other marketing channels, making the Portuguese OFR market a very consolidated one spread between conventional food retailers and mostly smaller independent ones (Table 3-2).

3.2.5.3 OFR stores: types, number, sales area & trends

No official data for the total number of specialised OFR stores in Portugal is available. It is assumed by the project partner Agrobio that the number of such stores is about 50 across the country.

4 RACHP use in the European organic and small food retail sector

4.1 Survey, interviews & studies review

4.1.1 Methodology

In order to gather information on the status quo of RACHP appliances used and parameters important for future purchasing decisions, two online surveys where developed to address 1) the RACHP servicing and contracting sector working for the small European food retail sector, in an aim to gain a better understanding of the nature and scope of RACHP technicians working in OFR/small (food) market segments.; and 2) the small food retail operators, including the OFR store operators, butcher stores, bakeries and farm shops; aiming at understanding the options and motivation of shop owners for the future introduction of new energy efficient and low GWP equipment in these sectors.

The surveys where hosted on a third-party survey software. Invitations to participate in the survey were sent out via the RefNat4LIFE newsletter, a European mailing list and via the project partners networks. Several phone calls and meetings were organised with shop owners to facilitate data collection for the end-user survey. Resulting from the overall response rates, especially from the end-user survey, a short, simpler version of the survey was drafted which would make technical details about the RACHP systems installed a voluntary feature. This led to additional responses. In total, the survey addressing the RACHP service and contracting sector received 35 complete responses while 54 complete responses were received for the one targeting the small food retail operators, representing 1,061 stores in Europe.

The survey questions focused mostly on identifying the following elements: energy footprints with a strong focus on electricity consumption for OFR and small stores, cooling (and heating) equipment used in stores including types of refrigerants, modalities of equipment installation and maintenance and awareness of regulations and investment criteria for choosing the relevant equipment.

In the surveys the following definitions for cooling equipment was used. The stock model described in chapter 4.3 is also based on these definitions:

Stand-alone system	Stand-alone systems are small hermetically sealed systems where the entire refrigeration system is factory assembled and typically enclosed in one cabinet. The equipment is designed as a plug-in display cabinet, i.e. easy to connect and with its compartments visible to the customers.
Condensing unit	The remotely installed "condensing unit" usually holds one to two compressors, the condenser and a receiver are usually connected via piping to small commercial equipment located in the sales area, e.g., cooling equipment such as display cases or cold rooms. In most cases, the unit comes pre-assembled.
Centralised systems	Centralised systems are used in larger supermarkets (sales area typically greater than 400 square meters). They operate with a pack of several parallel working compressors located in a separate machinery room. This pack is connected to separately installed condensers outside the building. The mostly custom-made system is assembled on site. Included in this category are secondary loop systems (chilled water systems) in which a secondary fluid (e.g. propylene glycol) is circulated as heat transfer medium to the individual evaporators throughout the store. The secondary loop is connected through a heat exchanger to the primary loop with compressor rack and direct expansion design.
Cold store	The cold store is a refrigerated room for storage of perishable goods in a backspace, not displayed in the sales area.

Refrigerators & freezers	Refrigerators and freezers include the combination of refrigerators and freezers as well as single refrigerators and single-cabinet freezers. They are usually designed with non-transparent openings and are, besides households, typically located in backspaces of commercial businesses.
Heat pumps	Heat pumps (HP) are used for heating supplies. For reversible air-conditioning (AC) systems and heat pumps which are used for cooling and heating, please allocate these systems in heat pumps and leave a comment: reversible HP/AC

4.1.2 Respondents profiles & basic information

The following overview presents data for the first longer, more detailed survey; and the second shorter survey for small food retail end-users:

All responses	Detailed survey	Short survey
Period of data collection	October 2019-March 2020	March 2020
Number of responses (complete)	37 (639 stores)	17 (422 stores)
Location of store	Germany: 81.1% (30) Spain: 8.1% (3) Netherlands: 5.4% (2) Belgium: 2.7% (1) France: 2.7% (1)	Netherlands: 70.6% (12) Germany: 17.7% (3) France: 5.9% (1) Portugal: 5.9% (1)
Category of business	Organic supermarkets/stores: 75.7% (28) Small supermarket: 5.4% (2) Farm shop: 5.4% (2) Small food market: 2.7% (1) Butcher stores: 2.7% (1) Other: 8.1% (3)	Small food market: 41.2% (7) Organic supermarkets/stores: 35.3% (6) Farm shop: 17.6% (3) Ice cream parlour: 5.9% (1)
Data basis for values provided	One individual store: 81.1% (30) Average value of all stores: 18.9% (7)	One individual store: 88.2% (15) Average value of all stores: 11.8% (2)
Building type	Shared building 5 parties: 46.0% (17) Independent building: 32.4% (12) Large building > 5 parties: 18.9% (7) Other: 2.7% (1)	*was not included in the short version*
Sales area (in m2)	<50: 13.5% (5) 50-100: 10.8% (4) 101-200: 37.8% (14) 201-400: 13.5% (5) >400: 24.3% (9)	<50: 11.8% (2) 50-100: 35.3% (6) 101-200: 11.8% (2) 201-400: 5.9% (1) >400: 35.3% (6)

4.1.3 OFR sector respondents profile

Since the OFR sector was the respondent group mostly represented in the survey, a short analysis of this response group from both surveys (long version and short version) shall be presented here:

Organic supermarket / store	
Number of responses (complete)	37 (2 conducted as interview)
Number of stores represented in replies	693
Location of respondents	Germany: 67.6.1% (27) Netherlands: 10.8% (2) Belgium: % 8.1% (3) France: 2.7% (1) Spain: 2.7% (1) Portugal: 2.7% (1)
Data basis for values provided	One individual store: 73.0% (27) Average value of all stores: 27.0% (10)
Total number of stores, and per size category (in m^2)	693 total stores 1-400 m^2: 165 >400 m^2: 528

4.1.4 Limitations & Conclusions

The conducted online surveys among small store operators should be viewed as limited in their explanatory power, given the following limitations:

- **Focus on Germany and the Netherlands:** Based on a varying degree of access to small store operators among the RefNat4LIFE project countries, especially in the OFR sector, the majority of responses were received from these two countries. The results are therefore especially relevant for a better insight into these two national markets with some of the highest total sales for the OFR sector.
- **Dominance of the organic food retail sector:** The intended target group of OFR store operators was in fact the one best reached through the surveys.
- **Personal interviews delayed due to Corona crisis:** Personal interviews with store owners in combination with visits to a selected number of OFR stores across Europe were planned to complement, verify and cross-check findings from the online surveys with more accurate, detailed and qualitative data. Both interviews and store visits had to be postponed after the outbreak of the Corona pandemics in February 2020, with only few exceptions. They therefore do not form part of this report, and are not expected to be executed during the remainder of the projectdue to ongoing restrictions.. To fill information gaps several phone interviews were implemented instead.

As a result, information from the survey is less accurate and less consistent than originally intended resulting in reduced accuracy of the absolute findings of the desk research and related conclusions; comparative findings are more accurate. Accuracy has been improved by applying complementary studies (see 4.1.5).

4.1.5 Complementary studies

To substantiate findings from the conducted surveys and personal interviews, additional scientific studies, public reports and other relevant documentation were reviewed for their contribution to quantifying the RACHP use in the European small food retail sector. Given the inconsistent classification of food retail types per country or data source, and the resulting data gaps, this measure was taken to put data received from the surveys and interviews into a broader context.

Chapter 4.2 presents the combined analysis of the conducted surveys, personal interviews and a review of the studies. To facilitate understanding, results are presented by topic mentioned in the survey, and by food retail type, where appropriate.

Relevant findings from the surveys are marked with a symbol, for easier reference.

4.2 Data analysis from surveys, interviews & studies review

4.2.1 Number of RACHP units per store

4.2.1.1 Small food retail

Only very limited information is available to determine the number of RACHP units per small food retail store or organic food retail store. As a general rule defined by the EnergyStar programme in the USA, the number of commercial refrigeration units, including display type refrigerated open or closed cases and cabinets as well as display type freezer units, is 1.26 per 92.8 m^2 for small supermarkets.

A study about the German food retail market estimates that on average 7.5 plug-in refrigerated cabinets are used in small stores of up to 400 m^2, with two-thirds of those being low temperature (LT) chests. Single systems or multi-compressor systems are not frequently used.

System manufacturers for the small and large food retail sector present at EuroShop trade fair[72] stated that from their experience the larger a food retail market, the lower the relative presence of plug-in refrigerated cabinets as compared to centralised refrigeration systems and condensing units. Plug-in systems are used typically for mobile and promotional purposes. Depending on their internal strategy this might be different for selected chains though – as was registered for the German OFR sector in this study with significant impact on the stock model. In stores of up to 400 m^2 plug-in units are the dominant type of refrigeration systems, with centralised systems playing a minor role. Table 4-1 provides an overview of the number of plug-in refrigerated cabinets by size of store, as well as the percentage of LT (negative temperature) versus MT (positive temperature) units. The categories of stores up to 400 m^2 and stores of up to 1,500 m^2 are relevant for this report (Steinmaßl, 2014).

[72] Interviews with various RACHP system suppliers at EuroShop trade show, 17-18.02.2020

Table 4-1: Overview on the number of plug-in refrigerated cabinets, percentage of low temperature (negative temperature, LT) and medium temperature (positive temperature, MT) by size of store (Steinmaßl, 2014).

	Small stores < 400 m²	Supermarket 400 – 1,5000 m²	Small hypermarket 1,500-2,500 m²	Large hypermarket 2,500+ m²	Discount stores 200-1,200 m²
Number of refrigerated cabinets	7.5	7.2	8.1	18.0	22.3
Percentage of LT units (%)	68.3	40.9	37.0	23.3	87.3
Percentage of MT units (%)	31.7	59.1	63.0	76.7	12.7

4.2.1.2 Bakeries

According to the German Artisan Baker Association, an average bakery shop of approximately 70 m² sales area contains 1 refrigerator, 1 freezer and 1 display cabinet (personal communication). As part of the normal set-up, the cooled area of the display cabinet is part of the running serve over counter cooled down to 7C° for sour cream or confectionary products, perishable goods, or snacks. It is 2-3 metres long on average.

A study from 2013 had already looked at 63 German artisan bakeries' set-ups as regards the type and number of refrigeration units installed, their availability in a typical bakery in terms of percentage share, as well as their average length in running metres (Table 4-2). The analysis among 95% of artisan bakeries and 5% of confectionaries found that 13% of all bakeries had a centralised refrigeration system. 84% of all bakeries visited had 2.3 refrigerators with a length of 2.3 metres on average, and 67% operated 1.4 refrigerated serve-over counters with an average length of 3.3 metres. The number of shops using air conditioning was relatively low ten years ago with 14% operating a centralised AC system and 6% operating a split AC unit. Centralised AC units were operating on average 8 hours per day during 180 days per year, while the split units operated 9 hours per day on 175 days per year (Fraunhofer ISI, 2013). Since it can be assumed that on average the number of refrigeration units have increased per typical store, following the overall trend towards larger but fewer bakery stores, a helpful indicator to estimate the total potential of RACHP unit replacement and energy-efficient operation across Europe is provided.

Table 4-2: Availability [%], average number and average length [m] of different cooling appliances in German artisan bakeries (Fraunhofer ISI, 2013).

	Availability [%]	Average number	Average length [m]
Refrigerator	84	2.3	2.3
Vertical cooling cabinet	38	1.3	2.4
Horizontal cooling cabinet	3	2.0	4.0
Refrigerated serve-over counter	67	1.1	3.3
Vertical freezer	48	1.4	1.8
Horizontal freezer	49	1.8	3.1

4.2.1.3 Butcher stores

A study from 2013 looked at 60 German butcher stores' set-ups as regards the type and number of refrigeration units installed, their availability in a typical butcher shop in terms of percentage share, as well as their average length in running metres (Table 4-3). The analysis found that 27% of all butcher shops had a centralised refrigeration system and 37% used waste heat recovery. On average, 88% of all butcher shops had 1.4 refrigerated serve-over counters with an average length of 5.7 metres, followed by 2.4 refrigerators with an average length of 2.2 metres present in 77% of all shops. The number of shops using air conditioning was relatively low ten years ago with 14% operating a centralised AC system, and 6% operating a split AC unit. Centralised AC units were operating on average 8 hours per day during 180 days per year, while the split units operated 9 hours per day on 175 days per year (Fraunhofer ISI, 2013). It can be assumed that on average the number of refrigeration units will have increased per typical store since the surveyed period of 2007-2010, following two major trends: 1) the overall trend towards larger but fewer butcher stores; and 2) the trend towards butcher stores offering more cooled and frozen food in addition to their typical product offering.

Table 4-3: Availability [%], average number and average length [m] of different cooling appliances in German butcher stores (Fraunhofer ISI, 2013).

	Availability [%]	Average number	Average length [m]
Refrigerator	77	2.4	2.2
Vertical cooling cabinet	60	1.2	2.7
Horizontal cooling cabinet	25	1.3	2.3
Refrigerated serve-over counter	88	1.4	5.7
Vertical freezer	23	1.1	1.6
Horizontal freezer	55	1.8	2.9

From interviews conducted at the EuroShop trade fair, RACHP suppliers from Poland confirmed that the typical set-up in a Polish butcher shop consists of four plug-in display refrigeration cases (serve-over counter) arranged in a horizontal straight line or in a V shape. A Portuguese supplier of RACHP units for butcher stores and fishmongers estimated 4-6 running metres in a typical national store with three plug-in units being installed. This was confirmed by another Poland-based supplier that estimated the number of plug-in units to be three in a typical butcher shop.

4.2.1.4 OFR stores

Findings from the survey in Germany confirmed that the trend towards larger organic supermarkets has already increased the demand for more cooling and refrigeration spaces overall. Particularly in Germany's specialised OFR sector, a strong trend towards the use of plug-in (stand-alone) appliances instead of remote equipment (condensing units or centralised refrigeration systems) can be observed. The installed stock of plug-in equipment is made up of new and second-hand equipment, partly taken over from the previous store tenant. According to survey results from Belgium, Germany and the Netherlands, centralised refrigeration systems in the OFR sector are estimated to employ a cooling capacity range of 24 to 29 kW for large stores (sales area 400-999 m²) and of 6-7 kW for small stores (< 400 m²). Therein, Belgium's large OFR stores use centralised refrigeration systems at the higher end of the cooling capacity range but use notably few plug-in equipment, representing an opposed strategy to Germany.

Survey results from the Netherlands indicated moderate use of plug-in equipment while the use of centralised refrigeration systems is comparable to the situation in Germany. As food stores in the Netherlands seldomly use centralised air conditioning, centralised refrigeration systems are able to cope with additional cooling demand which in Germany would be covered by plug-in equipment., Leading OFR chains in Germany estimate a total number of 12 plug-in refrigeration units per typical store (weighted average). Typically, these are split into some 15 running metres of wall-mounted MT refrigeration cabinets, and another 12 running metres of LT freezing cabinets. In addition, there is approximately three metres of display serve-over counter refrigeration units, and 4 metres of island freezer cases and bottle coolers. The overall presence of heat pumps in OFR stores can be assumed to be low.

In 548 OFR stores (out of a total of 689 OFR stores) covered by the online surveys, at least one stand-alone refrigeration system was installed. Condensing units were used in 162 stores, 146 of them being larger stores (more than 400 m^2 sales area). Centralised refrigeration systems were used in 587 stores, but again mainly in larger stores (527).

If distinguishing by sales area, the order of popularity of RACHP equipment types used (weighted balance accounting for the represented stores by each respondent) would be the following for small stores below 400 m^2: 1. Refrigerators and freezers, 2. Stand-alone units. All other types play a minor role. For stores with a sales area above 400 m^2, the order is as follows: 1. Stand-alone systems, 2. Refrigerators & freezers, 3. Heat pumps, 4. Centralised systems. Given their large cooling capacities, centralised systems dominate in terms of total installed capacity over stand-alone systems in large OFR stores. Survey results generally support the findings from research that the smaller an OFR store, the larger is its share of stand-alone (plug-in type) refrigeration systems on total installed capacity, while the share of centralised systems declines. Heat pumps are mostly used in larger stores.

For those survey respondents using stand-alone systems, 5.2 units are used per store on average. For those using refrigerators and freezers, 4.4 units are used per store on average; for condensing units 2.3 units per store; and for centralised systems 1.3 units.

Out of the 35 respondents to this question, only 16 had an air conditioning system installed in their stores.

4.2.2 Lifecycle costs vs. Initial Investment for RACHP equipment

4.2.2.1 Small food retail

Initial investment: A study from 2013/14 (Steinmaßl, 2014) calculated an average purchase cost per type of plug-in refrigeration unit used in the food retail sector:

- Beverage refrigerator: €1,000 (strongly dependent on size)
- Ice-cream chest, small: €500 - €800
- LT chest: €2,000 - €3,000

Lifecycle costs: The same study evaluated the average energy consumption of plug-in refrigeration units for small food retail stores. As a major conclusion, the study found that if the costs of plug-in refrigerated cabinets are viewed over their entire lifetime on the shop floor, comparatively small numbers of units can accumulate very considerable operating costs. Figure 4-1 provides an overview of the average values of power consumption and costs per type of plug-in refrigerated cabinets. One beverage refrigerator with just under 900 litre nominal volume over 10 years can cost around €3,100; a different refrigerator that is 360 litres smaller can cost €11,500. The decision to install an additional beverage refrigerator can cost the store owner a total of €8,400 more than necessary. The situation for LT refrigerated chest freezers is similar. One chest with an approximate nominal volume of 645 litres over ten years can cost €5,700; a different chest with just 395 litres (almost 40% lower nominal volume) can cost €21,000 over ten years. That is an additional cost of around €15,000 (Steinmaßl, 2014). It can be noted that, depending on the model, the energy costs (operational costs) can range from 52% to 91% over a ten-year lifetime of a beverage refrigerator, and 54-87% of a closed LT chest, amounting to very high prohibitive energy costs for small food retailers in particular in the long run. A low initial investment can work against total costs for cooling food and beverages, and therefore significantly affect competitiveness.

Type of refrigerated cabinet	Consumption [kWh/m³ per year]		Consumption [€/m³ per year]		Range
	from	to	from	to	Factor
MT shelves, open	4,360	19,815	785	3,567	4.5
MT shelves, closed	3,404	7,693	613	1,385	2.3
MT chests, open	7,133	35,018	1,284	6,303	4.9
MT chests, closed	1,179	1,983	212	357	1.7
LT shelves, closed	---	9,123	---	1,642	---
LT combination shelf/chests	---	14,268	---	2,568	---
LT chests, open with electric defrosting	---	14,947	---	2,690	---
LT chests, closed without electric defrosting	1,620	12,102	292	2,178	7.5
LT chests, closed with electric defrosting	1,869	19,745	336	3,554	10.6

Figure 4-1: Power consumption and costs of plug-in refrigerated cabinets (Steinmaßl, 2014).

The additional cost for plug-in refrigeration systems over their lifetime represents a loss in available cumulative capital that ultimately decides or at least partially determines a retailer's ability to compete. This is especially due to the highly varying energy performance of RACHP models (see 2013/14 study above) and applies in particular to the small food retail sector. While a focus on the lifecycle performance of RACHP units would be needed, reality shows that in most European countries the initial investment for RACHP technology is still the dominating factor when deciding on new systems. For instance, the Portuguese small food retail market is largely dominated by decisions based more on initial investment and less on the lifecycle perspective of RACHP equipment, as indicated by Portuguese suppliers. Other countries, such as those in central Europe, share this decision-making pattern. This was confirmed by several European RACHP system suppliers for the small food retail sector during the EuroShop trade fair in February 2020.

It can also be assumed that small business owners often take over existing stores from their predecessors including the RACHP installations, or they purchase already used (second hand) equipment. These systems are often maintained – even at a low energy efficiency – until they reach their end of life. An earlier investment in new technology based on improved life cycle costs is often not considered, despite the large differences in energy consumption that can be seen in the plug-in units mostly used in these smaller stores.

As a second finding, countries with higher energy costs show a higher interest in newly installing and replacing old units with energy efficient RACHP equipment.

4.2.2.2 OFR stores

As confirmed by participants of a dedicated workshop held at the BioFach trade fair for the organic food sector, an overall lifecycle perspective on the entire store taking into account electricity consumption, energy efficiency and CO_2 emissions would be preferable over an isolated analysis of the RACHP equipment.

It needs to be taken into account that a 100% use of renewable energies in many organic food shops is already making a positive contribution to the aim of reaching climate neutrality.

4.2.3 Lifetime of RACHP equipment & maintenance

4.2.3.1 Small food retail

As confirmed through performed interviews during the EuroShop trade fair, most small food retailers – including bakeries, butcher stores and the OFR sector – operate their RACHP equipment until it has reached its end of life. RACHP suppliers interviewed in February 2020 confirmed that although the lifetime of their equipment was set at eight years, most of their customers would extend this to 10-12 years in real life. An important factor in this context is the duration of rental agreements for the stores that are often between 10-15 years and have a strong influence on purchase decisions. As regards maintenance, they mostly rely on their trusted RACHP contracting and maintenance companies for the repair of such equipment.

Higher energy efficiency of new RACHP is (not yet) a deciding factor for advancing the switch to more climate-friendly equipment. As an overall finding, RACHP system suppliers do not have any direct contact with the small business owners in most cases, making an analysis of the demand structure and challenges faced by them difficult. The RACHP models produced are assumed to fit market needs as distributors order them; however, a direct feedback from the distributor to the RACHP system supplier about the OFR and small business owners' needs is not given.

4.2.3.2 Bakeries

According to the German Artisan Baker Association, appliances tend to be used as long as they still operate and are only replaced in case of a damage or leakage. Bakeries rely on store construction companies for mostly installations and equipment maintenance (personal communication). A similar situation exists in Belgium, according to information received from shop owners in Belgium (shecco, 2020).

4.2.3.3 OFR stores

In small dedicated OFR stores, a large number of re-used plug-in systems, stand-alone refrigerators and freezers are used. The average lifetime in years was estimated to be the following:

- Plug-in (Stand-alone) systems: 5 (Netherlands: 7)
- Condensing units: 15
- Centralised systems: 10
- Cold stores: 15
- Refrigerators / freezers: 7
- Heat pumps: 10
- Air Conditioning split: 10
- Air Conditioning centralised: 15

In addition, the age of RACHP appliances belonging to the same category varies significantly. As the conducted survey shows, most operators of RACHP in the OFR sector do not have access to or knowledge about the equipment installed in their stores, including basic information such as which refrigerants are used and the energy performance associated with them.

A reason for extending the lifetime of RACHP equipment concerns the fact that the rental agreements of small OFR store owners in countries like Germany typically cover a period of 10-15 years. As shop owners are not sure if the rental agreement will be prolonged thereafter, they shy away from replacing the RACHP equipment (or any other major shopfitting element) before a new contract is signed, to harmonise shop retrofitting and investment in any technical equipment with the start of a new rental period.

As regards the maintenance schedules for RACHP equipment, out of the 35 OFR surveyed, 40% (14) confirmed that their RACHP equipment would undergo yearly maintenance, or at least once every 1-2 years (13 respondents). Maintenance cycles of 3-4 years (3) and of more than four years (4) were significantly less common. This could point to a solid opportunity for RACHP maintenance staff who are able to monitor the energy performance of cooling equipment on a regular basis and advise on more sustainable choices as regards refrigerant selection or energy efficiency measures.

Personal interviews confirmed that for the Netherlands, it is estimated that a maintenance is carried out on RACHP equipment in supermarkets selling organic products 1-2 times per year on average. However, the inconsistent maintenance of RACHP systems is being noticed especially by larger companies with more stores who regard it a challenge for energy efficiency. A large OFR chain from Germany confirmed that the inconsistent maintenance of RACHP systems had led to a situation where plug-in units have significant energy efficiency losses. The company has now switched to a maintenance plan in which all plug-in units are maintained every three months. The additional costs are offset by the energy costs saved by this best practice. As may be concluded from the survey results, the OFR chain calculates a lifetime of just 3-4 years for stand-alone plug-in units.

However, in the specialised OFR stores maintenance is often only done after a breakdown of the system. Schönberger et al., 2013 indicates that improved maintenance in HVAC and refrigeration systems can reduce the carbon footprint of food retail stores by up to 30%.

As regards the type of RACHP maintenance companies, small OFR store operators tend to rely on a local refrigeration servicing company for maintenance and replacement of RACHP appliances.

This was also supported by the survey respondents, where 75% of those responding to the question (28 in total), used a local, often family owned, RACHP contracting company to maintain their equipment. Less common were regional companies, global players or inhouse staff. This is a first indicator for the RefNat4LIFE project that local RACHP maintenance companies should be a priority for training and knowledge transfer.

4.2.4 Decision making factors for RACHP equipment

4.2.4.1 OFR stores

When asked about the main deciding factors for new RACHP equipment in their stores, OFR operators state in the survey that, on average, energy efficiency would be most important when choosing a new unit. This is followed by the system's overall environmental performance and expected lifetime. Initial investment, advice from colleagues and the system brand are less important. However, as a sign of caution it needs to be noted that most respondents represented the German and Dutch market, where factors such as energy efficiency might already be more important than is the case in markets in Southern or Central Europe (see analysis on lifecycle cost vs. initial investment above). Other factors mentioned by individual respondents include noise levels, choosing an integrated RACHP system to optimise the store's entire cooling and heating system, system design, size and lighting, ease and cost of maintenance; use of waste heat and reliability.

The decision for or against a certain type of RACHP equipment is also influenced by whether or not the shop operator is also the owner of the building. For rented shop areas supplied by a centralised cooling or heating system, the decision is not with the tenant but the owner, making a switch to more energy-efficient units with natural refrigerants difficult or impossible.

4.2.5 Energy consumption, Renewable energy generation & Energy efficiency measures in stores

4.2.5.1 General food retail

Based on a market survey by EHI Retail Institute (2019c) representing about 23,000 food retail stores in Germany, Austria and Switzerland, total electricity consumption is split in the following way: 47% for refrigeration, 11% for ventilation and air conditioning, 22% for lighting and the remaining 20% for other uses. According to Schönberger et al., 2013, the electricity consumption in food retail stores splits into 50% for refrigeration, 20% for heating, ventilation and air conditioning and 5% for electric appliances and other internal processes. As a conclusion, refrigeration equipment is typically responsible for around 50% of total electricity consumption, and air conditioning for another 5 to 10%[73].

Regarding the electricity intensity of food retailers, Ferreira et al., 2020 indicated values below 346 kWh/m² per year as best practice benchmark, while typical energy intensities were found in the range from 500 to 1,000 kWh/m² per year, with discount stores (sales area < 1,000 m²), large supermarkets (1,000 to 3,000 m²) and hypermarkets at lower level and convenience stores at the higher end (no data for small supermarkets).

With regard to energy demand for heating and domestic hot water, survey responses and studies indicate 100-150 kWh/m² per year as a typical range of heating energy intensity in food retail, whereat small shops can also exceed 200 kWh/m² per year. The EHI Retail Institute (2019c) indicated 84 kWh/m² per year (21% of total energy consumption) as an average heating energy intensity of food retail among the 23,000 stores in Germany, Austria and Switzerland. According to this source, about half of this energy supply is provided by gas, followed by heat recovery with 22%, district heating and oil each with 8-10% and heat pumps with 6%.

4.2.5.2 OFR stores

As indicated by the respondents representing OFR shops, about half of the electricity consumption is used for refrigeration and air conditioning (weighted average), typically within a range from 40 to 60%. However, with 66% in average, respondents who operate one single small OFR shop (sales area 400 m²) tend to consume a higher share of their electricity bill for refrigeration and air conditioning. Two thirds of such stores indicated to use more than 60% of their electricity consumption for refrigeration and air conditioning.

91% of all OFR store operators surveyed had no renewable energy generation on site (98.9% among operators of stores with sales areas below 400 m²). Solar PV installations were used for renewable energy generation by the remaining 9% of store operators. Balancing the generated electricity with the energy demands, 30 large OFR shops (> 400 m²) would cover 13% of their total electricity consumption and one superette would reach a 9% coverage, whereas PV systems in 2 small OFR shops (< 400 m²) would provide 92% of their total electricity consumption. 2 farm shops indicated being able to generate 256% of their own electricity consumption. This information is based on the indicative data of the survey participants regarding generating their own electricity.

As regards the use of special energy efficiency features in stores, 86% of respondents used doors on cooling cabinets, but among small store owners of below 400 m² sales area, only 43% had this energy efficiency feature in their stores. Heat recovery was used by 76% of all 37 respondents. While nearly all larger OFR stores had this feature installed (98%), only 2% of small business owners used heat recovery. In terms of stores represented

[73] i.e. considering the electricity consumption of the compressor only within the 11% share for ventilation and air conditioning.

by the survey, out of the inventoried large OFR shops (> 400 m²), 31 stores in Belgium (100% of total) and 491 stores in Germany (99% of total) make use of heat recovery, as well as 4 stores in the category small OFR shops (< 400 m²) in Germany (15% of total). Some of the represented stores in the survey indicated operating centralised refrigeration systems without employing heat recovery. From this, significant energy saving potential for the smaller store category can be expected, as also public studies indicate (Karampour et al., 2016). Within the surveyed stores 10 stores in Germany showed optimisation potential as they currently do not employ heat recovery. These were distributed equally between large OFR stores (1% of all surveyed stores in this category with centralised refrigeration systems) and small OFR stores (79% of all surveyed stores in this category with centralised refrigeration systems). In the Netherlands, 130 stores within the smaller OFR stores show optimisation potential as they currently do not employ heat recovery (all surveyed stores in this category with centralised refrigeration systems). No such cases were identified in the other project countries due to the limited number of participants from the OFR sector.

Increased thermal insulation was a far less popular feature only used by 4% of all respondents. 13% of all OFR respondents did not use specific energy efficiency features, while the sub-group of store owners with an average sales area above 400 m^2 all had at least one kind of energy efficiency measure installed.

Only two out of 27 respondents had assessed the energy performance of their cooling (and heating) equipment in the store. It can therefore be assumed that the baseline to calculate potential savings would be missing for most small OFR store owners. This makes an informed choice for a selection of new RACHP technology rather difficult.

4.2.6 Refrigerants

4.2.6.1 Small food retail

As confirmed through an analysis of available models at the leading trade show for the (food) retail sector EuroShop in February 2020, most contemporary RACHP suppliers offer plug-in refrigeration units with R290 (propane). Where this is not yet the case, most companies interviewed have concrete plans to implement natural refrigerants in those units. A 100% switch to R290 in stand-alone units is therefore a strong trend and in most cases a market reality. This will benefit all newly installed RACHP units purchased by the small food retail sector that mostly relies on plug-in displays due to its small sales area. The availability of CO_2-based centralised refrigeration systems and condensing units is constantly increasing and today a strong market with multiple competitors has emerged in Europe. However, as aforementioned, often small food retailers still rely on the extended maintenance of available refrigeration units, or even purchase second hand equipment with less sustainable refrigerants. A delay in the adoption of natural refrigerant-based RACHP units is therefore to be expected, and confirms the underlying assumption of RefNat4LIFE that more support needs to be provided for the small food retail sector to encourage the adoption of more energy-efficient RACHP units with less harmful refrigerants.

4.2.6.2 Bakeries

According to the German Artisan Baker Association, the production part of artisan bakeries is already converting to liquid nitrogen for larger machines (personal communication). No data is available for the cooling equipment in the sales area as this decision is made by the store owner.

4.2.6.3 OFR stores

51.4% of respondents with knowledge on which sorts of refrigerants are being used indicated that R404A is used in their OFR store(s). This is followed by R134a mentioned in 48.7% of responses. The natural refrigerant propane R290 is ranked third with 32.4% of responses. R410A is mentioned in 19.0% of responses; R600a (isobutane) in 16.2%; and R507 and R449a in another 10.8% each. The natural refrigerant CO_2 (R744) is not very present in the cooling system of survey respondents, with only four responses (10.81%) stating that this refrigerant is used in their stores. Other refrigerants used include R407f, R22 and R12. When looking at the common applications for such refrigerants, one can note that stand-alone systems and centralised refrigeration systems are mostly still reliant on R134a, R404A and R410A, while the natural refrigerant R290 is becoming an established solution for stand-alone systems.

In the Netherlands, the main refrigerants used in specialised OFR are currently R134a and R404A according to available public information and expert analysis from STEK and KNVvK.

In Germany, according to interviews conducted with RACHP system suppliers, regional and national OFR chains have slowly started to adopt natural refrigerants (R290, R744) but show a much slower adoption rate as compared to conventional food retail chains. A large German OFR chain estimates that 30% of all plug-in units operating in their stores rely on natural refrigerants. However, the majority of systems currently running in their stores rely on R410A, followed by R134a.

4.2.7 Motivation of shop owners to switch to sustainable RACHP technology and natural refrigerants

4.2.7.1 Bakeries

According to the German Artisan Baker Association, an actual or perceived lack of available climate-friendly RACHP equipment holds the market back from higher sales to bakeries and their installers (personal communication).

4.2.7.2 OFR stores

As confirmed by interviewed RACHP system suppliers at the EuroShop trade fair, most organic food retail chains have not yet shown a decisive interest in a switch to natural refrigerants. Overall, a proactive approach is lacking, especially for small independent shop owners. In the Netherlands it is estimated that the capacity (financial, personnel) of the specialised OFR sector to switch to more sustainable RACHP technology is very low, given the small shop owners' struggle for profitability and the high burden of the initial investment.

A similar picture is painted for the German market where there is currently no general pronounced demand for replacing refrigeration units among specialised organic food retailers. As a reason it is cited that models used 10-15 years ago are still considered a good choice when looking at the cost-benefit ratio. In fact, according to one project partner, the German Association of Organic Processors, Wholesalers and Retailers (Bundesverband Naturkost Naturwaren BNN), a market for purchasing second-hand RACHP equipment exists in Germany.

However, as an initial sign of change, regional or national OFR chains have started showing interest in this topic: In an interview with a German regional OFR chain it was confirmed that no natural refrigerants have yet been tested, but that 2020 will see the initial test of two refrigeration units working with natural refrigerants. Another national OFR chain has started testing CO_2-based refrigeration units and has found the capital cost and some technical handling issues to be a challenge to overcome. The lack of expert personnel to maintain CO_2-based systems is another obstacle faced by those ready to invest in natural refrigerant systems. As reported by BNN, several small local or regional German OFR chains currently have one or two CO_2 systems running in test mode before they could be used as a blueprint for other stores. Another large national OFR chain from Germany is running pilot projects with R290-based systems. So far, results have been promising enough to test more units in 2020.

Specifically regarding the acceptance level of natural refrigerants, the survey provided a first indication of the size of the challenge: out of 34 respondents from this sector, a large majority of 82.4% confirmed they would have no reservations against the use of natural refrigerants. Even if this cannot be taken as a representative figure for the entire European market, it could indicate that convincing business owners to switch to natural refrigerants would not constitute a major challenge as such, but that other factors would need to be addressed by effectively communicating with them (see Decision making factors for RACHP equipment). Among the comments provided regarding which reservations OFR store operators would have against natural refrigerants use, the following factors were mentioned: safety considerations; limited capability of technicians to handle them; higher initial investment; and limited availability of appliances.

4.2.8 Interest in sustainability label for RACHP equipment

4.2.8.1 OFR stores

It is estimated that the interest in a dedicated campaign and label for the OFR sector is currently low in the specialised OFR sector in the countries surveyed. This was specifically confirmed in interviews conducted with stakeholders in Germany and the Netherlands, where small business owners do not attach much overall attention to the topic of RACHP and currently have no motivation to draw attention to their environmental performance. However, existing initiatives like sustainability monitors could be used to address this gap.

In interviews with Belgian retailers of organic food, a label was considered to be interesting from a marketing point of view under two conditions: 1) the principles/criteria of the label are in line with those applied by the shop; 2) the label has an acceptable cost for the shop.

4.2.9 Knowledge of F-gas Regulation

4.2.9.1 Bakeries

According to the German Artisan Baker Association, owners of bakery shops are normally aware of the F-gas Regulation and its implications for their business (personal communication).

4.2.9.2 OFR stores

Respondents to the survey showed a varying degree of knowledge on the F-gas Regulation, with 14 out of 34 respondents having no knowledge of this important piece of legislation. The remaining 59% were aware of the F-gas Regulation. This is a first indicator of the gap that exists for small OFR businesses in terms of policy update, and confirms that more or better information on its implications and other pieces of legislation should be provided to support the sector in future policy compliance.

4.3 Stock Model

To be noted, the word 'system' is used interchangeably in this subchapter with the words 'appliance', 'equipment' or 'unit'.

4.3.1 Methodology

A stock model was developed based on desktop research and categorisation of food retail type and store size. The following provides a short overview of the scope covered by the stock model, its structure and outcome, and the limitations of the resulting GHG emissions inventory. More detail is provided in the annex.

The performed analysis (as outlined in chapter 3.4) underlying the stock model assumptions focussed on OFR, bakery and butcher stores. However, due to a lack of consistent data to extract the share of independent food retail stores, local chains and specialised OFR stores from the total of food retail in Europe, the **stock model** relies on few data sources that provide comparable overall size categories per country in one year. For supermarket stores, Nielsen, 2017 (data from year 2015) was used as the main data source across selected European countries.

The emission modelling covers relevant appliances of RACHP sub-sectors according to the following table. Stand-alone systems refer to autonomous plug-in display cabinets, whereas refrigerators and freezers are large-dimensioned models out of the same appliance types used in domestic refrigeration. In the scope of the stock model, refrigerators and freezers are usually installed in the backspace of stores, without direct access for clients.

Within this scope, condensing units used for commercial refrigeration refers to a display case cabinet, or compounds of various such cabinets which may also include cold room(s), together constituting the evaporator side, whose condensing side (combined to one condensing block per appliance) is foreseen for outside installation. Condensing block and evaporator sides are connected via piping.

Table 4-4: RACHP sub-sectors and related systems with relevance to the stock model

Sub-sector	Systems (appliances)
Unitary air conditioning, including heat pumps	Single-split commercial air conditioners (thereafter denominated as split ACs) Multi-split air conditioners[74] Non-reversible heat pumps[75] Air conditioning chillers[76]
Chillers	Process chillers
Commercial refrigeration	Stand-alone (plug-in) systems

[74] Due to its minor relevance in small food retail, this equipment type was incorporated into the category of split commercial air conditioners by application of weighted scaling factors in the number of assumed appliances, thereby considering the difference in equipment size.
[75] According to the data collection, reversible heat pumps play a marginal role. They are assumed to be included in the categories single-split ACs and non-reversible heat pumps.
[76] Air conditioning chillers are incorporated into the category centralised systems for supermarkets (central refrigeration systems). AC chillers used in food retail would very seldomly not supply any refrigeration relevant mainly for food processing, and therefore have low significance for food retail.

	Condensing units Centralised systems for supermarkets (in this study also denominated as *centralised refrigeration systems*) Refrigerators and freezers

The stock of small food retail stores by category and therein installed appliances was established based on desk research and input by the project partners. The quantified stores for the five project partner countries Belgium, Germany, Netherlands, Portugal and Spain are presented by store category for selected years in the annex (see Table A-1). For simplification purposes, the numbers of appliances per store (see following table) were assumed as remaining constant over the years. For future projections, compound annual growth rates were used as shown in the annex (see Table A-3), using a combined approach of historic growth whenever known, and sector-relevant market indicators. A phased approach is used for 2020 onward by assuming reduced annual growth rates compared to the previous years up to 2019. To this end, two reductions of annual growth by 50% were assumed in 2020 and in 2023.

GHG emissions are calculated for each sub-sector and appliance type based on relevant technical parameters (see subsequent table and references). Underlying input parameters are defined on an annual level such as stock numbers, refrigerant distribution and energy efficiency ratio according to the predicted development derived for the BAU (business as usual) and MIT (mitigation) scenarios.

Appliance-related modelling parameters were derived from the online survey, expert consultations including the input by country partners and complementary sources (sector studies, branch-specific organisations and websites, statistics). Remaining gaps were filled with default values mainly obtained from the HEAT database.

The following table shows the numbers of RACHP appliances allocated to each store category. Countries are distinguished as far as data is available. The presented numbers are weighted average values[77], taking the varying numbers of subsidiary stores among different market players into account.

Some particularities were identified for the Netherlands. Food stores in this project country usually do not use central air conditioning which decreases the required cooling capacity by centralised refrigeration systems. Moreover, heating systems largely rely on fossil fuels and particularly on gas, heat pumps are currently less common than in Belgium and Germany.

The numbers of heat pumps include the use of reversible split ACs. Both appliance types have country-specific annual operating hours. Accordingly, split ACs in Belgium, Germany and the Netherlands have clearly more annual operating hours than heat pumps (factors from 2.8 to 3.0), while split ACs considerably dominate the annual operating hours in Portugal and Spain (factors 3.2 and 2.9, respectively).

Based on these parameters, the total numbers of installed appliances were established. The quantified appliances for the five project partner countries by store category and appliance type are presented in the annex for selected years (see Table A-2).

[77] For the weighted average values, the specific weight of each contribution was reflected. In the case of appliances per store, the provided value (number of appliances, distinguished by appliance type) by each food retailer was multiplied with the total number of stores it operates.

Table 4-5: Numbers of assumed RACHP appliances in use by store category

Store type	Country	Stand-alone systems	Condensing units	Centralised refrigeration[78]	Refrigerators and freezers	Split ACs	Heat pumps
Conventional supermarkets, 400-999 m²	Netherlands[79]	6.0	1.0	2.5	2.0	1.0	1.0
	All others[80]	7.2	1.0	4.78	1.0	3.0	2.0
Conventional superettes < 400 m²	Netherlands[81]	6.0	2.0	0.65	0.01	1.0	1.0
	All others[82]	7.5	1.0	1.75	1.0	2.0	1.0
Organic food retail, 400-999 m²	Belgium[83]	1.14	0.01	1.44	7.0	0.01	0.1
	Germany[84]	12.0	0.32	1.2	4.71	3.0	2.0
	Netherlands[85]	4.0	0.01	1.25	2.0	1.0	1.0
Organic food retail < 400 m²	Germany[86]	4.81	0.67	0.3	3.11	0.44	0.07
	Netherlands[87]	4.0	1.0	0.35	3.0	0.5	0.0
	All others[88]	3.32	0.30	0.35	4.28	0.69	0.02
Bakeries	All[89]	1.12	0.13	0.0	1.93	0.69	0.02
Butcher stores	All[90]	1.66	0.27	0.0	2.1	0.69	0.02
Other special. food shops (incl. farm shops)	All[91]	1.0	0.25	0.25	2.5	0.69	0.02

[78] The numbers of central refrigeration systems were scaled based on the standard unit size of 20 kW as defined in the subsequent Table (*Technical specifications of RACHP appliances for BAU and MIT scenario*)
[79] Source: Public information, STEK/KNVvK, own judgement
[80] Sources: Steinmaßl (2014), GIZ/HEAT, 2018, Survey within this project
[81] Source: Survey within this project
[82] Source: Steinmaßl (2014), GIZ/HEAT, 2018, Survey within this project
[83] Source: Survey within this project
[84] Source: Survey within this project
[85] Source: District food dynamics (2020)
[86] Source: Survey within this project
[87] Source: Survey within this project
[88] Source: weighted average from all collected survey data within this project; split AC and heat pump assumptions taken from weighted average of survey results in Germany and the Netherlands
[89] Source: Fraunhofer ISI, 2013; split AC and heat pump assumptions taken from weighted average of survey results on OFR stores < 400 m² in Germany and the Netherlands
[90] Source: Fraunhofer ISI, 2013; split AC and heat pump assumptions taken from weighted average of survey results on OFR stores < 400 m² in Germany and the Netherlands
[91] Assumed from farm shops and OFR shops < 400 m²

The following table outlines the technical key parameters used for the different RACHP appliance categories. For simplification and due to scarcity of data, these parameters were assumed equal for all countries and throughout all store types. However, variations in appliance dimensions were considered for central refrigeration systems (chillers) through individual scaling (i.e. adjustment of installed numbers per store type) based on a default unit size.

Table 4-6: Technical specifications of RACHP appliances for BAU and MIT scenarios

Appliance type	Lifetime[92] [years]	Main refrigerants[93]	Refrigerant initial charge[94] (IC) [kg]	In-use emission factor[95] [% of IC]	Cooling capacity[96] [kW]
Stand-alone systems	5	R404A, R134a; HC	0.6	0.01	1.2
Condensing units	15	R404A, R134a	4.0	0.1	5.0
Centralised refrigeration systems[97]	10	R404A, R134a, R507A (HC, CO_2)	36	0.1	20
Refrigerators and freezers	7	R600a	0.2	0.003	0.4
Split AC systems	10	R410A (R32, R290)	1.8	0.1	4.5[98]
Heat pumps	10	R404A (CO_2, R290, R32)	1.23	0.1 (est.)	3.5

Based on the parameters shown in the two tables above, GHG emissions are calculated by applying the two principle equations shown in the annex which distinguish between indirect and direct emissions. Indirect emissions result from electricity generation used for cooling, considering the annual electricity consumption and the country-specific grid emission factor (GEF). As shown in Figure 4-2 Belgium has a relatively low carbon intensity in its electricity supply, while Germany's electricity supply stands out showing the highest carbon intensity within the project partner countries (220% of Belgium's GEF). The Netherlands, Portugal and Spain as well as Italy, have a GEF ranging between 35% to 60% higher than Belgium's GEF.

---

[92] Source: HEAT database/ Public information, STEK/KNVvK, own judgement
[93] Numbers in brackets are mainly relevant for the future projection. No reliable assumptions were found for HFO refrigerants such as R-1234yf. As technical solutions using low-GWP, natural refrigerants already exist, a gradual shift to such refrigerants aligned with the EU F-gas regulation was also assumed in the business-as-usual (BAU) scenario.
[94] Source: Survey within this project; gaps taken from HEAT database/relation to cooling capacity
[95] Source: HEAT database; this value corresponds to the annual refrigerant leakage rate during the useful life of the appliance.
[96] Sources: Survey within this project; gaps taken from HEAT database and shecco (2018)
[97] Based on the defined cooling capacity in this table, and also reflecting the corresponding refrigerant initial charge, the numbers of central refrigeration systems per store type and country as presented in the annex were scaled to this unit size.
[98] Netherlands: 5.0 kW (surveys within this project)

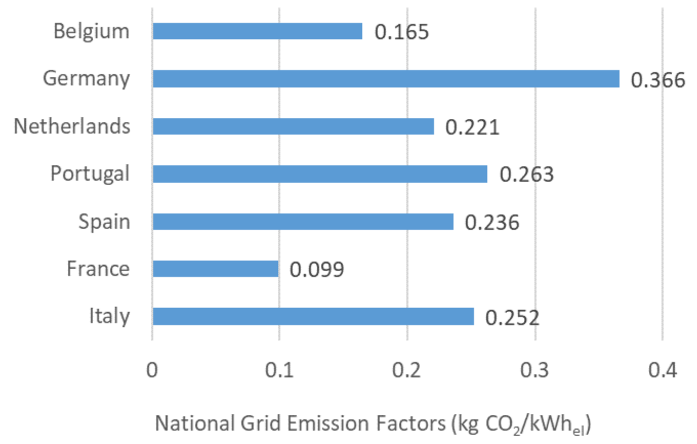

Figure 4-2: Grid emission factors for electricity supply in project partner countries, France and Italy. Source: IFI, 2019

The grid emission factors result from the energy mix used for the national power grids, as shown in

Figure 4-3. Coal-fired power plants are the major driver of high GEF values, in contrast to renewable energy generation which offsets CO_2 emissions. Even nuclear power plants have a relatively low carbon intensity. Such interrelations have a large impact on indirect and total RACHP-related GHG emissions and thus are a major reason for differences in the mentioned emissions and related mitigation potentials between countries.

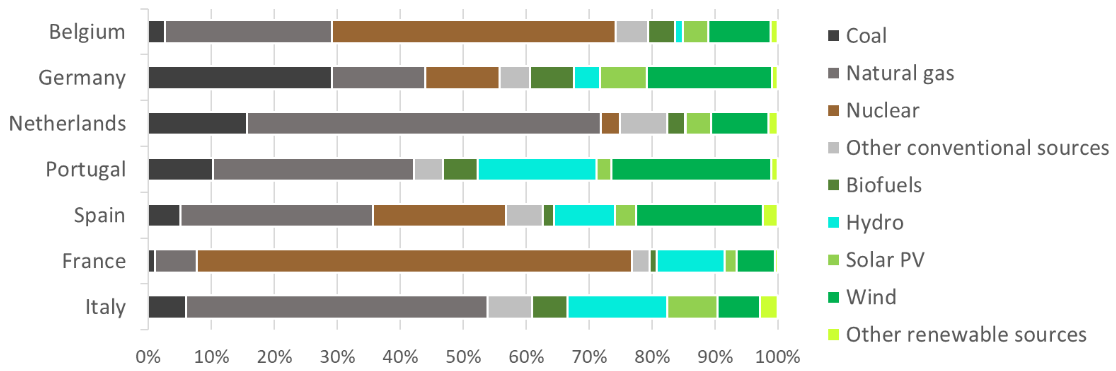

Figure 4-3: National energy mix in project partner countries. Source: IEA, 2020

The energy efficiency ratio (EER) values of all equipment types are calculated assuming a stepwise increase based on increments of 5 years as shown in the annex (see Table A-4). The current EER averages are taken from interviews and expert consultations, where adequate data was provided. Otherwise, values were assumed based on desk research reflecting current market products and minimum requirements stipulated by legally binding EU regulation. For the development of the future projection, the energy efficiency (EE) characteristics were assumed to increase up to EE classes in the range C to D for the BAU scenario until 2025, and to approximate EE class A for the MIT scenario. The runtime hours of the different appliance types were assumed based on the HEAT database which distinguishes values by country with underlying climate data. However, the climatic conditions have low relevance for self-contained small-scale commercial refrigeration appliances without condenser components placed outdoors (particularly stand-alone systems/plug-ins as well as refrigerators and freezers) as their operation relies mainly on the appliance design and end-user behaviour (e.g. how many door-openings per hour). For stand-alone systems, refrigerators and freezers, energy modelling was based on total energy consumption instead of EER values (see annex Table A-5), in conformity with the common declaration of appliance data and reference values in the EU regulations.

Direct emissions include refrigerant emissions from leakage of refrigerant gases. In the GHG modelling within this stock model, leakage was only taken into account during the use of the appliances (also denominated as servicing emissions). Leakage occurring (and presumably leading to refrigerant recharge) during installation and at end-of-life of the RACHP appliances was excluded from the GHG emission count. This is due to the defined system boundaries. These are limited to the direct sphere of influence of store operators. For this reason, transmission and distribution losses within the electricity supply grids (i.e. affecting indirect emissions) have also been excluded.

The historic and future trend assumptions regarding the use of refrigerant types are presented in Table A-6 of the annex. A progressive ongoing transition to low-GWP refrigerants was assumed for conventional supermarkets and for large OFR stores, leaving relatively low potential for additional emission mitigation effects in the MIT scenario. For the remaining store categories, significant differences between BAU and MIT were assumed for the point in time when the remaining store categories will tackle a comprehensive transition to low-GWP refrigerants and thus offer notable mitigation potential per unit (kg) of refrigerant charge. Therein, the BAU scenario was aligned with the requirements by the EU F-gas regulation. However, refrigerators and freezers currently on the market have already been converted to low-GWP refrigerants (mainly R600a), which was also assumed to a major extent for the installed stock in less progressive store categories (at least 85% R600a in 2015 and 96% in 2020).

4.3.2 Limitations

4.3.2.1 Store size category and food retail types

As an overarching limitation for the reliability of data presented in the stock model, the lack of available consistent data for the definition and quantification of small food retail stores and their sub-categories needs to be highlighted. This concerns not only the partly inconsistent separation of food retail types by different data sources, but also the quantification of stores per category, or total sales (turnover) per food retail type (as the latter served as indicator to assume the numbers of superette stores).

As outlined in sub-chapter 1.4, the quantification of relevant store types was based on the following data sets and assumptions for conventional small food retail:

- For general food retail stores with a sales area of 400 to 999 m², the number of shops is taken from population-specific indicators provided by Nielsen, 2017 (data from year 2015); and multiplied by the number of inhabitants in the same year.
- For general food retail stores with under 400 m² of sales area, the number of shops is derived from market shares on total food retail provided by Nielsen (2017; 2015 data) and multiplied with a sales area specific scaling factor. The sales areas were assumed from Belgium for Central and Western European countries including France, and from Spain for South European countries.
- As a preferred alternative for Nielsen, specific country data were used for the numbers of supermarkets (400 to 999 m² sales area) and superettes (supermarkets < 400 m² sales area).

The stock model assumes that OFR stores fit within the available data sets within superettes and small supermarkets (as defined by Nielsen). The remaining difference after subtraction of OFR stores from all supermarkets resulted in the number of conventional supermarkets and superettes.

The definition of OFR store numbers and size categories is therein limited to the five project partner countries. The actual numbers of OFR stores were identified for Belgium, Germany and the Netherlands (distribution between the size categories required estimates for Belgium and Netherlands), while the OFR store numbers for Portugal and Spain were estimated.

Likewise, the analysis of other small retail categories and GHG emission modelling, with a focus on bakeries, butcher stores and other specialised food stores, exclusively comprises the five project partner countries. Even within these countries, only limited data was found.

The numbers of bakeries and butcher stores in Portugal and Spain were taken from an EU study on low energy ovens (EC, 2014) which provides the number of bakery enterprises. The numbers of butcher stores in Portugal, Spain and Italy were assumed from a weighted scaling factor out of other partner and key countries (i.e. including France) which assumed the number of butcher stores per inhabitant. Belgium, Germany and the Netherlands rely on country data concerning the total numbers of bakery and butcher stores.

The combined category “other specialised food stores” explicitly includes farm shops. Other than for Belgium and the Netherlands, which include fish shops and other very specific businesses (e.g. cheese/deli and poultry in the Netherlands), this category only includes farm shops for Germany. No data was available for Portugal, Spain, France or Italy, neither with regard to farm shops nor fish shops or others.

The accuracy of data within the developed stock model is limited. For the status quo numbers of shops (mainly data for 2015, 2017 or 2018 were obtained), an accuracy margin of +/-30% is assumed. Future projections as well as the estimation of consumptions (electrical energy and HFC refrigerant) and of RACHP-related GHG emissions are subject to a greater accuracy margin.

4.3.2.2 Growth rates

The identified data basis for the assumption of historic and especially future growth is limited and does not consider any impact by the Covid-19 pandemic. The general approach and combinations in the application of sources is described in the previous sub-chapter. In cases where no reliable total numbers in different years allowed to calculate the market growth, specific compound annual growth rates for each year for the store categories in all countries have been derived using the following sources (resulting numbers provided in the annex, see Table A-3).

- Conventional retail: specific growth rates per store category were assumed from overall retail growth indicators and store-specific historic developments. In the same manner, projected growth rates from 2017 onward were based on NHH, 2018. For the Netherlands, Spain, France and Italy, harmonised growth rates were assumed for the historic growth up to year 2016 by taking the average growth between 2014 and 2015 in total numbers (Nielsen, 2017) and the growth projection by NHH, 2018.
- OFR stores: median values of organic retail sales growth within the 2013-2018 time period (FiBL data set), multiplied by the share of organic specialised shops within total organic sales (Agence BIO, 2017 and FiBL AMI survey 2016);
- Historic growth rates based on 2010-2013 change of bread consumption (AIBI, 2011 and AIBI, 2015); Germany: based on turnover development of bakeries in 2011 and 2018;
- Historic growth rates based on 2008-2013 change of per capita meat supply (Ritchie et al, 2017); Germany: based on turnover development of butcher stores in 2011 and 2018;
- Where no data were available, growth assumptions were based on general retail indicators or the used growth rates in the same size category. Particularly, the category “other specialised food shops” is largely based on general retail.

4.3.2.3 Installed RACHP appliances per store

Country-specific numbers of installed equipment per store are used as far as available from surveys, interviews and expert consultations. To a large extent, this is the case for OFR stores in Belgium, Germany and the Netherlands. For the other countries, weighted averages of the existing data are used. Other store categories are based on desk research: the configuration of RACHP equipment in conventional supermarkets and superettes relies on data from GIZ/HEAT (2018) and Steinmaßl (2014) and for bakeries and butcher stores on the configuration established specifically for Germany by Steinmaßl (2014) which has been assumed for all countries. Other specialised food shops (incl. farm shops) rely on OFR stores with a sales area under 400 m² for their RACHP equipment configuration.

As a general simplification, the number of installed RACHP appliances per store were assumed as remaining constant.

The underlying assumptions regarding the technical specifications of RACHP appliances have been presented in the previous sub-chapter (see Table 4-6). Due to scarcity of data and for simplification purposes, most parameters presented in Table 4-6 were assumed as uniform across all countries, store categories and scenarios. Varying dimensions of central refrigeration systems between different store categories and the incorporation of multi-split AC systems within the Split AC category were considered by applying scaling factors.

Country-specific operating hours based on climate data are used as underlying parameters to calculate the energy consumption.

4.3.2.4 Other assumptions and limitations

The calculation of GHG emissions is subject to the following assumptions:

- Direct emissions: Only in-use emissions occurring during the operation of the RACHP appliances are accounted in the GHG emission calculations (for more detail, see previous sub-chapter about the methodology).
- Leakage rates (refrigerant emission factors) with impact on direct emissions: The assumption of leakage rates relies on parameters taken from the HEAT database which are assumed to remain constant. Possible emission mitigation effects by improved handling of RACHP appliances containing high-GWP refrigerants, which may result in a decline of leakage rates, are not considered in the emission calculations for this stock model.
- Indirect emissions: Constant grid emission factors (GEF) are used on a country base (IFI data collection/evaluation 2016-2019) for all years included in the modelling.
- Electricity consumption with impact on indirect emissions: Purchase of certified green electricity[99] is not considered in the calculation of indirect emissions. Distribution and transmission losses in the electricity supply grid are excluded as these are considered outside the system boundaries of the project scope.
- Increasing the utilisation of heat recovery allows for potential additional energy and emissions savings by reducing the fuel consumption for conventional heating systems with relevance mainly to small food retail (stores < 400 m² sales area). This effect was not considered due to scarcity of data.

For the approximation of GHG emissions in the wider selection of countries and store categories as presented in the sub-chapter 4.3.3.2, the electricity consumption for refrigeration and air-conditioning in large supermarkets and hypermarkets as well as for small supermarkets and superettes in the further countries was assumed based on the following energy intensities, assuming RACHP equipment contributed a 50% share of the total energy consumed by each store:

[99] Several OFR chains use certified green electricity for their electricity supply; potentially several other players out of different store categories do so as well. If this was taken into account, indirect emissions by these players would be offset. This effect is of special relevance in the German OFR sector where according to BNN most stores already use certified green electricity. The situation in other countries is largely unknown.

Table 4-7: Estimated electrical energy intensity by supermarket store size (adopted from Ferreira et al, 2020)

Store category	Electrical energy intensity [kWh/m² per year]
Hypermarkets (sales area > 2,500 m²)	591
Large supermarkets (1,000 - 2,499 m²)	584
Small supermarkets (400 - 999 m²)	700
Superettes (sales area < 400 m²)	1,000

The direct emissions were assumed from the store-specific emissions calculated in the project partner countries, France and Italy, using weighted averages for the estimations in further countries, distinguishing between a cluster for Southern European countries and the remaining countries including France. The direct emissions in large supermarkets and hypermarkets were therefore assumed from the weighted averages of store-specific emissions in small supermarkets.

4.3.3 Results

In the following, the baselines (BAU scenarios) and estimated cumulative mitigation potentials until 2025 are presented in regard to GHG emissions, energy consumption and HFC consumption, including an overview of underlying quantification of stores by country and store type. In conformity with the scope of the elaborated stock model, all illustrations herein refer exclusively to the effects related with the operation of RACHP appliances. Within the scope of this analysis, HFC consumption refers to the amount of refrigerant refilled due to leakage during the operation of RACHP equipment, resulting from in-use emissions (for more detail, see Table 4-6). Despite its data uncertainty (status quo numbers of stores estimated at an accuracy margin of +/-30%), the presented scope of data is unique in the organic and small food retail market segment.

4.3.3.1 RACHP-related energy and carbon intensity per sales area by store type in selected countries

In the following, the annual electricity consumption required for the operation of RACHP appliances and related GHG emissions are analysed per m² sales area. 2018 is the reference year for this analysis, outlooks are provided for the timeframe 2021 to 2025.

The area-specific RACHP electricity consumptions and GHG emissions are based on the following assumed average sales areas for all considered store types in the five project countries (see Table 4-8[100]).

Regarding conventional small supermarkets in the size category 400-999 m², the average sales areas are based on country data for Belgium and Spain. The values for Germany and Portugal are assumed equal to the average sales area in the respective neighbour country. With 861 m², conventional small supermarkets in Belgium and Germany have a significantly larger average sales area compared to the Iberian Peninsula (637 m²), stores of the same category in the Netherlands are assumed an average size in between (700 m²). OFR stores in the same size category (400-999 m²) have a smaller average sales area of around 600

[100] Numbers with indices are based on country analysis, from which numbers marked with asterisk (*) are derived.

m² in Belgium and Germany, and 700 m² in the Netherlands. No large OFR stores in this size category were identified for Portugal and Spain.

The average sales area of superettes and small OFR shops was assumed in a range between 150 and 200 m² in most partner countries, except for superettes in Germany with an average sales area of 291 m² and in the Netherlands with an average sales area of 250 m².

Representing the smallest shop formats in food retail, the average sales areas of bakery stores, butcher stores and other specialised food shops are in a range from 70 to 100 m².

Table 4-8: Assumed sales area (m²) by store type and country.

Store category	Belgium	Germany	Netherlands	Portugal	Spain
Conv. supermarkets, 400-999 m²	861[101]	861*	700[102]	637*	637[103]
Convent. superettes, < 400 m²	167[104]	291[105]	250[106]	191*	191[107]
Bakery stores	70*	70[108]	70*	70*	70*
Butcher stores	80*	80[109]	80*	80*	80*
Other specialised food shops	97*	97[110]	97*	-	-
OFR shops 400-999 m²	600[111]	592[112]	700[113]	-	-
OFR shops < 400 m²	150[114]	159[115]	160[116]	150*	150*

* Values are adopted from other countries

Resulting from the assumed sales areas, the following area-specific RACHP electricity consumptions (RACHP energy intensities) were estimated based on year 2018 for the five project countries (see Figure 4-4). RACHP-related energy intensities in conventional small supermarkets (sales area 400-999 m²) were typically in a range of 150 kWh/m² per year, whereat stores in the Netherlands had RACHP energy intensities as low as 105 kWh/m² per year in average while stores in Portugal and Spain slightly exceeded 200 kWh/m² per year. Compared to the OFR stores in the same size category, conventional small supermarkets and superettes (sales area < 400 m²) typically employ a larger cooled display area (refrigerated area). The density of installed RACHP equipment per sales area is particularly high for conventional superettes and small OFR shops, contributing to their comparably high RACHP energy intensities. Another essential driving factor is the widespread use of inefficient equipment by purchasing appliances at low price ranges (including second hand) which are often operated in worn-out conditions and tend to follow poor maintenance routines. In Germany and the Netherlands, the greater role of well-

101 Nielsen (2017)
102 Public information, STEK/KNVvK expert analysis
103 Mercasa (2016)
104 Nielsen (2017)
105 HDE (2019)
106 Public information, STEK/KNVvK expert analysis
107 Mercasa (2016); data from 2015
108 Survey within project, 2020.
109 Assumption oriented on bakery stores and other specialised food shops
110 BNN, 2020; data from 2018
111 Survey within project, 2020
112 BNN, 2020; data from 2018
113 District food dynamics, 2020
114 Natex Bio (2016)
115 BNN, 2020; data from 2018
116 Public information, STEK/KNVvK expert analysis

organised retail chains within conventional superettes, combined with the condition that they dispose of larger sales areas for similar sizes of RACHP equipment, facilitates that the associated energy intensities are at relatively low levels (in a range of 200 kWh/m² per year instead 350-400 kWh/m² per year as in the other partner countries). Another important condition allowing for the relatively low RACHP energy intensities for both conventional supermarket store categories in the Netherlands is the marginal role of central air conditioning and heat pumps (see also Table 4-5).

RACHP-related energy intensities of small OFR stores were found in similar ranges of around 165 kWh/m² per year in 2018, as few differences in the shop formats were identified across the partner countries. While the installed capacity of centralised refrigeration systems in large OFR shops (400-999 m² sales area) is a bit higher for Belgium, the differences in the extensive (Germany) or low to minimum (Belgium and the Netherlands) use of stand-alone systems in comparable sales areas largely affect the RACHP energy intensity. As a result, large OFR stores in Germany required RACHP energy intensities of more than 110 kWh/m² per year in 2018, while large OFR stores in Belgium and the Netherlands required about 65 kWh/m² per year in 2018. The data reliability for bakery stores, butcher stores and other specialised food stores (including farm shops) is limited, including the assumed average sales areas. According to the estimates for 2018, bakery stores required RACHP intensities around 95 kWh/m² per year, butcher stores in the range of 115 kWh/m² per year (Portugal and Spain slightly above average for both store types) and other specialised food stores approximately 130 kWh/m² per year. It is noteworthy that specialised food stores are assumed to use centralised refrigeration systems in some cases, which can be also relevant for process cooling (e.g. milk in farm shops).

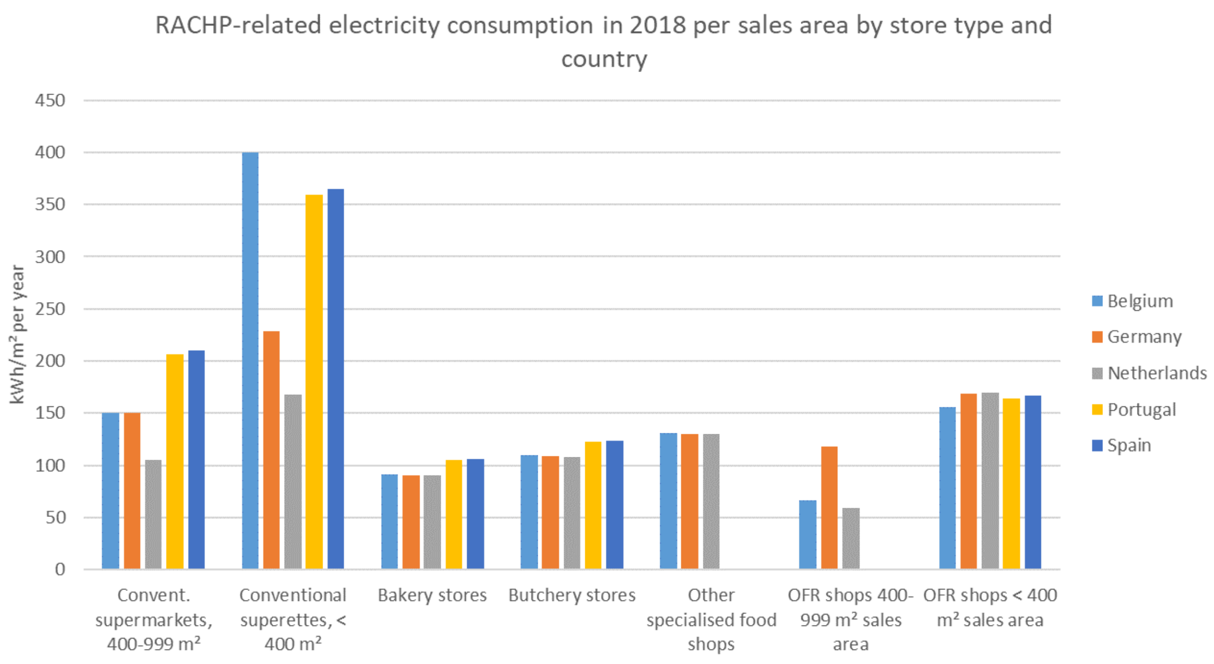

Figure 4-4: RACHP-related electricity consumption in 2018 per sales area by store type and country (kWh/m² per year in 2018)

Most OFR store types in the partner countries offer significant RACHP-related energy saving potential per sales area, as depicted in Figure 4-5. All RACHP energy mitigation potential is derived from the additionality of the developed mitigation scenario over a baseline (business as usual (BAU) scenario) which already assumes slight gradual energy efficiency improvements. The largest mitigation potential of area-specific RACHP energy consumption (i.e. energy intensity) was identified for the stores with sales areas below 400 m², amounting to 21 to 22 kWh/m² per year estimated in year 2025 for most partner countries, and even 24 kWh/m² in Germany. German large OFR stores (sales area above 400 m²) follow with an estimated reduction potential of 15 kWh/m² per year in 2025. With around 5 kWh/m² per year in 2025, Belgium's and the Netherlands' large OFR stores offer the lowest reduction potential within OFR stores in the selected countries, since their current RACHP energy intensity is comparably low and, in contrast to stand-alone systems, less further technological improvements regarding energy efficiency are assumed for centralised refrigeration systems which are widely used in these stores.

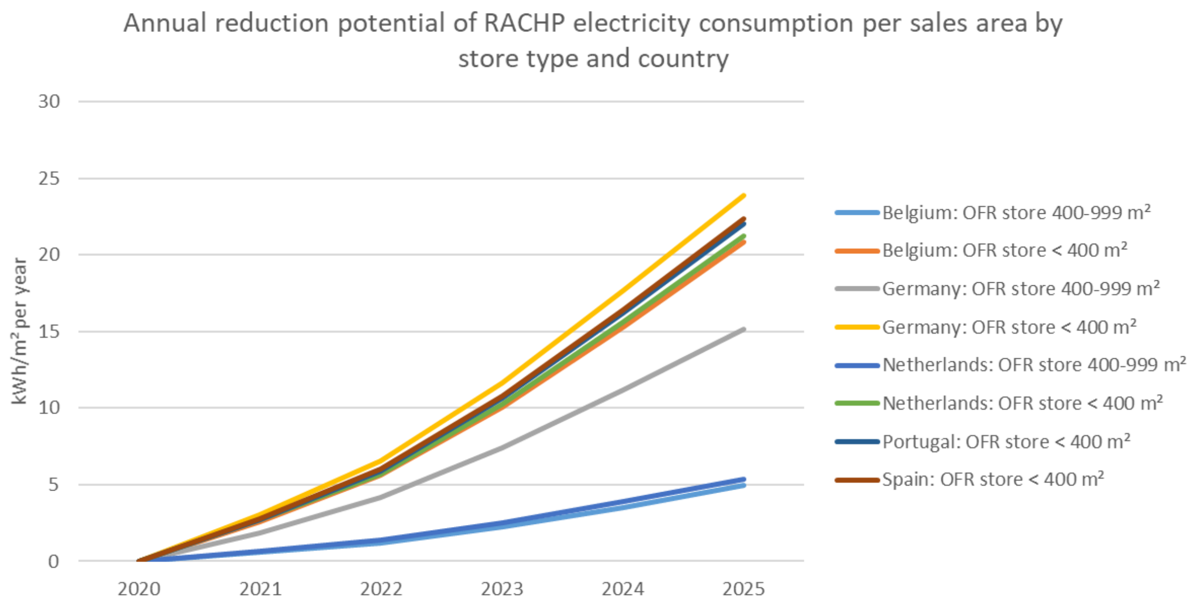

Figure 4-5: Annual RACHP-related electricity saving potential per sales area by store type and country (kWh/m² per year)

The sales area-specific RACHP-related carbon footprint of all store categories in the five partner countries is presented in Figure 4-6 (in kg of CO_2 equivalent per m² sales area and per year), based on the year 2018. Compared to the RACHP energy intensity (see Figure 4-4), additional variables affecting the GHG emissions are refrigerant leakage of RACHP equipment as well as the country grid emission factor. The latter drives the carbon footprint particularly in Germany, mainly due to large contributions of carbon-intensive coal-fired power plants to the national electricity mix. The use of centralised refrigeration systems, which are more prone to refrigerant leakage, increases the RACHP-related carbon footprints of small supermarkets and large OFR shops (sales area 400-999 m² for both). Facilitated by their relatively small average sales areas, demanding a higher density of installed RACHP equipment per square metre, Portugal's and Spain's conventional supermarket stores as well as Belgium's superette stores were responsible for the largest RACHP carbon footprints in 2018 (approximately 130 kg CO_2eq/m² per year for small supermarkets and around 200 kg CO_2eq/m² per year for superettes). With around 62 and 80 kg CO_2eq/m² per year respectively, the lower end of RACHP carbon footprint in 2018 within these store categories was marked by the Netherlands.

German small food retail stores lead the RACHP carbon footprints of all other store categories, small OFR stores (sales area < 400 m²) standing out therein with 90 kg CO_2eq/m² per year in 2018, followed by other specialised food shops with 83 kg CO_2eq/m² per year. Based on the year 2018, large OFR stores (sales area of 400-999 m²) contributed with 68 kg CO_2eq/m² per year, butcher stores with around 48 kg CO_2eq/m² per year and bakery stores with approximately 40 kg CO_2eq/m² per year. It is noteworthy that according to BNN most OFR stores in Germany compensate energy related GHG emissions (indirect emissions) by purchasing certified green electricity. The offset effect is exemplary indicated by showing the shares of indirect emissions (in hatched areas) in the presented RACHP carbon footprints in the following figure. This aspect has not been applied for the entire report though as respective data were not part of the research. Assuming a 100% use of certified green electricity across all German OFR stores, the remaining RACHP carbon footprints by direct emissions added up to 25 kg CO_2eq/m² per year in large OFR stores and 28 kg CO_2eq/m² per year in small OFR stores. In the four other partner countries, large OFR stores as well as bakery and butcher stores presented RACHP carbon footprints in the range of 20 to 40 kg CO_2eq/m² per year in 2018, with bakery stores pointing towards the lower end, butcher stores and large OFR stores towards the upper end of this range. For other specialised food stores and small OFR stores, RACHP carbon footprints were estimated in the range of 55 to 75 kg CO_2eq/m² per year.

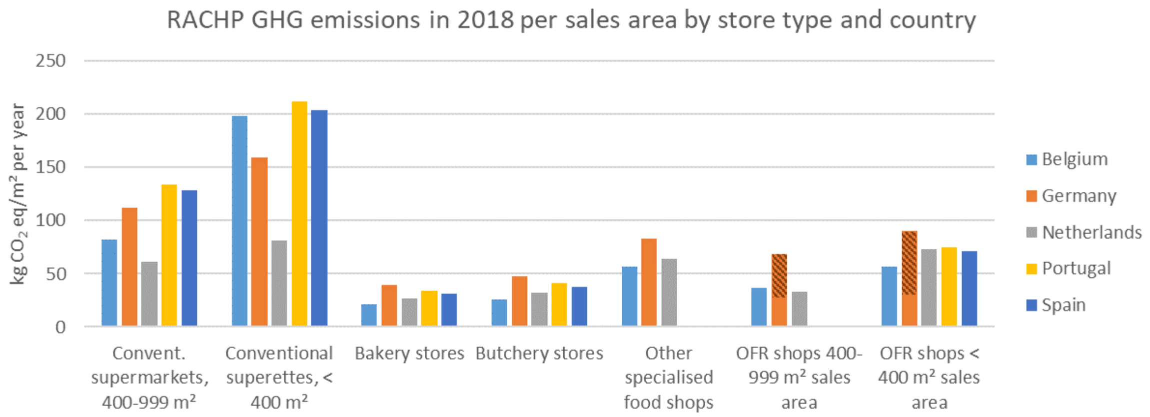

Figure 4-6: RACHP GHG emissions in 2018 per sales area by store type and country (kg CO_2eq/m² per year in 2018)

All RACHP emission mitigation potential is derived from the additionality of the developed mitigation scenario over a baseline (BAU scenario) which already assumes slight gradual energy efficiency improvements and complies with the EU F-gas regulation requiring a gradual uptake of refrigerants with low GWP values. With around 18 kg CO_2eq/m² per year in 2025, Germany's small OFR shops (sales area < 400 m²) stand out for the greatest estimated area-specific RACHP emission mitigation potential, followed by the Netherlands', Portugal's and Spain's small OFR shops (each approximately 16 kg CO_2eq/m² per year in 2025). At medium level, Germany's large OFR shops and Belgium's small OFR shops offer RACHP-related emissions saving potentials projected in the range between 14 and 15 kg CO_2eq/m² per year in 2025, while Belgium's and the Netherlands' large OFR stores demonstrate RACHP emission mitigation potentials estimated from 9 to 11 kg CO_2eq/m² in 2025. If a 100% use of certified green electricity is assumed for all OFR stores in Germany, for both large and small OFR stores, the area-specific mitigation potential of direct emissions is located at the lower end of the range for total mitigation potentials by OFR stores at about 9 kg CO_2eq/m² in 2025 (see dashed lines). It needs to be highlighted though that improvements in energy efficiency are considered very important to reduce the overall energy demand and release pressure on power grids.

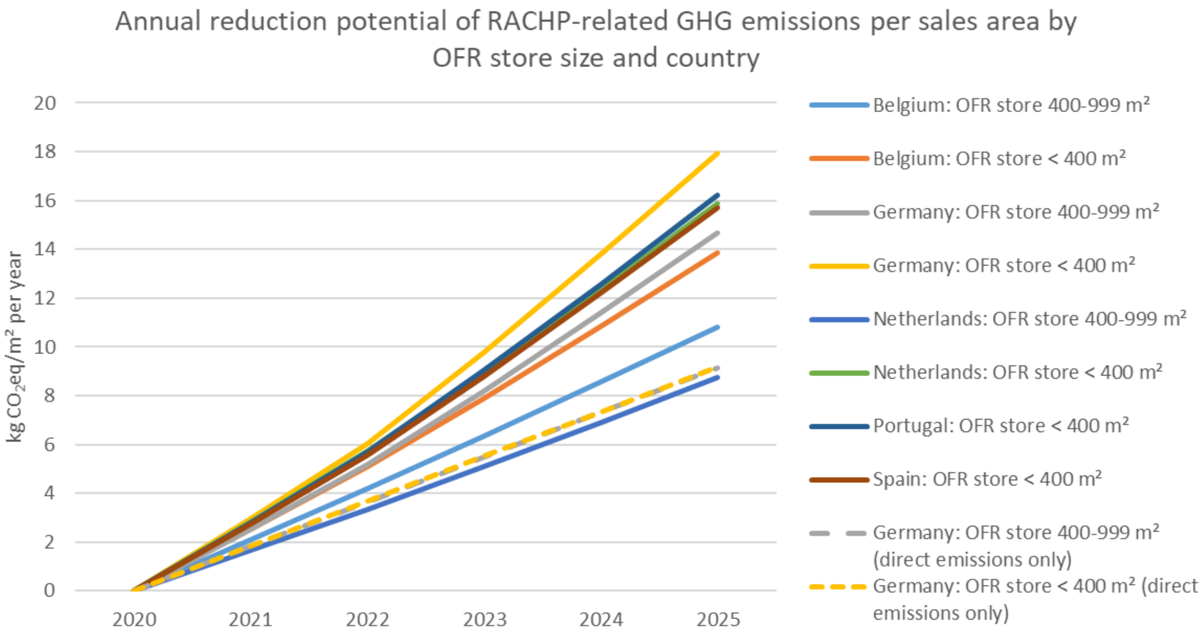

Figure 4-7: Annual RACHP-related GHG emission mitigation potential per sales area by store type and country (kg CO_2eq/m^2 per year)

4.3.3.2 EU-wide overview of selected countries

With a focus on supermarket stores in all size categories[117], the following graph puts the small food retail market segment (i.e. limited to stores up to 1000 m² of sales area) into relation with the overall food retail for a wider selection of European countries: 16 EU member states plus Norway, Switzerland and United Kingdom (UK). For illustrative purposes, the quantified stores are shown per million habitants. Conventional supermarket/superette stores and OFR stores are both included in the respective overall size category. As illustrated below, the major shares in terms of store numbers fall into the observed store categories up to 1000 m² of sales area, largely due to the contributions by superettes[118]. In comparison, the Netherlands have the lowest share of small food retail stores on all supermarket stores including superettes (67%), followed by France and Germany in the range of 75%. In contrast, Poland stands out as having by far the largest share (99%), followed by Austria, Czech Republic and Italy which all exceed 90%. Within the project partner countries, Spain followed by Belgium and Portugal have the greatest shares in the range of 80%.

[117] Besides small supermarkets and superettes, this compilation partly includes large supermarkets and hypermarkets; all kinds of specialised food stores are excluded. OFR stores are assumed to be contained in the respective overall store size category.
[118] Particularly the quantification of superettes is subject to a wider accuracy margin as the numbers for most countries were derived based on turnover per sales area compared to small supermarkets.

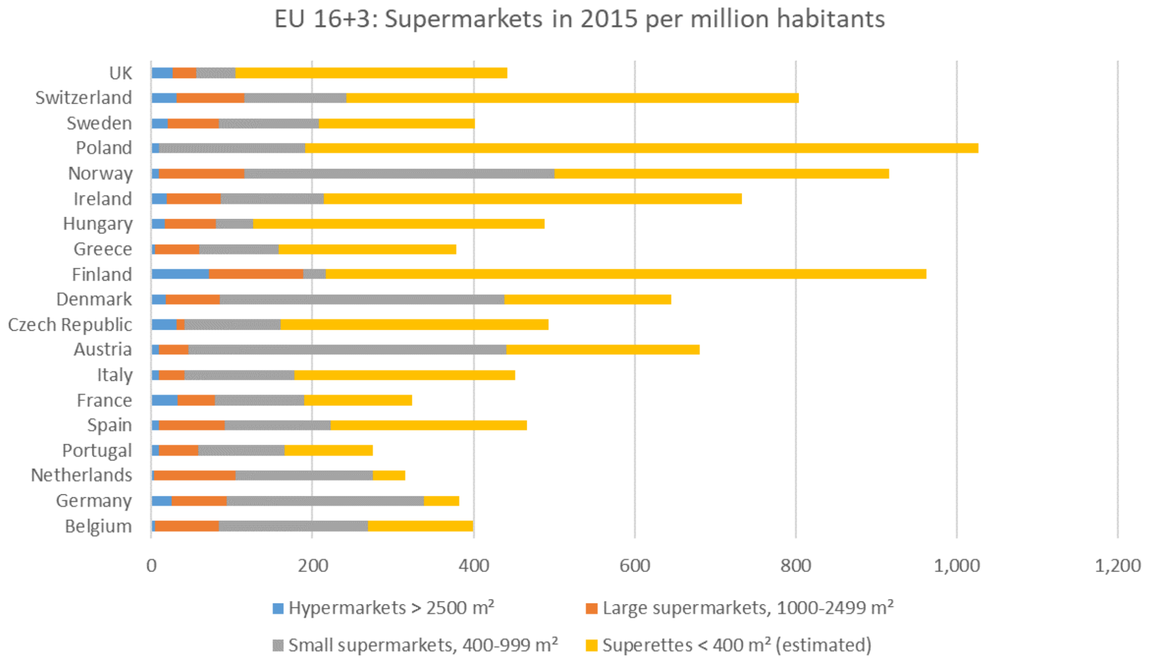

Figure 4-8: Quantified supermarkets per million habitants by supermarket store size for selected EU (16) and other (3) European countries in 2015.

On the aggregated "EU 16+3" [119] level of 19 countries, RACHP-related GHG emissions for supermarkets of all sizes exceeded 18 Mt CO_2eq in 2015[120] (accuracy margin +/- 30%). Thereof, small supermarkets (sales area 400-999 m²) alone contributed approximately 40%, and superettes were estimated to contribute another 27% to the total RACHP emissions of supermarkets of all sizes in the selected countries. Due to the trend of embracing a lower level of organisation and relatively delayed updating of technology to the latest state of the art, it is expected that especially the RACHP-related GHG emissions caused by superettes contain a significant amount of unexploited emission mitigation potential.

Further analysis focuses on the project partner countries Belgium, Germany, the Netherlands, Portugal and Spain. France and Italy are included in the initial sector overview as both countries represent important markets for OFR/small food retail. For this selection of countries, bakery stores, butcher stores and other specialised food shops are included as 'further store types' in the assessment. The category other specialised food shops includes farm shops and, where identifiable, fish shops, cheese/delicatessen, poultry shops. However, data on quantified stores in this category are available to a limited extent (for Belgium, Germany and the Netherlands only).

Total RACHP-related emissions in food retail across the seven selected EU countries were estimated to exceed 10 Mt CO_2 eq in 2015[121]. With approximately 39% of total RACHP emissions, small supermarkets (sales area 400-999 m²) were responsible for the major share of RACHP emissions associated with all food retail in the selected countries in 2015. Superettes (sales area < 400 m²) contributed another 14% approximately. Based on the limited data availability, further store types contributed an approximate share of 8% of total

[119] 16 EU member states plus Norway, Switzerland and United Kingdom (UK), according to Figure 4-8

[120] According to extrapolated emission accounting based on the five partner countries and based on the core store size categories up to 1000 m² of sales area. GHG emissions for the larger stores were extrapolated using energy-intensity benchmarks for the respective supermarket type (see Table 4-8).

[121] This approximation was derived by extrapolation using energy-intensity benchmarks for the store categories with sales areas greater than 1000 m² (see Table 4-7).

RACHP emissions. The remaining 39% were contributed by the larger supermarket stores with sales areas above 1000 m².

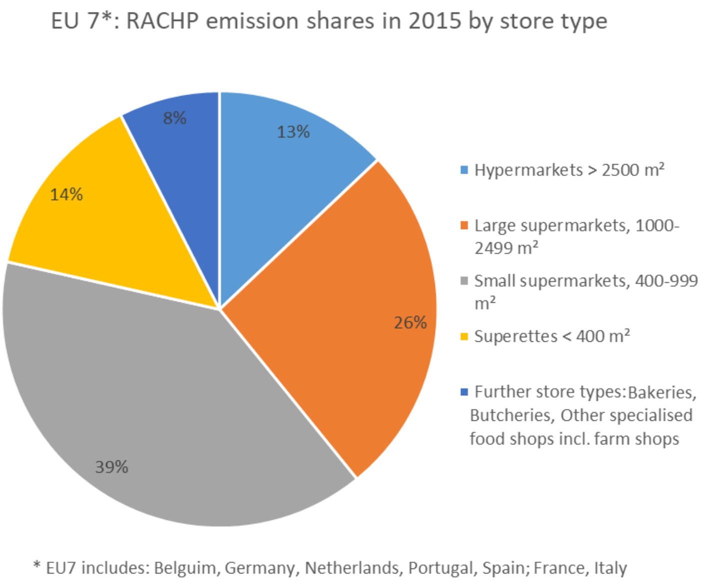

Figure 4-9: Distribution of RACHP emissions in food retail in 2015 by store type for project partner countries, Italy and France.

Due to great variations in population and food retail structure, the shares of GHG emissions caused by RACHP appliances per store category are highly heterogenous across the countries. For most observed countries, small supermarkets (sales area 400 to 999 m²) were leading in the shares of all RACHP emissions in food retail in 2015, with the exception of the Netherlands and Spain where large supermarkets (sales area 1,000-2,499 m²) contributed the largest shares.

Exclusively for the project partner countries Belgium, Germany, the Netherlands, Portugal and Spain, supplemented by France and Italy, the following graph shows the number of food retail stores by country and store type with up to 1000 m² sales area. The previously presented store numbers are extended by the store types bakeries, butcher stores, other specialised food stores and OFR stores in two size categories. In order to avoid double-counting, all OFR shops are subtracted from the respective overall supermarket category (sales area 400-999 m² and sales area < 400 m², respectively). The remaining supermarkets and superettes in the general category are therefore denominated as "conventional".

Either bakeries or butcher stores are the dominant store type in most countries. It is worth mentioning that the category "other specialised food shops (including farm shops)" was only able to be filled with data in Belgium, Germany and the Netherlands. In Belgium and Germany, other specialised food shops are leading in number of stores which in Germany are only based on data for farm shops.

While this market segment is still emerging, the share of OFR stores remains relatively low. Small OFR stores (sales area < 400 m²) have competitive shares with conventional superettes in Germany, the Netherlands, and to some extent Belgium and France.

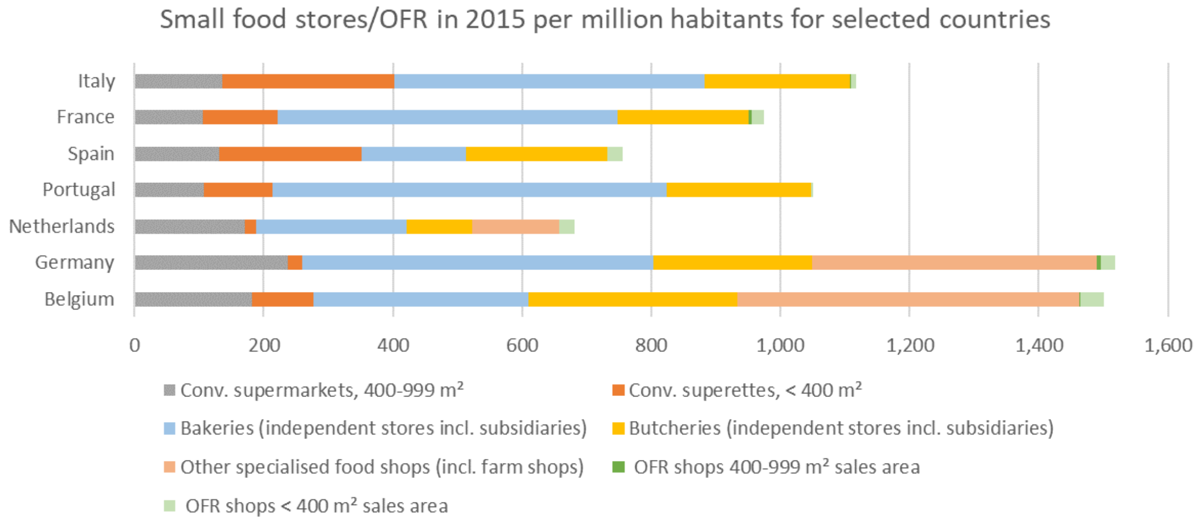

Figure 4-10: Quantified food retail stores per million habitants by store category for project partner countries, France and Italy

Based on the classification of food retail into conventional and OFR categories, the role of small food retail and its associated RACHP emissions is analysed in more detail. The following figure illustrates the distribution of RACHP emissions in 2015 for small food stores, excluding conventional small supermarkets. In this selective view, either further store types or conventional superettes dominate RACHP emissions in most countries, whereat the dominance of the latter is partly due to the lack of data for other specialised food shops (including farm shops) in Portugal, Spain, France and Italy. Further store types, which are constituted by bakeries, butcher stores and other specialised food shops, clearly dominate in Germany with approximately 79% of total RACHP emissions in small food retail excluding conventional small supermarkets, in the Netherlands with about 71% and in Belgium with around 54% of the total RACHP emissions.

In 2015, large OFR stores (sales area 400 to 999 m²) contributed about 4% of total RACHP emissions within the selected store categories in Germany, 2% in France, 1% in Belgium and the Netherlands and 0.5% in Italy. Small OFR stores (sales area < 400 m²) reached a share in the range of 12% of RACHP emissions in the selected market segment in the Netherlands, facilitated by a relatively low presence of conventional superettes. Small OFR stores were responsible for 4% of total RACHP emissions in the considered stores categories in Belgium and Germany, followed by 3% in Spain and France, while small OFR stores contributed minor shares of 1% in Portugal and Italy in 2015. On the aggregated level of the seven countries contained in the figure, large OFR shops (400 to 1000 m² sales area) were responsible for RACHP emissions in the range of 35 kt CO_2eq, and small OFR shops for RACHP emissions in the range of 63 kt CO_2 eq. In further store types, the operation of RACHP equipment was estimated to contribute more than 800 kt CO_2eq of GHG emissions in 2015, while conventional superettes were responsible for approximately 1.5 Mt CO_2eq of GHG emissions. As described in the prior sub-chapter, the grid emission factors, which greatly differ across the analysed countries, largely affect the resulting indirect and total GHG emissions (see also **Fehler! Verweisquelle konnte nicht gefunden werden.**).

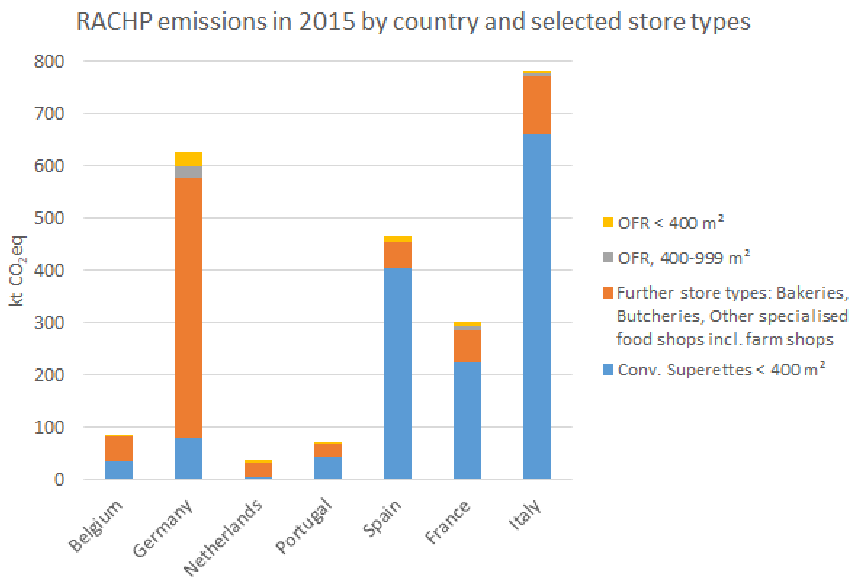

Figure 4-11: Total RACHP-related emissions in small food retail excluding conventional supermarkets by country and store type in 2015.

The following figure presents the aggregated baseline (BAU scenario) of GHG emissions associated with the operation of RACHP equipment in all small food retail stores by project partner country from 2015 to 2025. German small food retail is responsible for the major proportion of RACHP emissions within this country group. In 2020, Germany's contribution to total RACHP-related emissions of 3.7 Mt CO_2eq is estimated at 63%, followed by Spain with 23%. The remaining countries are responsible for contributions from approximately 6% (Belgium) down to 4% (the Netherlands and Portugal). Over the total observation period, BAU emissions are projected to decline by nearly 40% for Belgium and Germany, by up to 45% for the Netherlands and Spain, and by about 33% for Portugal. Beside depending on the development of appliance stock and the number of stores, this decrease is due to basic improvements of energy efficiency assumed in the BAU scenario and the stepwise conversion to RACHP equipment employing low-GWP, natural refrigerants in conformity with the EU F-gas regulation.

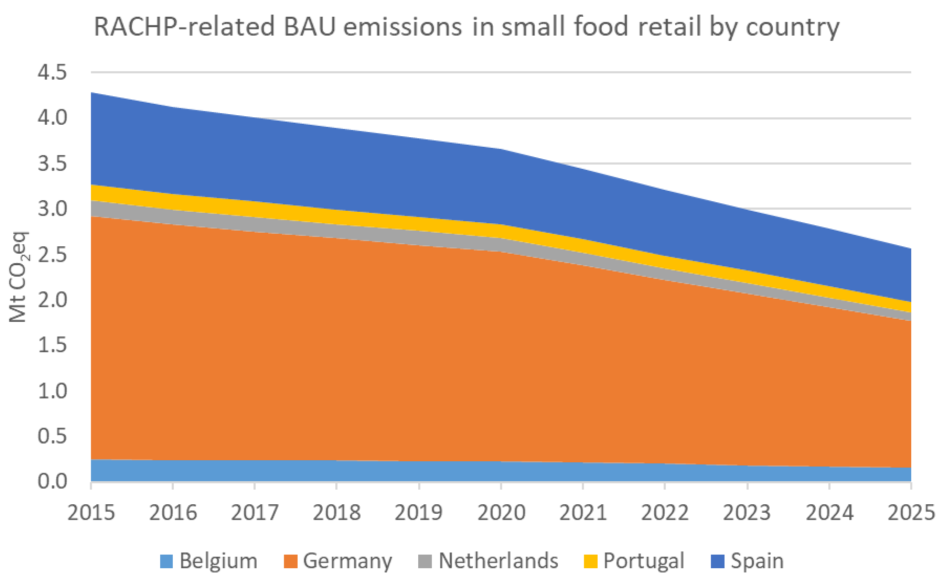

Figure 4-12: Projected total RACHP-related emissions in small food retail by country from 2015 to 2025 in the BAU scenario

Compared to the baseline (BAU), additional energy efficiency improvements and an accelerated conversion of RACHP appliances to low-GWP, natural refrigerants are employed in the mitigation scenario with special relevance to the smallest store categories below 400 m² sales area. These additional measures are expected to achieve additional RACHP emission reductions of approximately 400 kt CO_2eq in 2025, as depicted in Figure 4-13. Cumulative emissions savings from 2021 to 2025 are projected to amount to 1.1 Mt CO_2eq. With an estimated 28% share of the total amount across the five selected countries in 2025, Spain stands out as having an above average emission reduction potential. An important factor for this relatively large potential is the significant role of food stores below 400 m² sales area in Spain. With about 56% of the total potential in 2025, German small food retail offers the greatest emissions savings of all partner countries. 7% of the total reduction potential of the five partner countries are attributed to Belgium's small food retail, followed by Portugal (5%) and the Netherlands (4%).

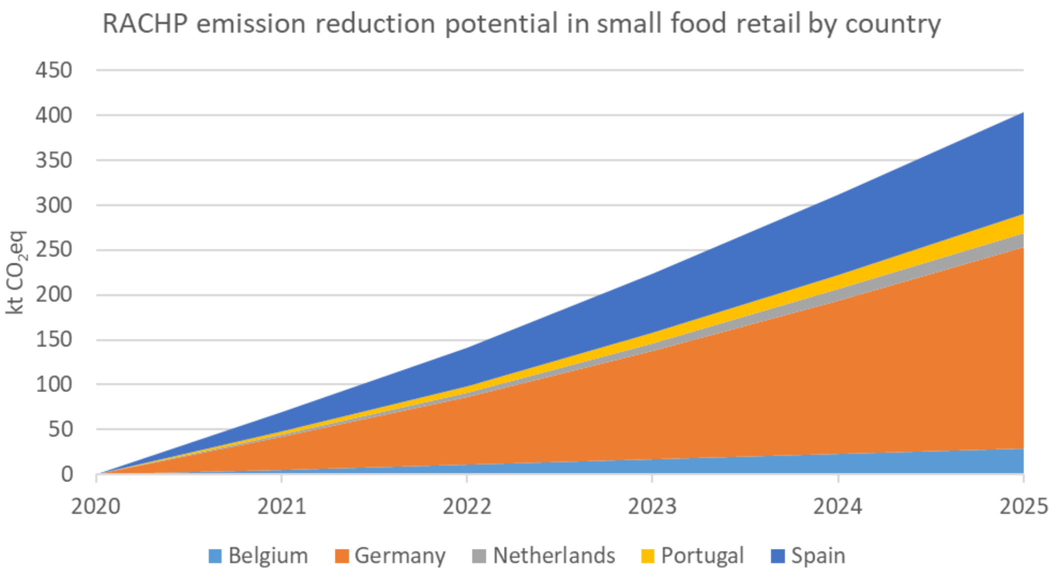

Figure 4-13: Projected total RACHP-related emission reduction potential in small food retail by country from 2020 to 2025

4.3.3.3 Country summaries

In the following, a profound overview is provided for all five partner countries. RACHP-related GHG emissions, energy consumption and HFC consumption are analysed on aggregated national level per store category under consideration of the status quo (year 2018) and related mitigation potentials (cumulative figures for the years 2021 to 2025). The consumption of refrigerants is only analysed for HFCs and limited to refilling based on the assumed leakage rates occurring during their operation. RACHP appliances which are already converted to HFC-alternative, low-GWP refrigerants are not considered in the following assessment.

RACHP-related mitigation potentials in the small food retail sector are derived by subtraction of the projected MIT scenario from the projected baseline (BAU) scenario. The BAU scenarios are aligned with the limitations of HFC use in conformity with the EU F-gas regulation which also affects the mitigation potential of direct emissions caused by refrigerant leakage, and are oriented around energy efficiency class D with regard to projected energy consumptions and related indirect mitigation potentials by RACHP appliances (for more information, see sub-chapter 4.3.1 and Table A-4 to Table A-6 in the annex). Energy reductions can be achieved by improving the energy efficiency of RACHP appliances which contribute to GHG mitigation through a reduction of indirect emissions. The consumption of HFC refrigerants can be reduced by technological conversion to HFC-free, low GWP alternatives. Due to their high GWP values, direct emissions are almost exclusively due to the leaking of HFC refrigerant, commonly occurring during the operation of RACHP appliances.

4.3.3.4 Belgium

4.3.3.4.1 RACHP-related GHG emissions

In the following figure, the distribution of Belgium's GHG emissions caused by the operation of RACHP appliances in small food retail is shown by store types with up to 1000 m² sales area for the year 2018. The largest amount of emissions within Belgium's small food retail sector was caused by conventional supermarkets (150.7 kt CO_2eq), followed by conventional superettes and other specialised food shops (the latter including farm shops), each of which contributed around 13% to the total GHG emissions of 234 kt CO_2eq in the analysed market segment. Butcher stores and bakeries were each responsible for 3% of the total GHG emissions. In comparison, OFR shops had the lowest GHG emission shares in 2018, with contributions of 0.4% (4.5 kt CO_2eq) by OFR shops with a sales area below 400 m^2 and 2% (0.9 kt CO_2eq) by those larger than 400 m^2.

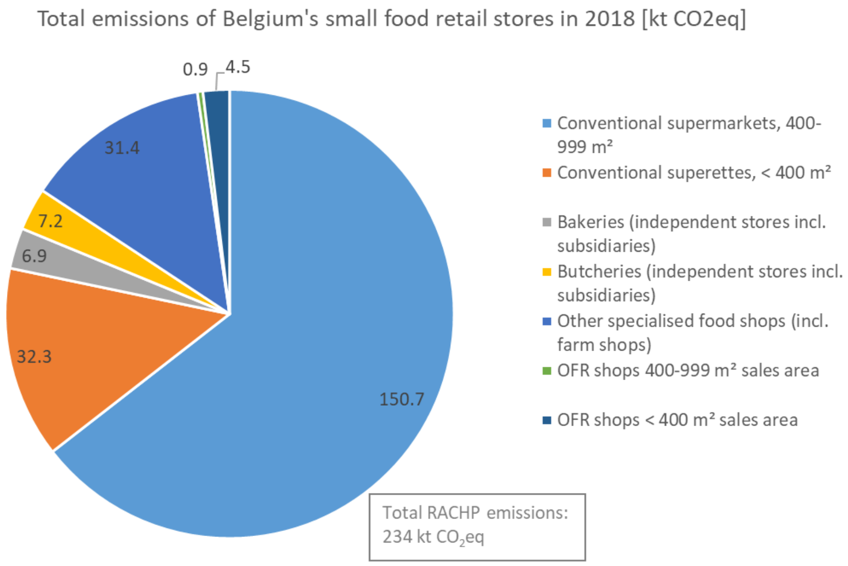

Figure 4-14: Total GHG emissions caused by operating RACHP equipment in Belgium's small food retail stores in 2018.

Figure 4-15 presents the GHG emissions by RACHP appliances in 2018 for the selected store categories in Belgium, whereas the column to the right combines bakeries, butcher stores and OFR shops due to their relatively low shares. From bottom to top in each column, the shares of each RACHP appliance type are displayed. As this illustration clearly indicates, conventional supermarkets had by far the largest share of centralised refrigeration systems (89% of total RACHP emissions), conventional superettes (78%) and other specialised food shops (including farm shops, 67%). For these store types, the other equipment types (stand-alone systems, condensing units, refrigerators and freezers, heat pumps and split AC) had marginal shares of total RACHP GHG emissions. Within the combined category bakeries, butcher stores and OFR shops, the emission shares differ significantly from the beforementioned categories, dominated by stand-alone units. The distribution of RACHP-related emissions within these store categories is analysed in the subsequent figure.

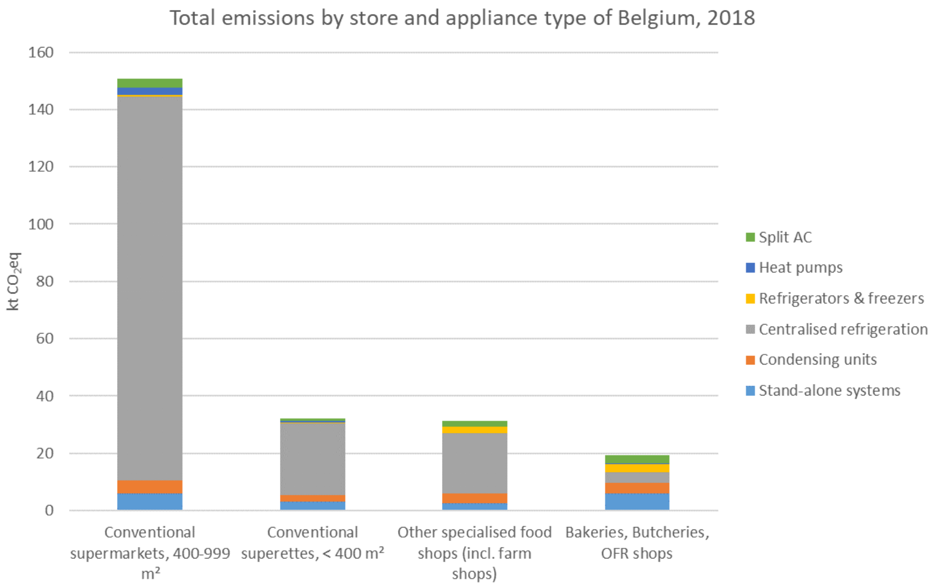

Figure 4-15: Total RACHP emissions by store and appliance type of Belgium's small food retail sector in 2018.

Figure 4-16 illustrates the RACHP-related emissions for bakeries, butcher stores and OFR shops in 2018. In comparison to the OFR shops, bakeries and butcher stores do not exhibit any emissions caused by centralised refrigeration systems. With around 30% for both store types, stand-alone systems had the largest share in bakeries (2.41 kt CO_2eq) and butcher stores (2.67 kt CO_2eq). For bakeries, the remaining emissions are divided into comparable shares for split ACs, refrigerators and freezers and condensing units (around 20% each). Condensing units contribute a share of 28% to the total GHG emissions of butcher stores, followed by split ACs and refrigerator and freezers (ca. 15% each). Heat pumps caused by far the lowest amount of emissions in bakeries and butcher stores (<1%).

In large OFR shops (sales area 400 to 999 m^2), centralised refrigeration systems largely dominated GHG emissions with a share of 95% (0.86 kt CO_2eq). The marginal remaining share is constituted mainly by refrigerators and freezers plus stand-alone units, whereas heat pumps and split ACs together contributed less than 1%. In OFR shops with a sales area below 400 m^2, 60% of emissions are caused by centralised refrigeration systems (2.73 kt CO_2eq), whilst 20% are caused by stand-alone units (0.81 kt CO_2eq). Condensing units as well as refrigerators and freezers caused 8% of total RACHP emissions each. Split ACs and heat pumps contributed less than 5% to the total RACHP emissions.

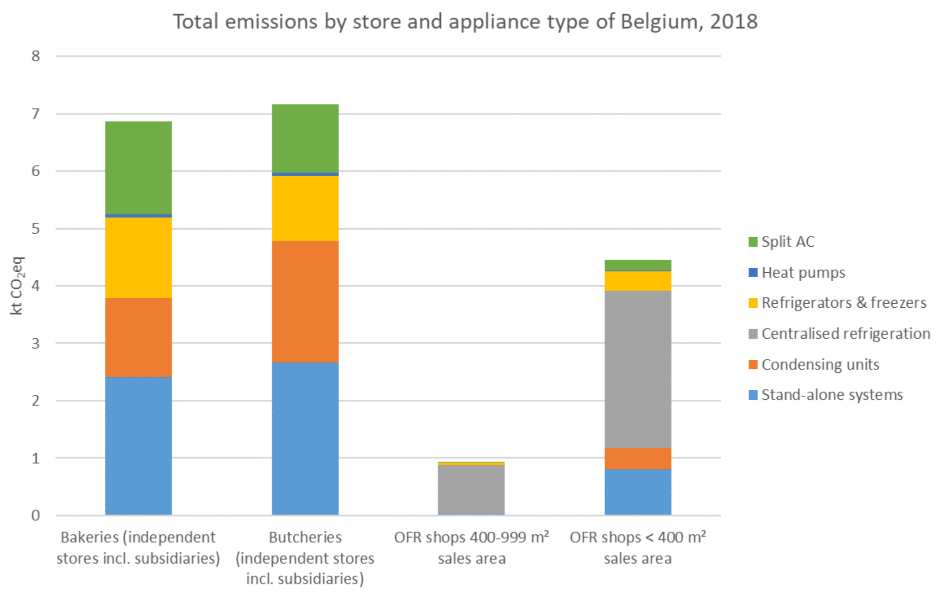

Figure 4-16: Total RACHP emissions of selected small food retail store types in Belgium by store and appliance type in 2018.

Figure 4-17 shows the cumulative emission reduction potential of small food retail in Belgium by store and appliance type from 2021 to 2025. The cumulative reduction potential results from the difference between the projected RACHP GHG emissions under the BAU scenario and the respective emissions projected under the MIT scenario.

Model predictions show the greatest emissions saving potential for conventional supermarkets, followed closely by conventional superettes and other specialised food shops (incl. farm shops). Within these store types, centralised refrigeration systems offer the largest reduction potential with a share of around 70 to 80% of total emission reduction potential. The second largest emission reduction potential within the mentioned store types is attributed to stand-alone units with a share of 10 to 15%.

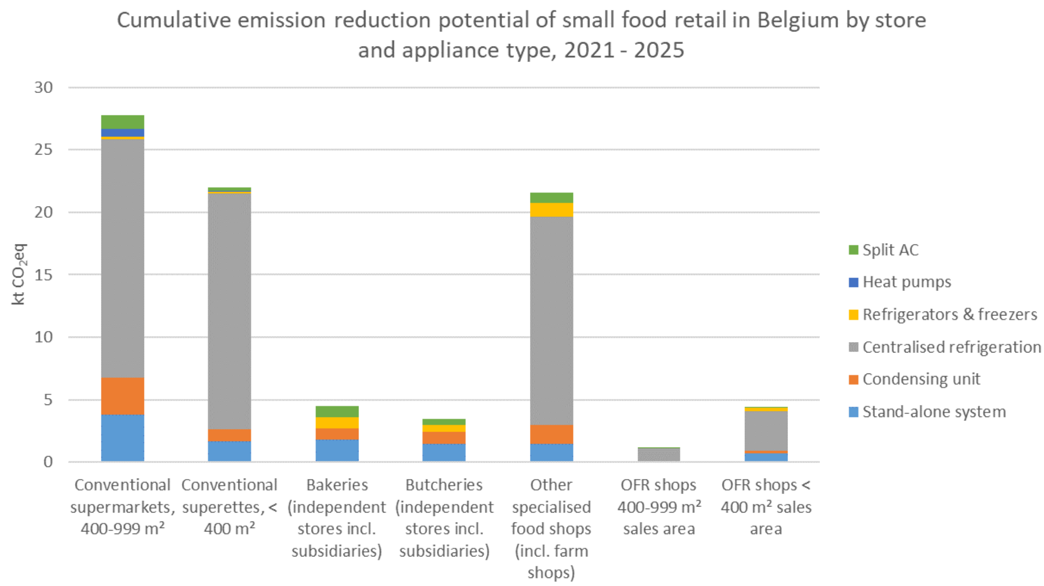

Figure 4-17: Projected cumulative RACHP-related emission reduction potential in Belgium's small food retail by store and appliance type from 2021 to 2025.

Figure 4-18 illustrates the projected RACHP emission reduction potential of bakeries, butcher stores and OFR shops within Belgium. The greatest projected emission reduction potentials within this closer selection of store types was identified for bakeries and OFR shops with a sales area below 400 m², both approximating 4.5 kt CO_2 eq within the 5-year time period. Stand-alone systems are most important for GHG emission reductions in bakeries and butcher stores with a share of 40 to 60% of the total reduction potential. For OFR shops, centralised refrigeration systems have the largest emission reduction potential, adding up to more than 95% of the total emission reduction potential for large OFR shops (sales area 400 to 999 m²) and around 80% for small OFR shops.

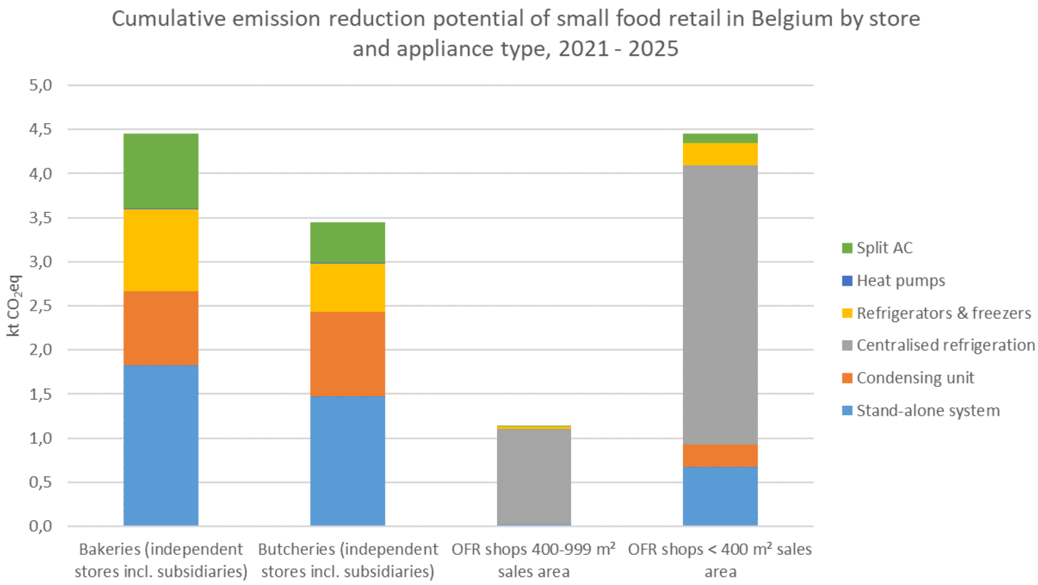

Figure 4-18: Projected cumulative RACHP emission reduction potential of selected small food retail store types in Belgium by store and appliance type from 2021 to 2025.

4.3.3.4.2 RACHP-related energy consumption

Figure 4-19 shows the total RACHP-related energy consumption of small food retail in Belgium by store and RACHP appliance type in 2018. The store type is shown on the x-axis and the appliance type is represented by the applied colour scheme. Conventional small supermarkets consumed by far the greatest amount of energy, followed by other specialised food shops and conventional superettes in a comparable medium range. Centralised refrigeration systems consumed the greatest amount of energy within conventional small supermarkets (75% of total energy consumption for RACHP use), superettes (60%) and other specialised food shops (45%). The general trend showing a mutual relationship between centralised refrigeration systems and autonomous appliances, particularly stand-alone systems, is well pronounced across the different store types: the smaller the store size, the greater the role of stand-alone systems, and vice versa. This relation can be observed by comparing conventional small supermarkets with superettes, or by comparing both OFR store size categories in the subsequent illustration. Figure 4-20 analyses the further store types which are characterised by an overall lower energy consumption.

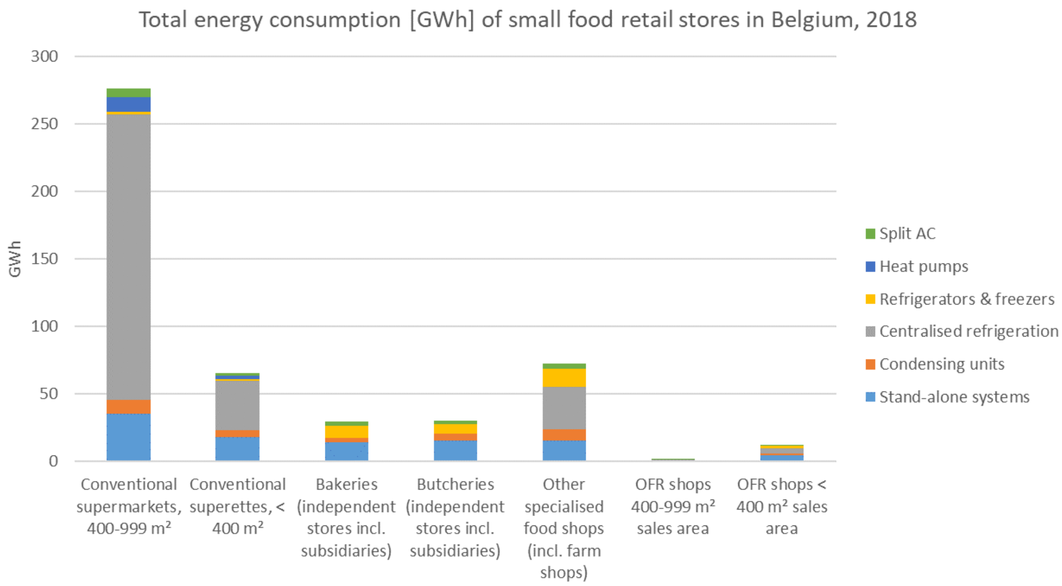

Figure 4-19: Total RACHP-related energy consumption of small food retail in Belgium by appliance and store type in 2018.

A deeper insight into less energy-consuming stores (bakeries and butcher stores as well as OFR shops) is depicted in Figure 4-20 in which centralised refrigeration systems are assumed to play no role. These store types consumed about half of their RACHP-related energy by stand-alone systems, followed by refrigerators and freezers with less than 30%. Centralised refrigeration systems were responsible for over 95% of the RACHP energy consumption of large OFR shops (sales area between 400 and 999 m^2). For small OFR shops, most of the energy was consumed by stand-alone systems (40%), followed by centralised refrigeration (30%).

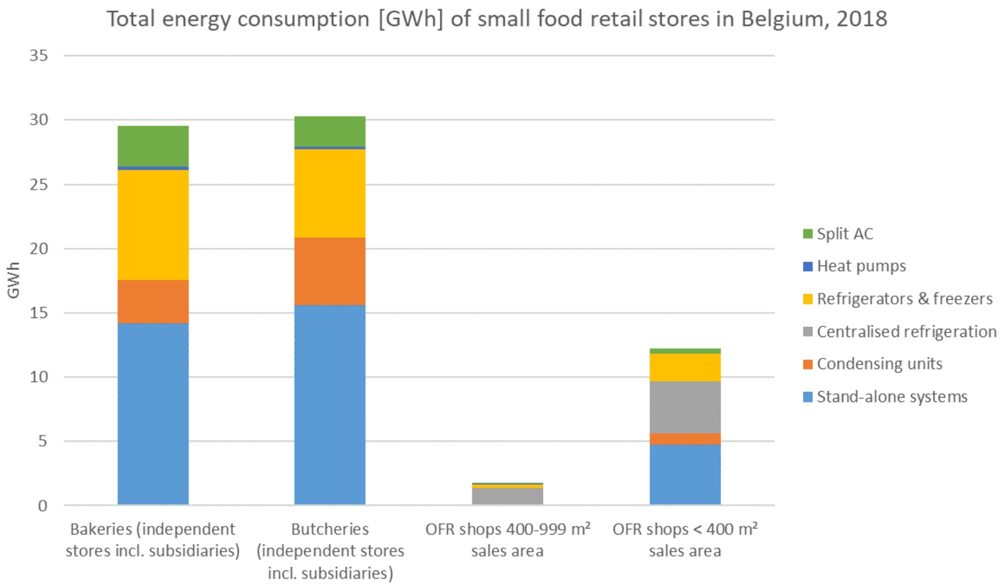

Figure 4-20: Total RACHP-related energy consumption of selected small food retail stores in Belgium by store and appliance type in 2018.

The cumulative energy reduction potential for the years 2021 to 2025 is shown in Figure 4-21. The store type is shown on the x-axis and the appliance type is indicated by the colours used within the columns in the diagram. With the underlying assumptions, stand-alone systems show the largest energy reduction potential with a share ranging between 45 and 60% for the time period from 2021 to 2025 for all small food retail store types except large OFR shops. Centralised refrigeration systems offer the second largest energy reduction potential for conventional small supermarkets (32% of total RACHP emissions per store type) and superettes (18%).

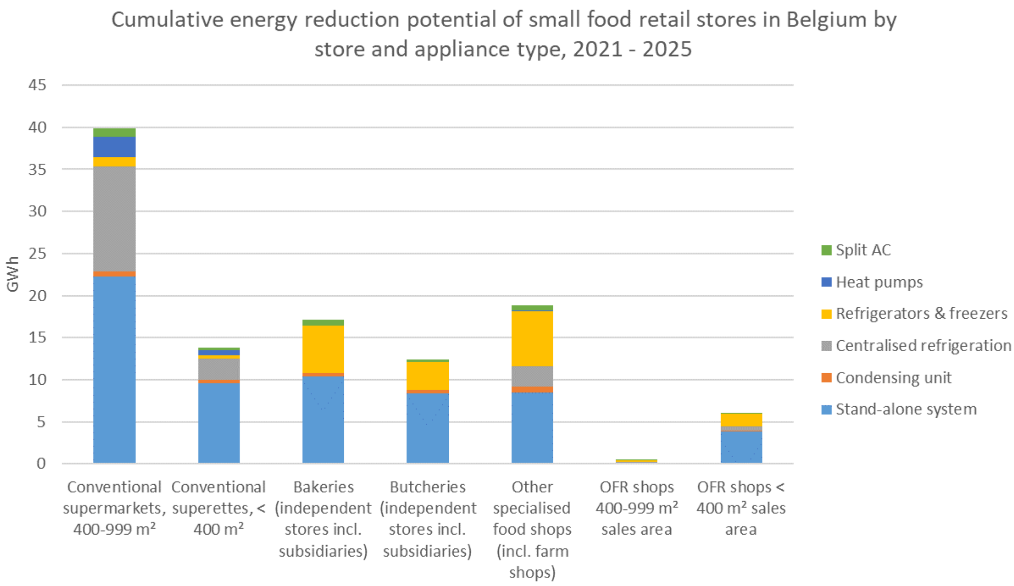

Figure 4-21: Projected cumulative RACHP-related energy reduction potential of small food retail in Belgium by store and appliance type from 2021 to 2025.

For the small, less energy-consuming store types (bakeries, butcher stores, other specialised food shops (incl. farm shops) and OFR shops), the reduction potential is shown in Figure 4-22. Besides the dominant role of stand-alone systems, the second largest energy reduction potential could be achieved by refrigerators and freezers (around 30%), leaving only marginal energy saving potential to other appliance types. As discussed in the prior figure, further energy saving potential by centralised refrigeration systems is still relevant for other specialised food shops, mainly due to their usage in farm shops.

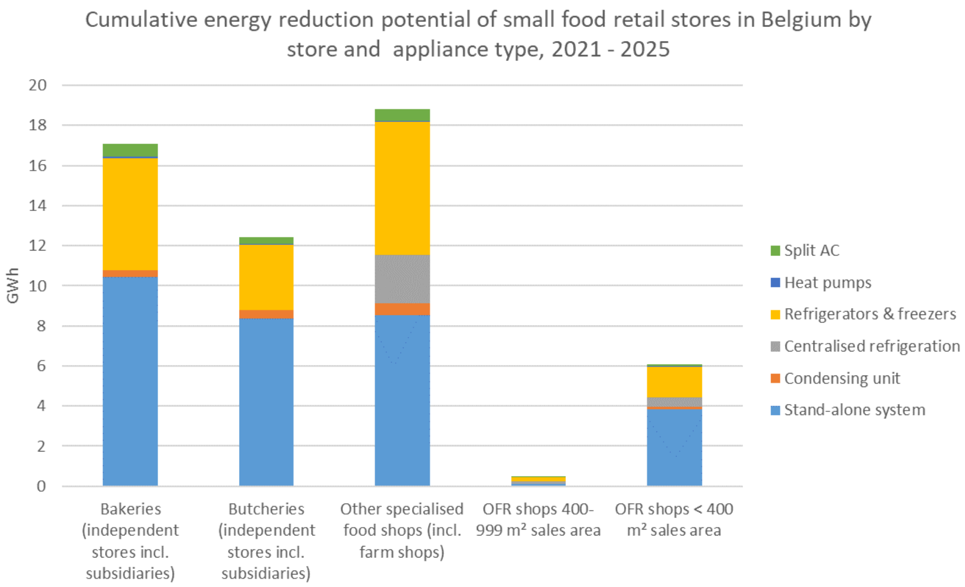

Figure 4-22: Projected cumulative RACHP-related energy reduction potential of selected small food retail stores in Belgium from 2021 to 2025.

4.3.3.4.3 HFC consumption

The figure below shows the total HFC refrigerant consumption of small food retail in Belgium by store and appliance type in 2018. Due to their high refrigerant charges centralised refrigeration systems consumed the most HFC refrigerant with shares ranging between 80% and 90% for different store types (except for bakeries and butcher stores which are assumed not to use this appliance type). This was followed by marginal shares of split ACs and condensing units. Because of their comprehensive utilisation in large equipment dimensions, most of the HFC was consumed by conventional small supermarkets. Conventional superettes and other specialised shops (incl. farm shops) follow in a medium range, while all other store types have a marginal HCF consumption.

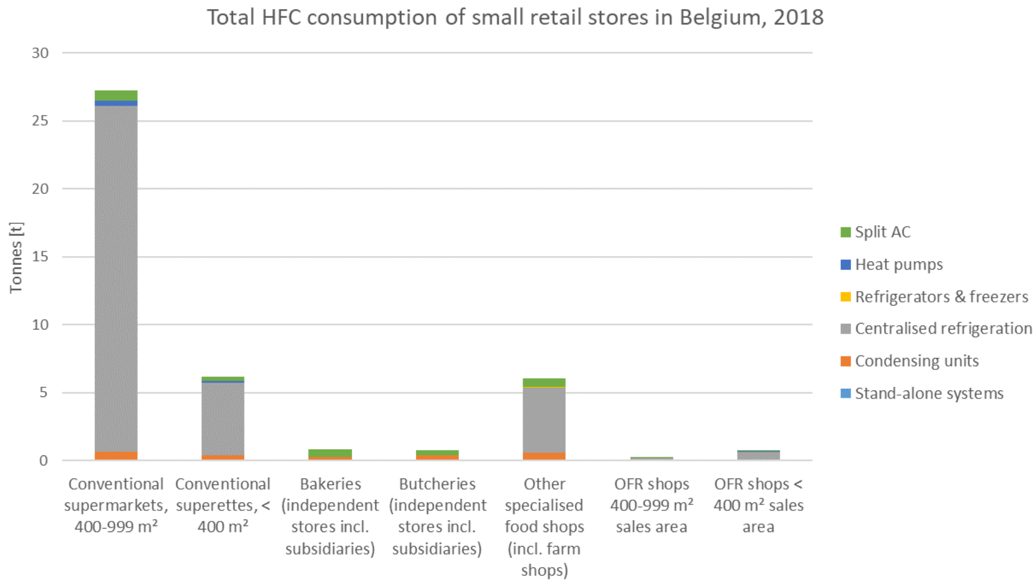

Figure 4-23: Total HFC refrigerant consumption of small food retail in Belgium by store and appliance type in 2018.

Figure 4-24 gives a better insight into the HFC refrigerant consumption of bakeries, butcher stores and OFR shops. Also due to their relatively low number of stores, large OFR stores (400 to 999 m² sales area) consumed less than 200 kg of HFC refrigerant in 2018, 99% of which was used for centralised refrigeration systems. Each of the other store types consumed around 750 to 800 kg of HFC refrigerant in 2018. Split ACs were identified as the main consumers of HFC refrigerant in bakeries (67% of total HFC consumption per store type) and butcher stores (50%), followed by condensing units which left only marginal shares to other appliance types. Besides their dominant usage for centralised refrigeration systems (82%), small OFR shops (sales area < 400 m^2) consumed HFC refrigerant mainly for split ACs and condensing units (share of ca. 8% each).

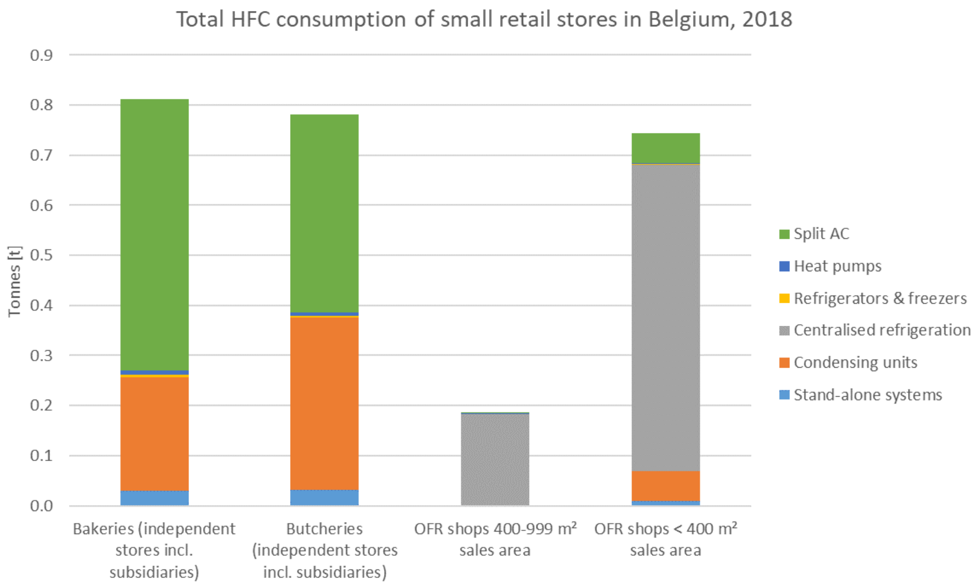

Figure 4-24: Total HFC consumption of selected small food store types in Belgium in 2018.

Figure 4-25 shows the cumulative reduction potential of HFC refrigerant consumption, which results from the difference between the projected BAU HFC consumption and the respective MIT HFC consumption for each store and appliance type between 2021 and 2025. Conventional small supermarkets have the greatest potential to reduce their HFC consumption, followed by other specialised food stores (incl. farm shops) and conventional superettes. All of these store types have the greatest potential for reducing HFC consumption in centralised refrigeration, due to the comprehensive usage of this appliance type.

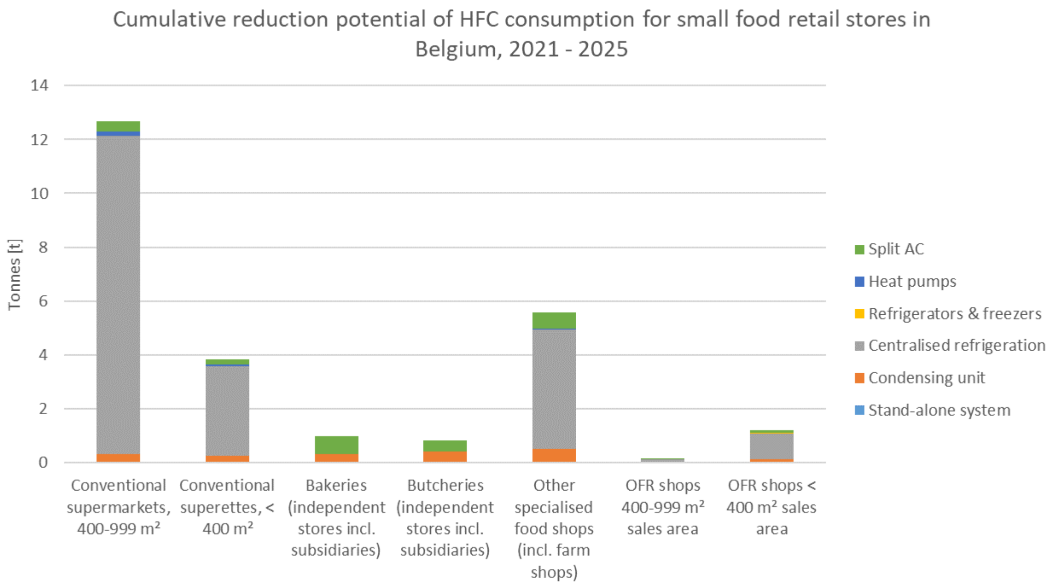

Figure 4-25: Projected cumulative reduction potential of HFC consumption for small food retail in Belgium by store and appliance type from 2021 to 2025.

Figure 4-26 shows the cumulative reduction potential of HFC refrigerant consumption specifically for bakeries, butcher stores and OFR shops in Belgium from 2021 to 2025. Bakeries and butcher stores show the greatest reduction potential of HFC consumption within the usage of split ACs, followed by condensing units. The largest reduction potential for OFR shops is associated with centralised refrigeration systems. At a relatively low range, further reduction potential for HFC consumption can be exploited by split ACs and condensing units for small OFR shops (sales area below 400 m²).

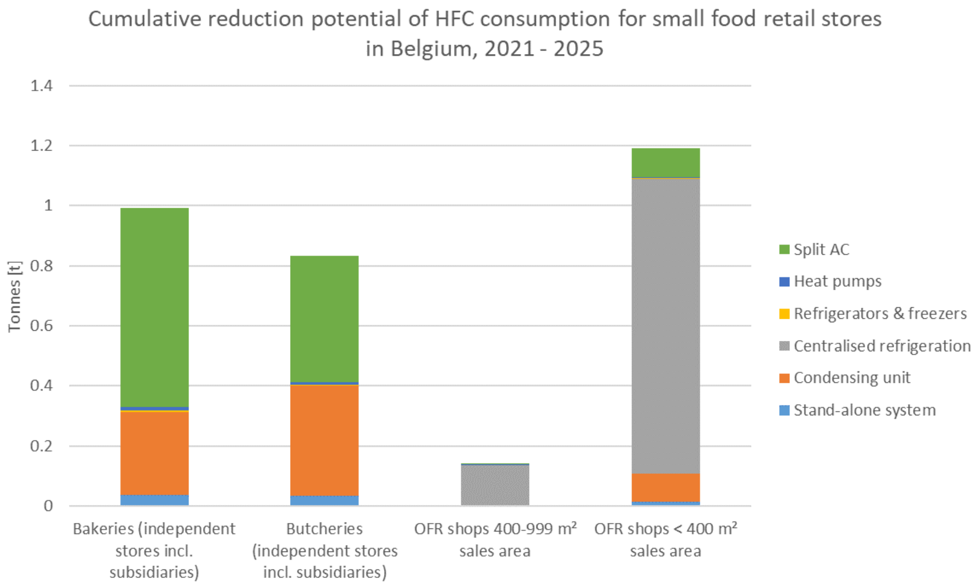

Figure 4-26: Projected cumulative reduction potential of HFC consumption for selected small food retail stores in Belgium from 2021 to 2025.

4.3.3.5 Germany

4.3.3.5.1 RACHP-related GHG emissions

In the following figure, the distribution of GHG emissions in Germany's small food retail caused by the operation of RACHP appliances in 2018 is shown by store type up to 1000 m² sales area (Figure 4-27). With 75% of total RACHP-related emissions, the largest amount was emitted by conventional small supermarkets (sales area 400 to 999 m²). 12% of the total RACHP emissions were emitted by other specialised food shops, which in the case of Germany consist exclusively of farm shops. Bakeries (5%), butcher stores (3%) and conventional superettes (2%) were responsible for minor shares of the total RACHP emissions. Each OFR store type emitted ca. 1% of the total GHG emissions.

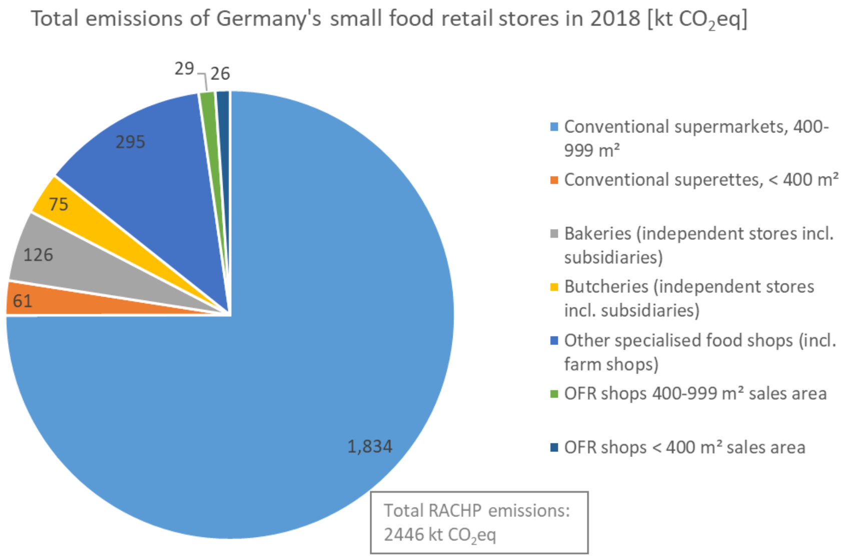

Figure 4-27: Total GHG emissions caused by operating RACHP equipment in small food retail stores in Germany.

Figure 4-28 presents the total GHG emissions by RACHP appliances in 2018 for the selected store categories in Germany's small food retail, whereas the column to the right summarises the store types bakeries, butcher stores and OFR shops due to their relatively low shares of total RACHP emissions. The RACHP appliance types are distinguished by different colours within the columns. The store types are displayed on the x-axis. As this figure clearly indicates, centralised refrigeration systems had by far the largest share of total emissions for conventional small supermarkets with a share of around 85%, and also dominate the RACHP emissions by other specialised food shops (i.e. farm shops) with a share of around 60%. Within the combined category bakeries, butcher stores and OFR shops, centralised refrigeration systems had a relatively low share of total emissions with around 17%, contributed only by farm shops since bakeries and butcher stores are assumed to not use any centralised refrigeration systems. Stand-alone units had the largest share of emissions in bakeries, butcher stores and OFR shops with 40 %. Within other specialised food shops each further appliance type (stand-alone units, condensing units and refrigerators and freezers) emitted around 10% of the store type's total GHG emissions. For conventional small supermarkets, stand-alone systems were the second largest emitters with a share of around 6%. Condensing units, refrigerators and freezers, heat pumps and split AC units had a marginal share of the total GHG emissions with less than 5%.

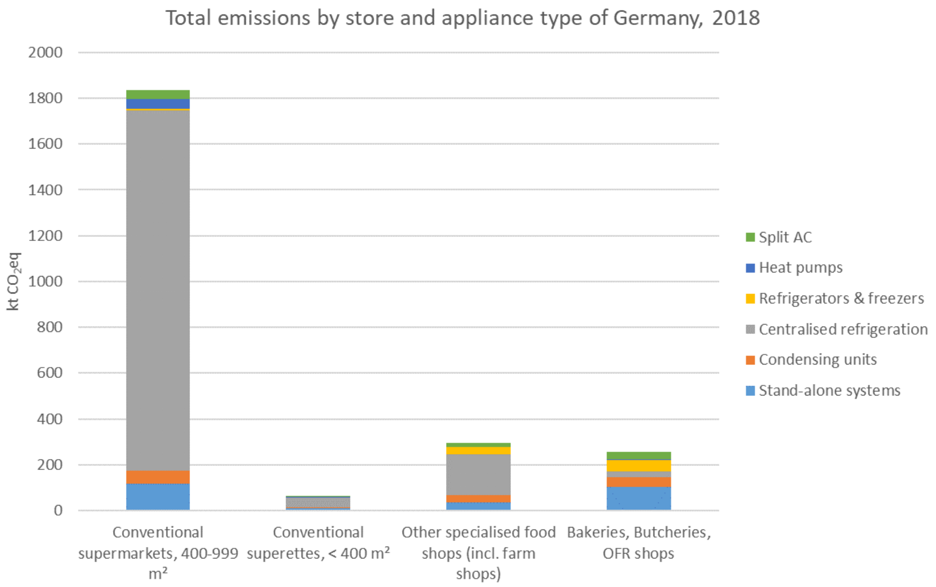

Figure 4-28: Total RACHP emissions by store and appliance type of the German small food retail sector in 2018.

Figure 4-29 shows the total RACHP emissions of small food retail for selected store types (conventional superettes, bakeries, butcher stores and OFR shops) in 2018. As centralised refrigeration systems are not used, stand-alone systems had the largest share of total RACHP emissions of bakeries and butcher stores (around 40%). Refrigerators and freezers as well as condensing units reached further significant shares (in the range of 20%), followed by split ACs (around 15%) in bakeries and butcher stores. Heat pumps contributed marginal amounts of the total emission within bakeries and butcher stores (<1%).

Regarding OFR shops, centralised refrigeration systems dominated total RACHP emissions with shares of 55% and 40% for large OFR shops (sales area between 400 and 999 m^2) and small OFR shops (sales area below 400 m^2), respectively. Stand-alone units ranked second with 25% and 30% of total RACHP emissions in large and small OFR shops, respectively. Still, condensing units contributed 16%, refrigerators and freezers 8% of the total RACHP emissions in small OFR stores. Split ACs and heat pumps contributed less than marginal shares (up to 2%) to the total GHG emissions of small OFR shops. Concerning large OFR stores, the minor remaining shares split into larger contributions by heat pumps (6%) and split ACs (5%), while refrigerators and freezers (4%) and condensing units (2%) played a marginal role.

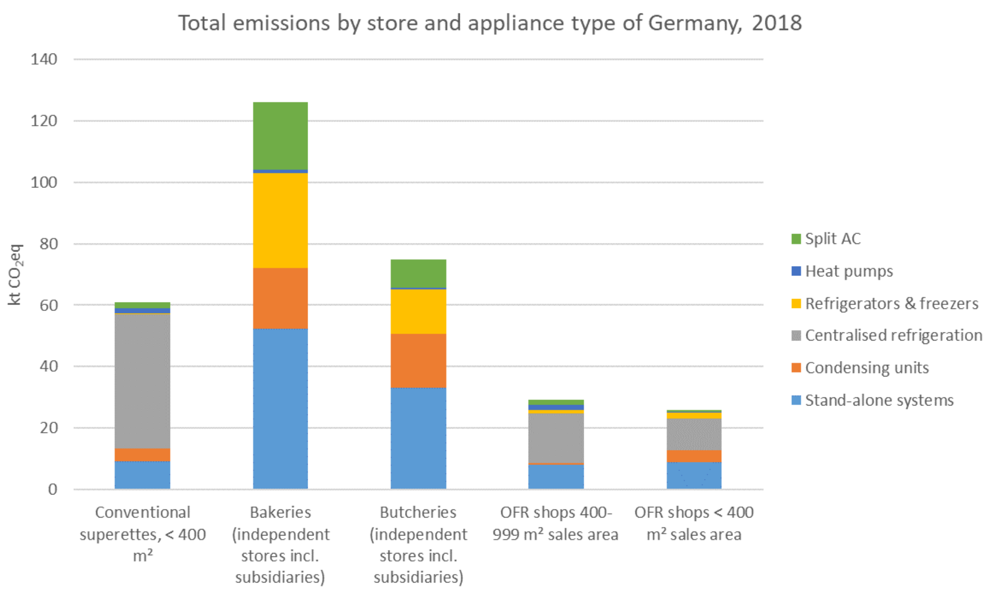

Figure 4-29: Total RACHP emissions of selected small food retail store types in Germany by store and appliance type in 2018

Figure 4-30 illustrates the cumulative RACHP-related emission reduction potential of small food retail in Germany by store and appliance type from 2021 to 2025. Model predictions indicate the greatest RACHP emissions saving potential for conventional small supermarkets followed by other specialised food shops (i.e. farm shops) which might be underestimated due to lack of or uncertainty in the quantification of specialised stores other than farm shops (e.g. fish shops, cheese/deli shops). For conventional small supermarkets and farm shops, centralised refrigeration systems offer the largest reduction potential with a share of around 60% to 70% of the total projected RACHP emission reduction potential by the respective store type. Stand-alone systems demonstrate significant additional mitigation potential (up to 23% for conventional small supermarkets), besides some additional mitigation potential by refrigerators and freezers for farm shops (both in the range of 10 to 15%). The remaining store categories present lower emission mitigation potentials in a relatively close range and will be analysed in more depth in the following figure.

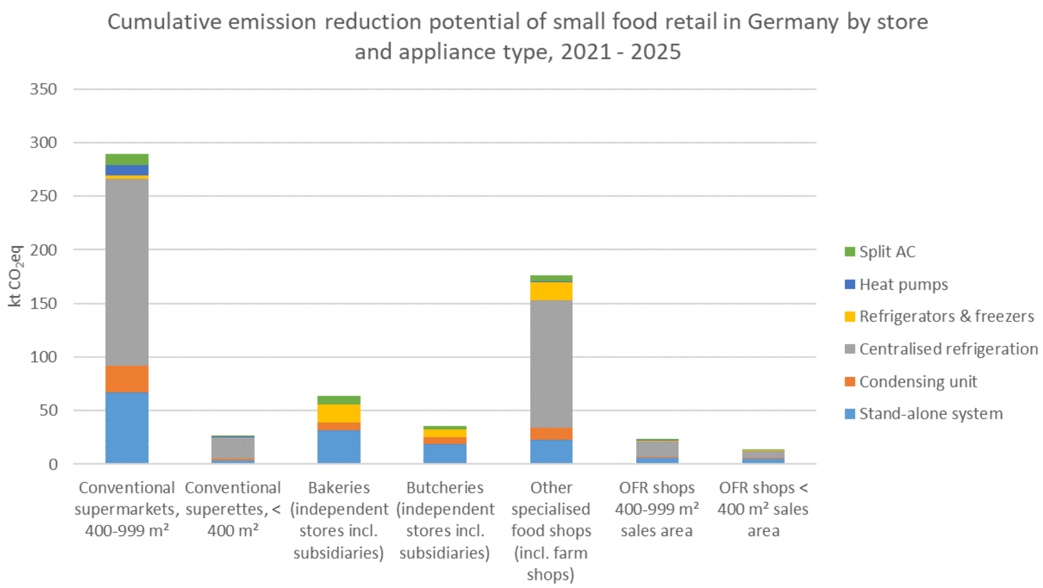

Figure 4-30: Projected cumulative RACHP emission reduction potential of small retail in Germany by store type and appliance type from 2021 to 2025.

Figure 4-31 presents the projected RACHP emission reduction potential of conventional superettes, bakeries, butcher stores and OFR shops. Within this closer selection of store types, bakery stores stand out with the greatest emission mitigation potential (64 kt CO_2eq). In the medium range, a group of store types constituted by butcher stores, conventional superettes and large OFR shops (400 to 999 m² of sales area) offering mitigation potential between 24 and 35 kt CO_2eq, followed by small OFR stores (< 400 m²) with 14 kt CO_2eq of mitigation potential.

For bakery and butcher stores, stand-alone systems demonstrate the greatest emission reduction potential with shares from 50% to 53% of total RACHP emission mitigation potential per store type, followed by refrigerators and freezers with 26% and 20%, respectively. Concerning bakeries, condensing units and split ACs provide another 12% share each. For butcher stores, condensing units (17%) dominate over split ACs (9%). Mitigation potentials associated with heat pumps are marginal for these store types. Regarding OFR stores, centralised refrigeration systems offer the largest RACHP emission reduction potential both for large OFR stores (63%) and small OFR stores (46%). For both size categories, stand-alone systems rank second, but have a higher share in small OFR stores (35%) compared to large OFR stores (26%). With regard to small OFR stores, recognisable additional emission mitigation potentials are attributed to condensing units (10%) and refrigerators and freezers (7%). Additional emission mitigation potentials beyond the key appliances are marginal for large OFR stores including not only heat pumps and split ACs but also refrigerators and freezers and condensing units (all between 2 and 3% shares of total mitigation potential by the store type).

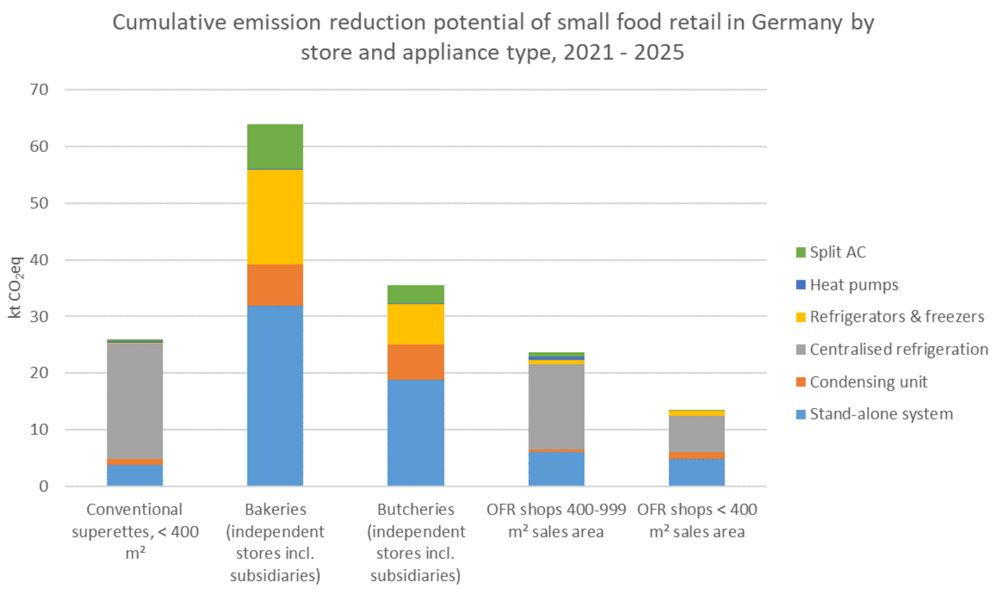

Figure 4-31: Projected cumulative RACHP emission reduction potential of selected small food retail store types in Germany by store and appliance type from 2021 to 2025.

4.3.3.5.2 RACHP-related energy consumption

Figure 4-32 shows the total RACHP energy consumption of small retail in Germany by store and appliance type in 2018. The store type is shown on the x-axis and the appliance type is represented by the applied color scheme. The largest amount of energy associated with the operation of RACHP equipment was consumed by conventional small supermarkets, followed by other specialised food shops (i.e. farm shops) and bakeries by a factor of 5. Except for bakery and butcher stores, centralised refrigeration systems dominated within total RACHP-related energy consumption, thereby reaching shares in the range of 75% for conventional small supermarkets, and still more than half of the total for conventional superettes, followed by other specialised food shops (43%) and lowest relevance for OFR shops (from 24% to 37%) where stand-alone systems are the leading energy consumer out of all RACHP appliances. The general trend of mutual relationship between centralised refrigeration systems and autonomous appliances, particularly stand-alone systems, is well pronounced across the different store types: the smaller the store size, the greater the role of stand-alone systems, and vice versa. The less energy consuming store types are analysed in more detail in the following figure, not including conventional small supermarkets and farm shops.

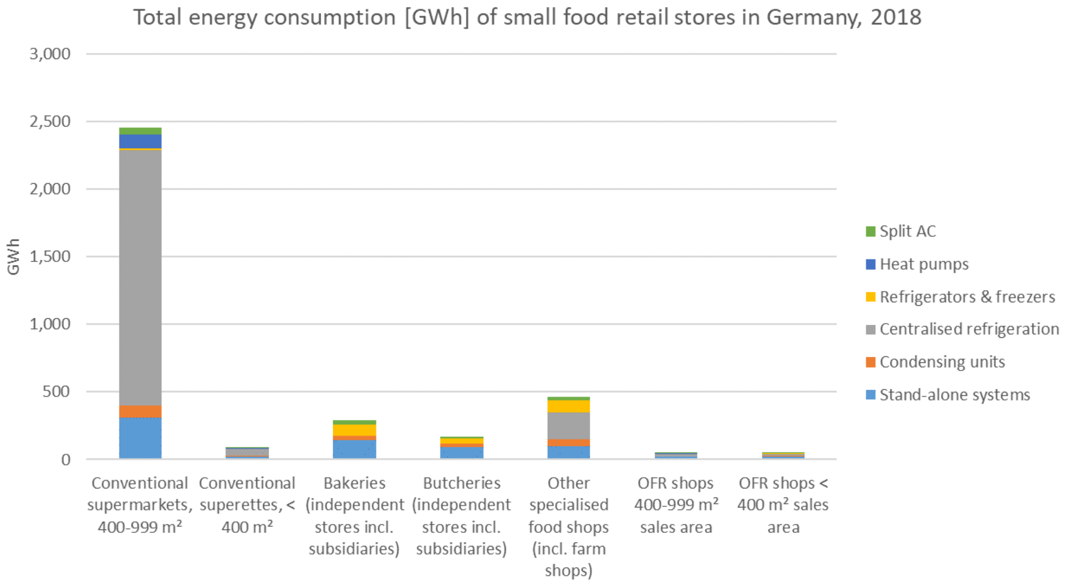

Figure 4-32: Total RACHP related energy consumption [GWh] of small food retail in Germany by appliance and store type in 2018.

Figure 4-33 shows an exclusive illustration of RACHP energy consumption by the less consuming store types within Germany's small food retail in 2018. According to the overall assumption, centralised refrigeration systems were not relevant within bakeries and butcher stores in Germany. For these store types, about half of the RACHP-related energy was consumed by stand-alone systems, followed by refrigerators and freezers (around 25%). Condensing units consumed comparable amounts of energy in bakery and butcher stores, but given the difference in total RACHP energy consumption, they reached a greater share of butcher stores (16%) compared to bakeries (11%).

Regarding the OFR market segment, stand-alone systems consumed almost half of the total RACHP-related energy (43% in large OFR stores, 49% in small OFR stores), followed by still significant contributions from centralised refrigeration systems (shares of 37% in large OFR, 24% in small OFR stores). In small OFR shops, condensing units (13%) and refrigerators and freezers (11%) contributed recognisable further shares to total RACHP energy consumption, leaving marginal amounts to the remaining RACHP appliances (2% by split ACs, 1% by heat pumps). In large OFR shops, shares by further RACHP appliance types of total RACHP energy consumption stayed below 10% (led by heat pumps with 8%, refrigerators and freezers with 6%, split ACs 4%, condensing units 2%).

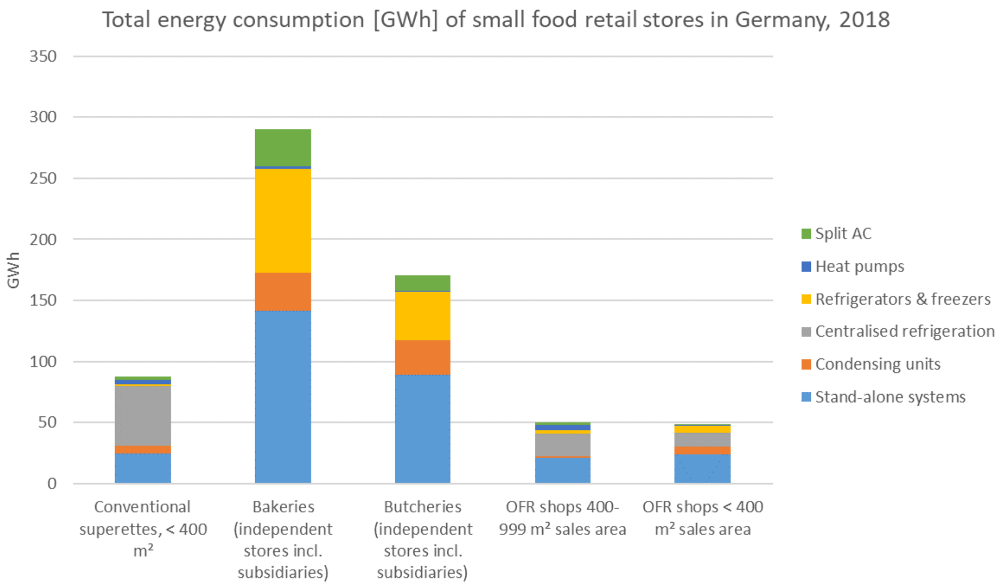

Figure 4-33: Total RACHP-related energy consumption of selected small food retail stores in Germany by store and appliance type in 2018.

Figure 4-34 shows the projected cumulative energy reduction potential by RACHP appliances in Germany's small food retail for the years 2021 to 2025. Store types are shown on the x-axis and the appliance type is indicated by the colour scheme within the columns in the diagram. Stand-alone systems show the greatest energy reduction potential, contributing about half of the total energy saving potential associated to RACHP equipment for conventional small supermarkets and other specialised food shops (i.e. farm shops). Stand-alone systems contribute even higher shares for the remaining store categories (ranging between 60% and 76%). These store types will be analysed in more detail in the subsequent figure. With a share of 30%, centralised refrigeration systems demonstrate the second largest RACHP energy saving potential (for conventional small supermarkets, and this appliance type offers a share of 13% for farm shops. For the latter store type, refrigerators and freezers rank second (35%) in their share of total RACHP energy saving potential.

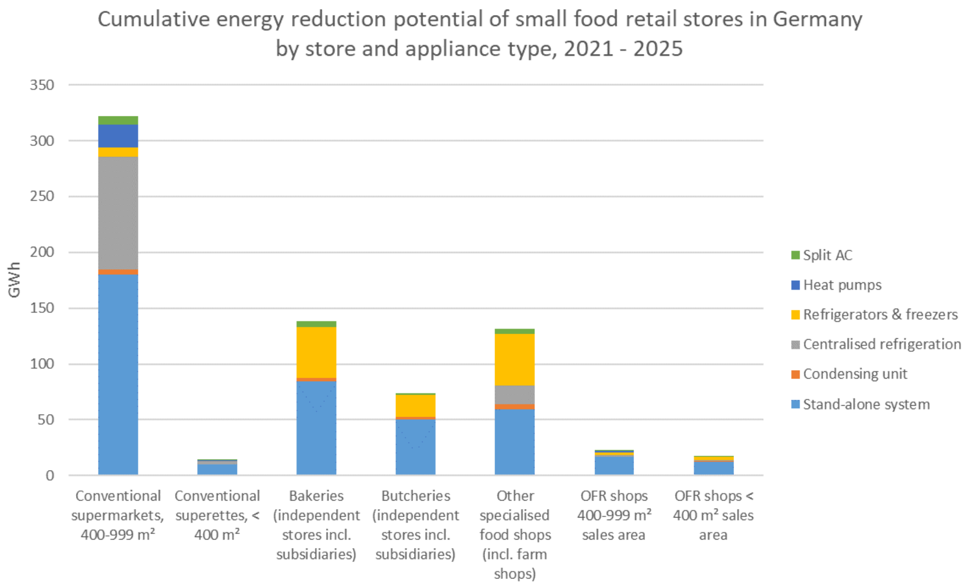

Figure 4-34: Projected cumulative RACHP related energy reduction potential of small food retail in Germany by store and appliance type from 2021 to 2025.

For the exclusive selection of small, less energy-consuming store types (conventional superettes, bakeries, butcher stores and OFR shops), the cumulative RACHP-related energy reduction potential from 2021 to 2025 is shown in Figure 4-35. Stand-alone systems offer by far the greatest energy saving potential with shares from 60 to 70% for bakeries, butcher stores and superettes. For OFR shops, the energy saving potential reaches even shares around 75%. Except for superettes, the second largest energy reduction could be achieved by refrigerators and freezers ranging from 10 to 33%. For bakeries and butcher shops, refrigerators and freezers reach the upper end of this margin with at least 27% (butcher stores), leaving only marginal energy saving potential to other appliance types (up to 4% for split AC, up to 3% for condensing units. For OFR shops, refrigerators and freezers offer energy saving potential from 10% (large OFR stores) to 15% (small OFR stores). Here, centralised refrigeration systems (8% for large OFR, 5% for small OFR) and heat pumps (6%, for large OFR only) still offer recognisable energy saving potential. The share by the remaining RACHP appliance types are marginal in this market segment.

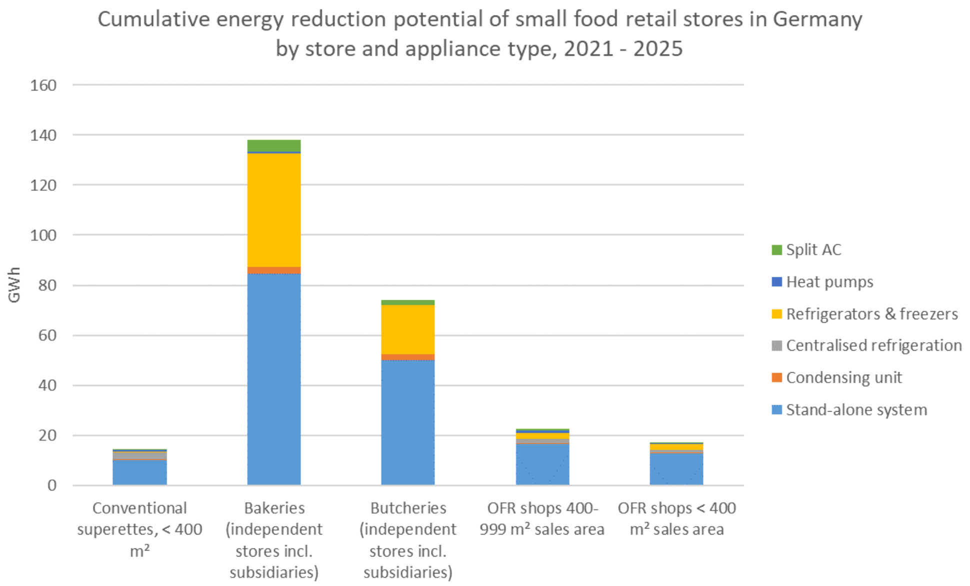

Figure 4-35: Projected cumulative RACHP-related energy reduction potential of selected small food retail stores in Germany from 2021 to 2025.

4.3.3.5.3 HFC consumption

Figure 4-36 shows the total consumption of HFC refrigerant in small food retail in Germany by store and appliance type in 2018. Most HFC was consumed by conventional small supermarkets, other specialised food shops (i.e. farm shops) and bakeries. Within supermarkets and other specialised food shops most HFC was consumed by centralised refrigeration with shares around 80% in specialised food shops and 90% in conventional small supermarkets, leaving relatively low shares by split ACs and condensing units.

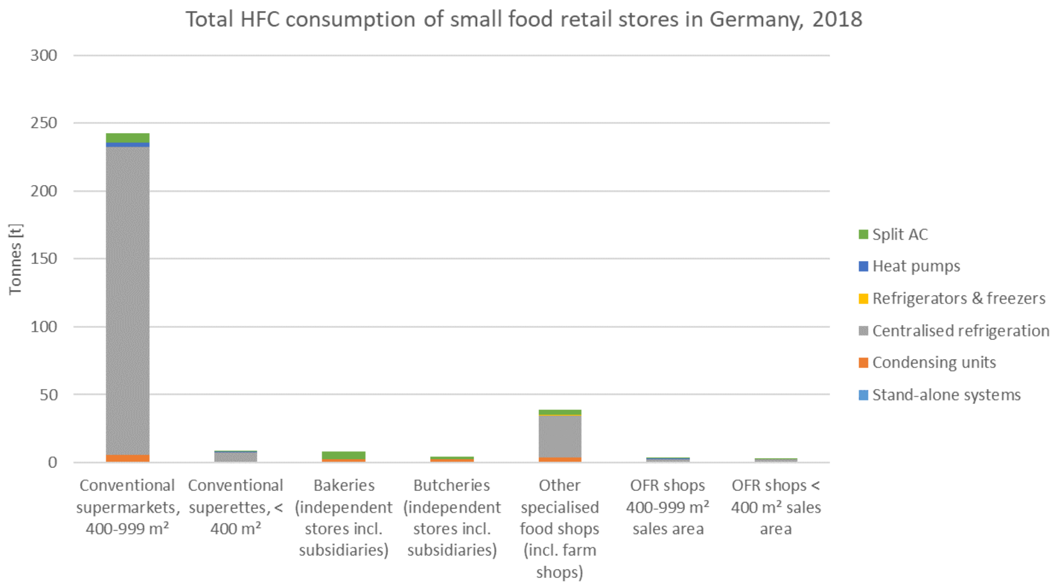

Figure 4-36: Total HFC consumption in Germany's small food retail by store and appliance type in 2018.

Figure 4-37 provides a selective overview of the RACHP-related consumption of HFC refrigerants by conventional superettes, bakeries, butcher stores and OFR shops. Both superettes and bakeries consumed around 8 tonnes of HFCs in 2018, followed by butcher stores with around 0.45 tonnes. Large OFR shops consumed around 3.2 tonnes of HFC refrigerant, small OFR shops approximately 2.5 tonnes. Within superettes and OFR shops, most HFC was consumed by centralised refrigeration ranging from 80 to 90% of the total

HFC consumption by each store category. Condensing units held most of the remaining share of HFC consumption in small OFR stores (ca. 20%) , leaving a minor share to Split ACs (ca. 10%) and a marginal share to refrigerators and freezers (<1%). In large OFR stores, Split ACs (10%) contributed most to the remaining share with minor contributions by heat pumps (around 1%) and condensing units (around 2%). Superettes demonstrate a blend between both OFR store categories, with relatively low shares by condensing units and split ACs (around 6% each) and a marginal share of heat pumps (around 2%). In bakery and butcher stores, split ACs were responsible for the largest amounts of HFC consumption (65% and 50% of store type total, respectively), followed by condensing units (25% and 40%, respectively). In contrast to the other store categories, bakeries and butcher stores also consumed HFC refrigerants in stand-alone systems at low but recognisable shares (< 5% each) of total HFC consumption per store type.

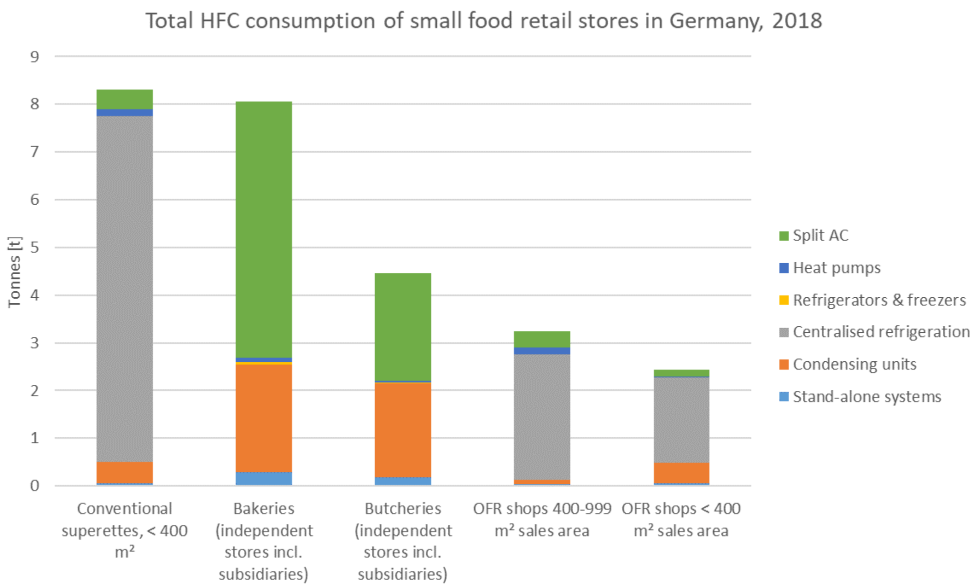

Figure 4-37: Total HFC consumption of selected small food retail store types in Germany in 2018.

Figure 4-38 shows the cumulative reduction potential of HFC consumption of Germany's small food retail stores from 2021 to 2025. By far, conventional small supermarkets have the greatest potential to reduce their HFC consumption, followed by other specialised food stores (i.e. farm shops). Centralised refrigeration systems demonstrate the greatest reduction potential of HFC consumption in conventional small supermarkets, superettes, other specialised food shops and OFR shops. Split ACs, followed by condensing units share a major reduction potential for HFC consumption in bakery and butcher stores. In the same order, both appliance types also bear most of the remaining reduction potential of HFC consumption in farm shops and conventional small supermarkets. In the subsequent figure, a closer look at the reduction potentials of store categories with lower HFC consumption is provided.

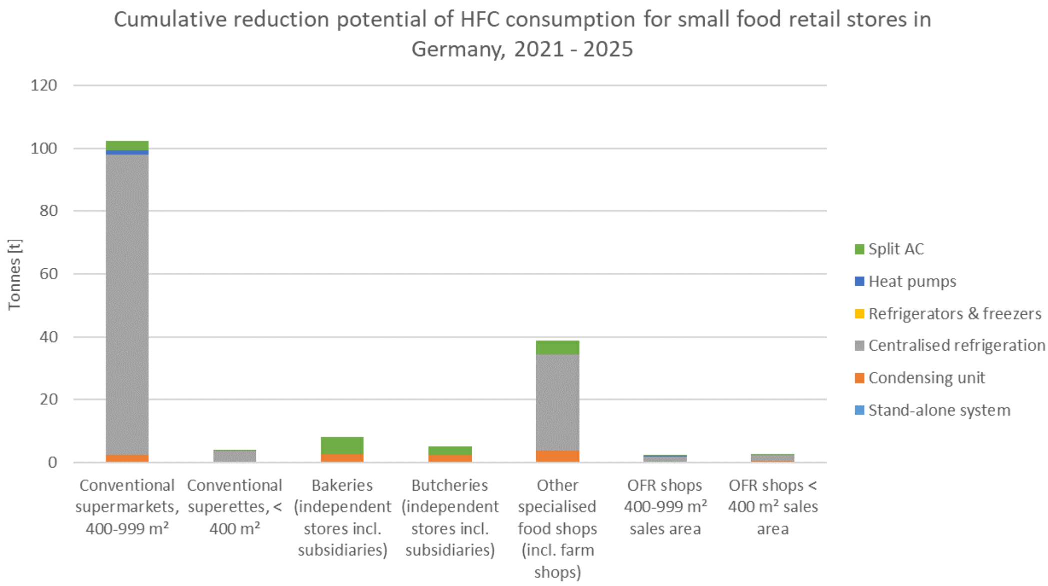

Figure 4-38: Projected cumulative reduction potential of HFC consumption for small food retail in Germany by store and appliance type

Figure 4-39 shows the cumulative reduction potential of HFC consumption within the closer selection of superettes, bakeries, butcher stores and OFR shops. Bakeries and butcher stores demonstrate the greatest reduction potential of HFC consumption. For bakeries, split ACs offer most of this potential (ca. 70% of total reduction potential by store type), followed by condensing units (ca. 30%). Both appliance types hold equal share of HFC reduction potential for butcher stores, leaving only a minor additional share by stand-alone systems (<5%). For the OFR shops, centralised refrigeration systems offer most of the reduction potential of HFC consumption ranging from 70 to 80%. Further significant reductions in HFC consumption can be obtained by condensing units represent in small OFR shops (ca. 20% of total potential), and by split ACs in large OFR shops (ca. 10%). Only marginal further reduction potentials for HFC consumption are represented by split ACs in small OFR shops (ca. 6%), as well as heat pumps (5%) and condensing units in large OFR shops (< 5%).

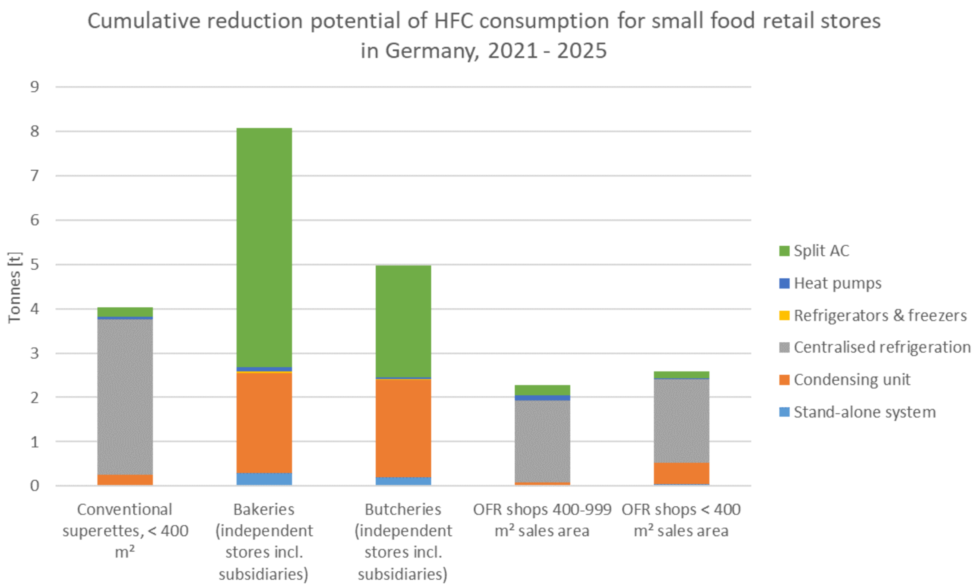

Figure 4-39: Projected cumulative reduction potential of HFC consumption [t] for selected small food retail stores in Germany from 2021 to 2025.

4.3.3.6 Netherlands

4.3.3.6.1 RACHP-related GHG emissions

In the following figure, the distribution of the Netherland's GHG emissions in the small food retail sector caused by operating RACHP appliances in 2018 is shown by store type up to 1000 m² sales area (Figure 4-40). RACHP emissions in the Netherland's small food retail sector were mainly caused by conventional small supermarkets (77%), followed other specialised food shops (including farm shops) which contributed around 9% to the total GHG emissions of 157 kt CO_2eq in the analysed market segment. Conventional superettes and bakeries were each responsible for 4 to 5% of total RACHP-related GHG emissions, followed by butcher stores and small OFR shops with a sales area below 400 m² (3% by each). Due to their low number (10 stores were identified), large OFR shops (sales area 400-999 m²) had marginal RACHP GHG emission shares in 2018 (<0.2%).

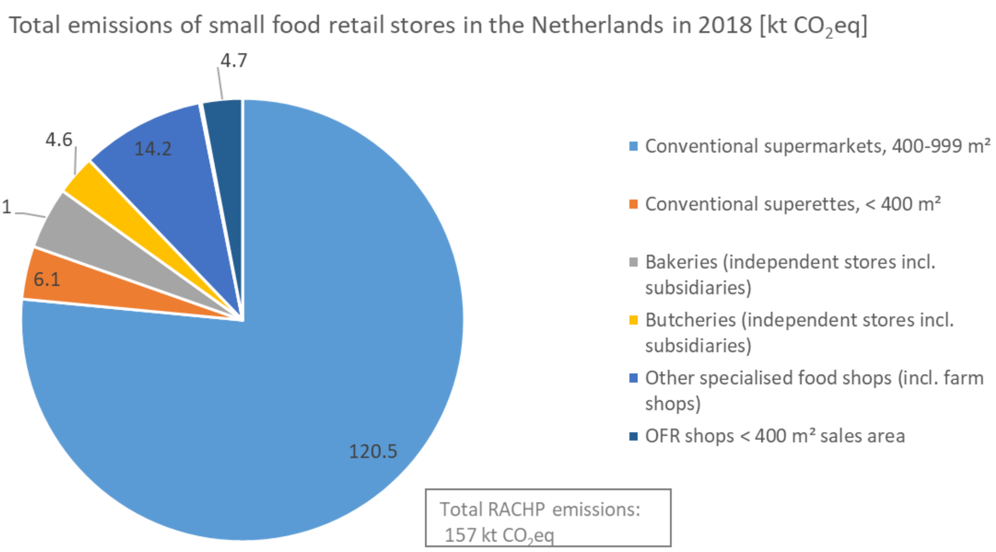

Figure 4-40: Total GHG emissions caused by operating RACHP equipment in small food retail stores in the Netherlands.

Figure 4-41 presents total GHG emissions by RACHP appliances in 2018 for small food retail in the Netherlands by store category, whereas the column to the right summarises the store types conventional superettes, bakeries, butcher stores and OFR shops due to their relatively low shares of total RACHP emissions in small food retail. RACHP appliance types are classified by different colours within the columns in the figure. The store types are displayed on the x-axis. Centralised refrigeration systems had by far the largest share of total RACHP-related emissions for conventional small supermarkets (around 83% of total per store type), superettes (ca. 51%) and other specialised food shops incl. farm shops (around 64%). RACHP emissions within the combined category bakeries, butcher stores and OFR shops are dominated by stand-alone systems (ca. 33%), with condensing units following close (22%), and centralised refrigeration systems, refrigerators and freezers as well as split ACs contributing further significant shares (around 15% each). These store categories as well as conventional superettes are analysed more in depth in the subsequent figure. For conventional small supermarkets, stand-alone systems and condensing units provided recognisable shares (6-7%), whereat refrigerators and freezers, heat pumps and split ACs had marginal shares (altogether less than 5% of total RACHP emissions by the store category). Within other specialised food shops, stand-alone systems and condensing units emitted each around 10% of the store's total RACHP emissions, with the remaining share split into 6-8% for refrigerators and freezers as well as split ACs.

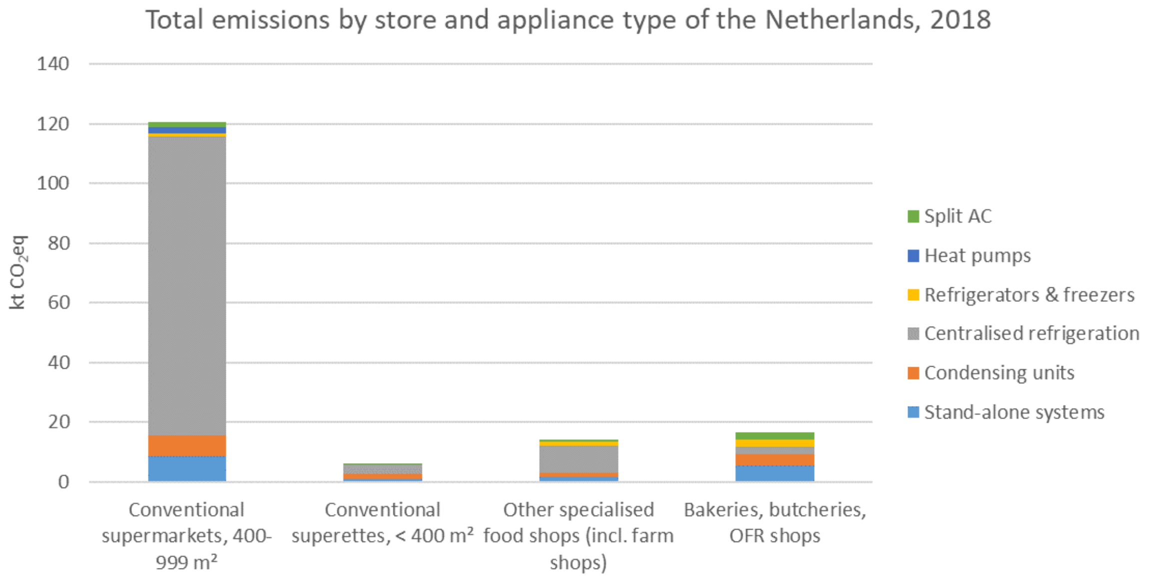

Figure 4-41: Total RACHP emissions [kt CO_2eq] by store and appliance type of the Dutch small food retail sector in 2018.

Figure 4-42 illustrates the RACHP-related emissions for the closer selection of conventional superettes, bakeries, butcher stores and OFR shops in 2018. With shares of 37-40% of total RACHP emissions for each store type, stand-alone systems had the largest share in bakeries and butcher stores where centralised refrigeration systems are assumed not to be used. For bakeries, the remaining emissions are divided into comparable ranges for split ACs, refrigerators and freezers and condensing units (around 20% share by each). For butcher stores, condensing units contributed a share of 27% to the total GHG emissions, followed by split ACs and refrigerator and freezers (16-17% each). Heat pumps caused by far the lowest amount of emissions in bakeries and butcher stores (1% for each). Centralised refrigeration systems were responsible for the greatest share of RACHP emissions in other specialised food shops (64%) and superettes (51%).

In small OFR shops (sales area below 400 m^2), about 48% of RACHP emissions were caused by centralised refrigeration systems with further notable contributions by condensing units and stand-alone units (around 22% each). Refrigerators and freezers (5%) and split ACs (3%) contributed minor shares of total RACHP emissions. With 83% of total RACHP emissions, large OFR shops were largely dominated by centralised refrigeration systems. Stand-alone systems contributed another 10%, leaving minor shares to heat pumps (4%), refrigerators and freezers and split ACs (both about 2%).

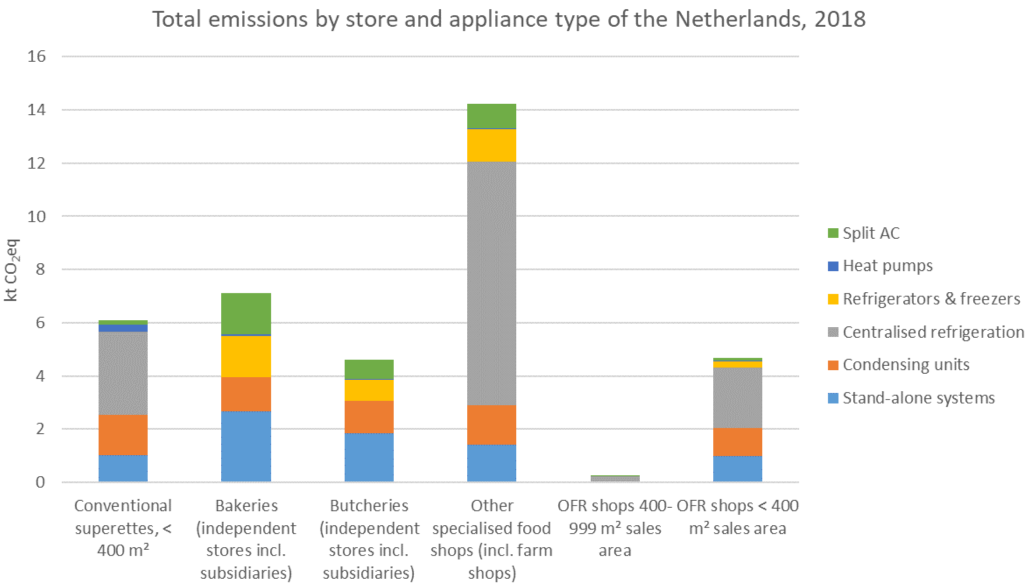

Figure 4-42: Total RACHP emissions of Dutch small food retail by store and appliance type in 2018.

Figure 4-43 illustrates the cumulative RACHP-related emission reduction potential of small food retail in the Netherlands by store and appliance type from 2021 to 2025.

Model predictions show the greatest potential for saving RACHP emissions in conventional small supermarkets followed by other specialised food shops (incl. farm shops). Within these store categories, centralised refrigeration systems demonstrate the largest reduction potential with shares of around 55% and 75%, respectively, with regard to total RACHP emission reduction potential of each store type. Stand-alone systems reach about 20% of the remaining share of total RACHP emission reduction potential for conventional small supermarkets, and approximately 10% for other specialised food shops. For both store categories, remaining shares contributed by refrigerators and freezers, heat pumps and split ACs are in low to marginal ranges (< 10% each). The same applies for the role of condensing units for the emission mitigation potentials in other specialised food shops, while this equipment type contributes about 15% to the total mitigation potential in small conventional supermarkets. The other store categories with relatively lower RACHP emission mitigation potential are discussed in the subsequent figure.

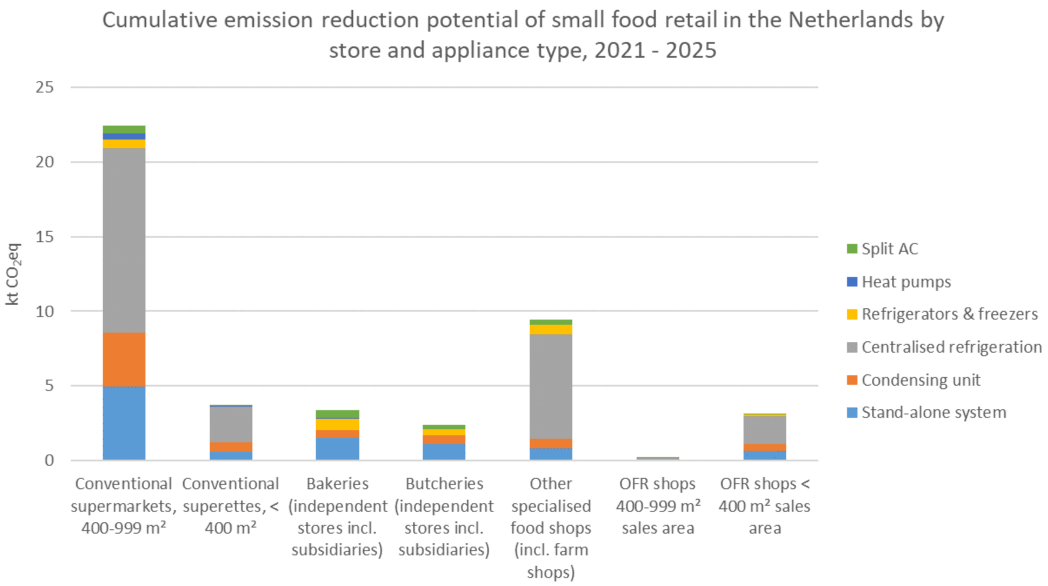

Figure 4-43: Projected cumulative RACHP emission reduction potential of small food retail in the Netherlands by store type and appliance type from 2021 to 2025.

Figure 4-44 shows the cumulative RACHP-related emission reduction potential of selected small food retail stores in the Netherlands (conventional superettes, bakeries, butcher stores as well as large and small OFR shops). Within this selection, the greatest RACHP emission mitigation potentials are projected for conventional superettes and bakeries, followed by small OFR shops (sales area below 400 m²). At medium range, butcher stores offer further significant mitigation potential, while large OFR stores (sales area 400-999 m²) contribute marginal saving potential, as very few such stores exist.

Within bakeries and butcher stores, stand-alone systems demonstrate the greatest RACHP emission reduction potential with shares of around 45% each. Condensing units as well as refrigerators and freezers present an RACHP emission reduction potential in the range of 15-25% each for both store types, followed by split ACs (ca. 15%). Heat pumps have a negligible share on the total emission reduction potential (< 1%), centralised refrigeration systems are assumed not to be relevant for both store types.

For conventional superettes and OFR shops of both sizes, centralised refrigeration systems demonstrate the greatest RACHP emission reduction potential with almost 90% in large OFR stores and shares in the range of 60-65% for conventional superettes and small OFR stores. In these two store categories, stand-alone systems as well as condensing units contribute to the total RACHP emission reduction potential with shares of around 15-20% each. The further RACHP equipment types refrigerators and freezers, split ACs and heat pumps (each < 5%) contribute marginally, same as for large OFR stores for which only stand-alone systems reach a significant contribution (> 5%) to the mitigation potential besides centralised refrigeration systems.

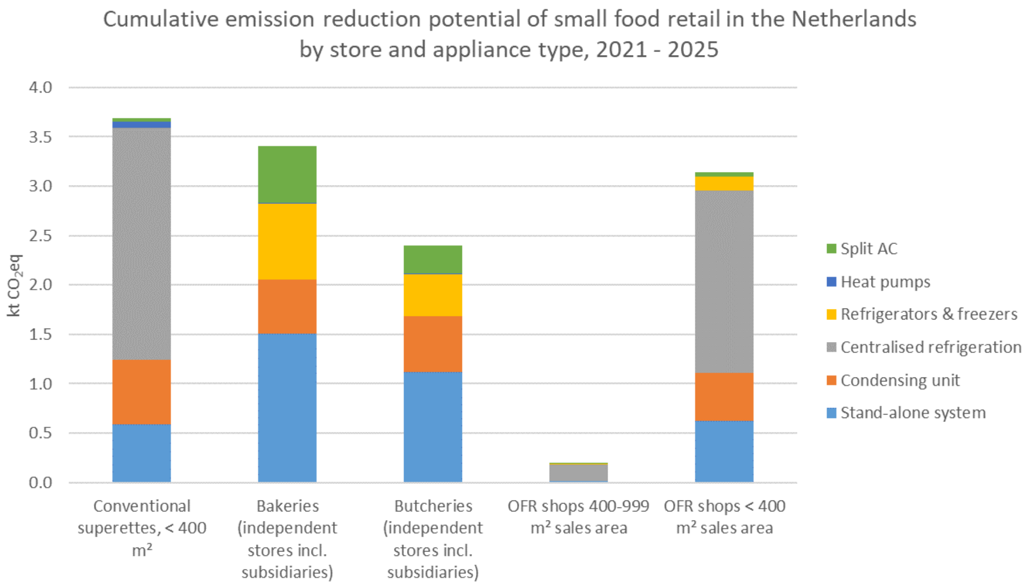

Figure 4-44: Projected cumulative reduction potential of RACHP emissions for selected small food retail stores in the Netherlands from 2021 to 2025.

4.3.3.6.2 RACHP-related energy consumption

Figure 4-45 shows the total energy consumption by operating RACHP appliances in small food retail stores in the Netherlands by store and appliance type in 2018. The store type is shown on the x-axis and the appliance type is represented by the applied colour scheme in each column. With around 210 GWh, conventional small supermarkets consumed by far the greatest amount of energy. All other store categories consumed 30 GWh or less and are analysed in more detail in the subsequent figure. In conventional small supermarkets, centralised refrigeration systems were responsible for the greatest amount of RACHP-related energy consumption (about 70% of total per store type), followed by stand-alone systems (almost 20%) and condensing units (> 5%), leaving minor shares below 5% to any of the further RACHP appliance types.

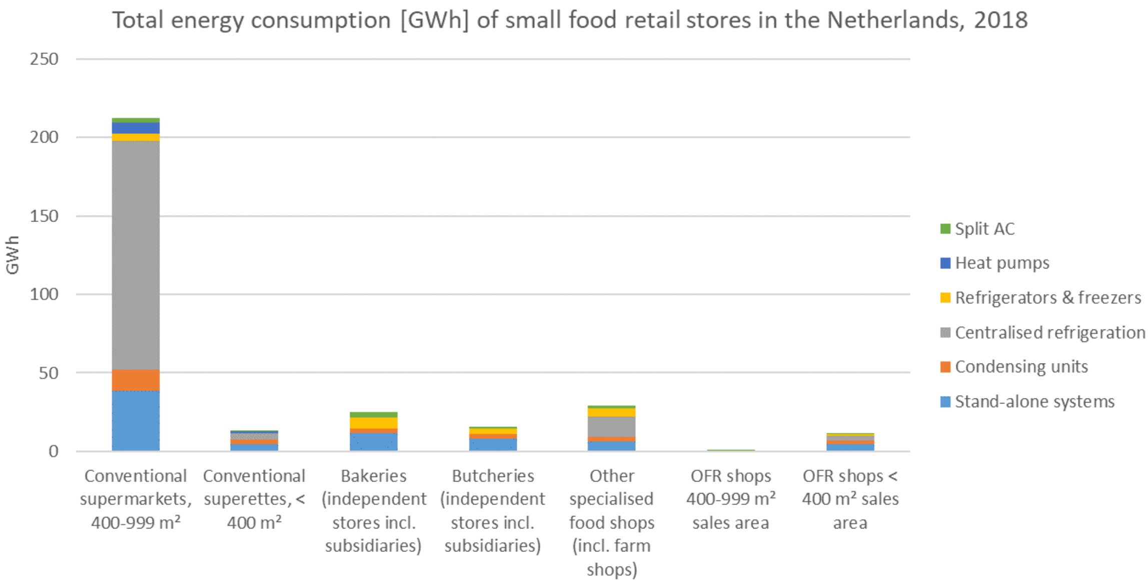

Figure 4-45: Total RACHP-related energy consumption [GWh] of small food retail in the Netherlands by appliance and store type in 2018.

Figure 4-46 shows the store types with relatively lower total RACHP energy consumption in 2018 (superettes, bakeries, butcher stores, other specialised food shops and OFR shops of both size categories). The estimated energy consumption for the operation of RACHP equipment in conventional superettes was split into comparable shares by centralised refrigeration systems and stand-alone systems (each ca. 35% of total RACHP energy consumption per store type), with a further significant share by condensing units (> 20%), leaving minor shares to heat pumps (ca. 5%) and split ACs (< 5%).

Centralised refrigeration systems dominated the RACHP-related energy consumption of other specialised food shops (incl. farm shops, > 40%) and large OFR shops (sales area 400-999 m², > 60%), with stand-alone systems ranking second (> 20% for both store types). In other specialised food shops, refrigerators and freezers (almost 20%) and condensing units (ca. 10%) contributed further significant shares to the total RACHP-related energy consumption, leaving a minor share to split ACs (ca. 5%) and a marginal share to heat pumps (< 1%). In large OFR shops, most of the remaining shares were distributed among heat pumps as well as refrigerators and freezers (both ca. 5%), with marginal contributions by split ACs and condensing units (< 5%). Regarding small OFR stores (< 400 m²), stand-alone systems contributed the leading share (ca. 40%), followed by centralised refrigeration systems (ca. 30%) of total RACHP energy consumption. Condensing units were responsible for another relevant share (ca. 20%) of total RACHP energy consumption by OFR shops, followed by refrigerators and freezers (ca. 10%), leaving a marginal contribution to split ACs (ca. 1%).

As general modeling assumption, centralised refrigeration systems played no role in bakeries and butcher stores. For these store types, most of the RACHP energy in 2018 was consumed by stand-alone systems (each around 50% of total consumption), followed by refrigerators and freezers (around 30% in bakeries, around 25% in butcher stores). Split ACs and condensing units consumed most of the remaining shares (ca. 10-15% each per store type), leaving only marginal shares by heat pumps.

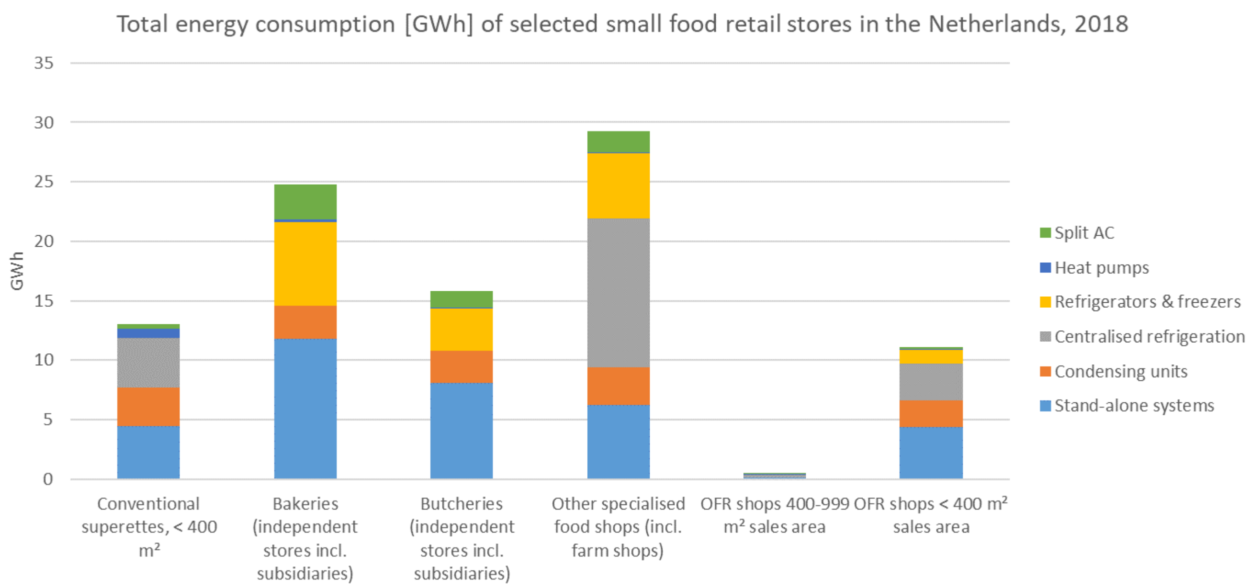

Figure 4-46: Total RACHP-related energy consumption of selected small food retail stores in the Netherlands by store and appliance type in 2018.

Figure 4-47 shows the cumulative RACHP-related energy reduction potential of small food retail stores in the Netherlands for the years from 2021 to 2025. Store types are shown on the x-axis and the appliance type is indicated by the colours within each column in the diagram. For all store types stand-alone systems offer the greatest energy reduction potential with shares ranging between 45 and 75%. For conventional small supermarkets, stand-alone systems offer more than 60% of the projected RACHP energy reduction potential, with centralised refrigeration systems ranking second (ca. 20%). Refrigerators and freezers offer recognisable additional energy saving potential (> 5%), leaving low to marginal shares to the further RACHP appliances.

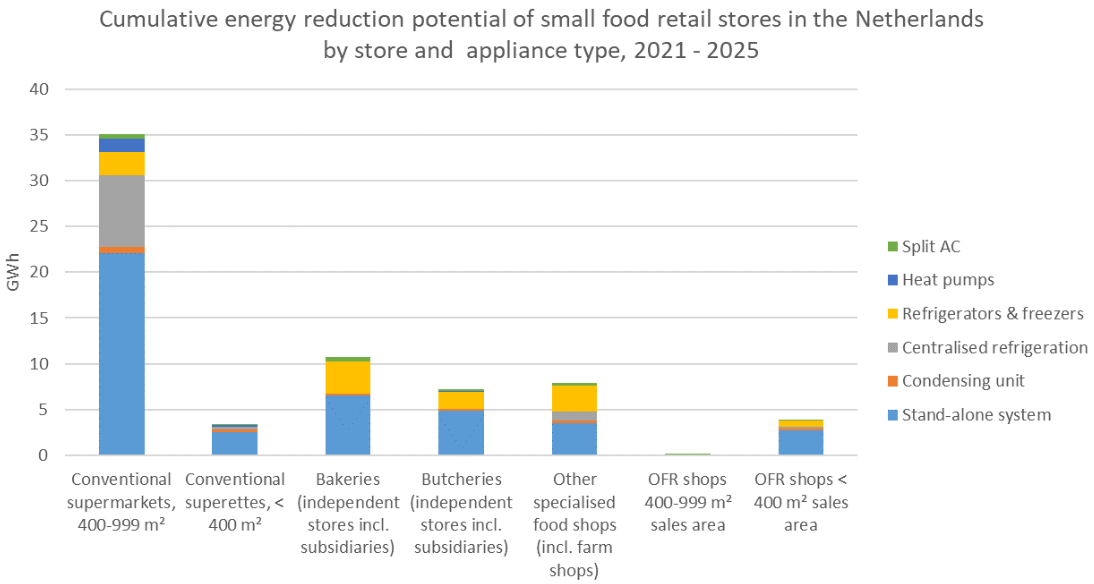

Figure 4-47: Projected cumulative RACHP-related energy reduction potential of small food retail in the Netherlands by store and appliance type from 2021 to 2025.

Figure 4-48 presents the RACHP-related energy reduction potential for the small, less energy-consuming store types (superettes, bakeries, butcher stores, other specialised food shops (incl. farm shops) and OFR shops in both size categories). As mentioned in the previous overall figure, stand-alone systems present the greatest saving potential (45-75%) across all observed store types. Refrigerators and freezers reach significant additional shares of total RACHP energy reduction potential in the range of 35% in bakeries and specialised food shops and of ca. 25% in butcher stores. With about 10-15%, refrigerators and freezers contribute lower shares to the RACHP energy mitigation potential in OFR shops. Centralised refrigeration systems offer significant further saving potential for large OFR stores (sales area 400-999 m², ca. 20%), followed by other specialised food shops, conventional superettes and small OFR shops (around 10% for each). Condensing units offer recognisable reduction potential for conventional superettes and small OFR shops, same as heat pumps for conventional superettes and large OFR shops (all ca. 5-7%). Other than that, condensing units, split ACs and heat pumps contribute with marginal shares (< 5%) for each store type to the total RACHP energy reduction potential.

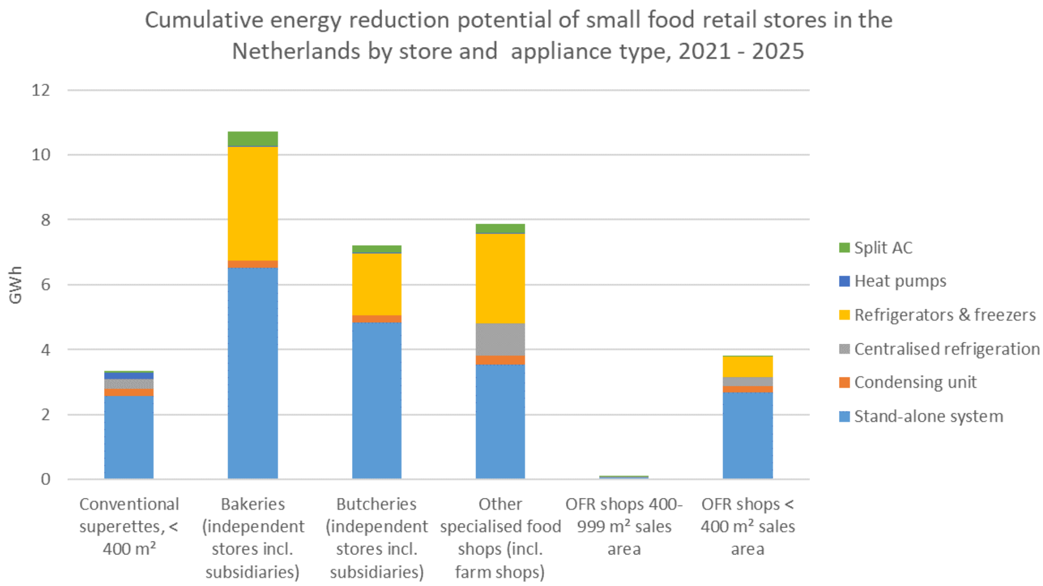

Figure 4-48: Projected cumulative RACHP-related energy reduction potential of selected small food retail stores in the Netherlands from 2021 to 2025.

4.3.3.6.3 HFC consumption

Figure 4-49 shows the total HFC refrigerant consumption of small food retail in the Netherlands by store and appliance type in 2018. HFC refrigerant was predominantly consumed by conventional small supermarkets (approximately. 19 tonnes), with estimated consumption of all other store types below 3 tonnes. Centralised refrigeration systems accounted for comparable shares of more than 90% of total HFC consumption in conventional small supermarkets and contributed around 80% to total HFC consumption in other specialised food shops. Condensing units were responsible for a minor share (< 5%) of HFCs consumed in conventional small supermarkets, with marginal additional shares by split ACs, heat pumps and stand-alone systems (each < 2%). The distributions within further store types with lower HFC consumptions are analysed more in detail in the subsequent figure.

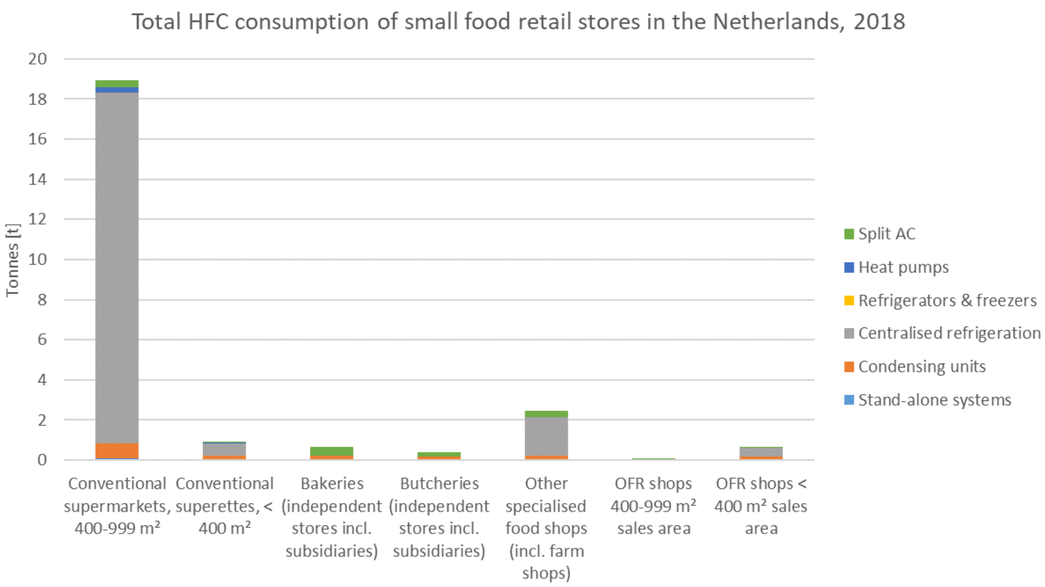

Figure 4-49: Total HFC consumption of small food retail in the Netherlands by store and appliance type in 2018.

Based on year 2018, Figure 4-50 gives a deeper insight into the HFC refrigerant consumption of conventional superettes (0.9 tonnes of HFC consumption), bakeries (0.7 tonnes), butcher stores (0.4 tonnes), other specialised shops incl. farm shops (2.4 tonnes) as well as large OFR shops with sales areas from 400 to 999 m² (0.04 tonnes) and small OFR shops below 400 m² (0.7 tonnes). Besides their dominant role in small conventional supermarkets and other specialised food stores (80-90% of total HFC consumption), centralised refrigeration systems also contributed the clearly largest shares of total HFC consumption in large OFR stores (> 90%) as well as conventional superettes and small OFR stores (both ca. 70%). Condensing units were large further contributors to total HFC consumption in conventional superettes and small OFR stores (both ca. 25%), with less relevance for other specialised food stores (< 10%) and a marginal role in large OFR stores (ca. 1%). Split ACs contributed a recognisable share of total HFC consumption in other specialised food shops (> 10%) and at low ranges in conventional superettes and OFR shops of both size categories (each ca. 5%), leaving only marginal shares to stand-alone systems and heat pumps (all < 5%) as well as refrigerators and freezers (<1%).

In the absence of centralised systems in bakeries and butcher stores (modelling assumption), most HFC in these stores was consumed by split ACs (ca. 65% by bakeries, 50% by butcher stores), followed by condensing units (ca. 30%, respectively 45%). Stand-alone systems contributed with shares in the range of 4% of total HFC consumption for both store types with marginal further contributions by heat pumps and refrigerators and freezers (all 1% or below).

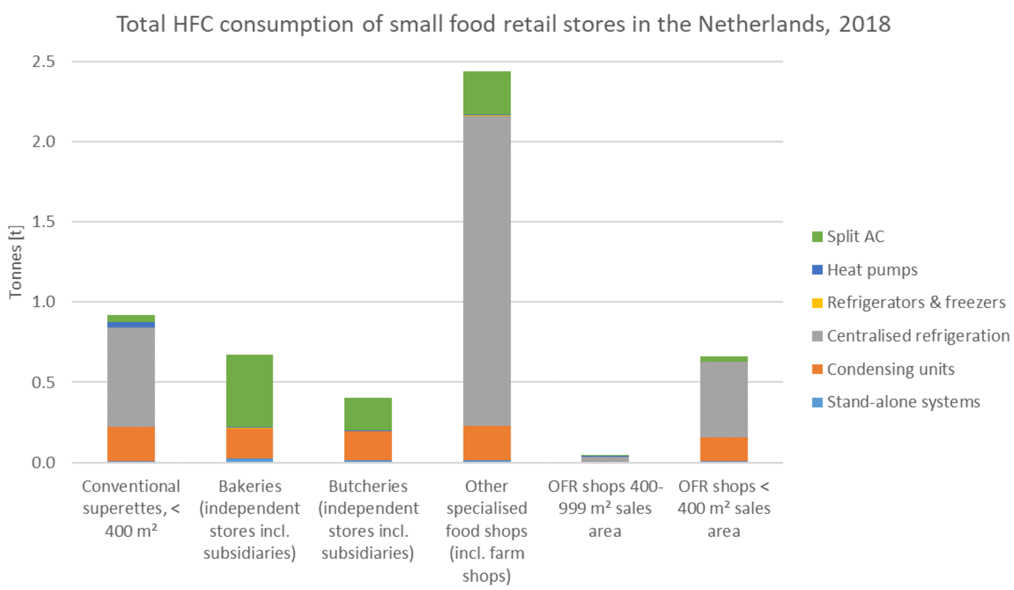

Figure 4-50: Total HFC consumption of selected small food retail store types in the Netherlands in 2018.

Figure 4-51 shows the projected cumulative reduction potential of HFC consumption by small food retail stores in the Netherlands from 2021 to 2025. Conventional small supermarkets have by far the largest reduction potential of HFC consumption, followed by other specialised food stores (incl. farm shops) and small OFR shops. For all the mentioned store categories as well as conventional superettes and large OFR shops, centralised refrigeration systems offer the greatest potential for reducing HFC consumption (share of total reduction potential around 80-90% per store type, around 70% for superettes and small OFR shops). For conventional small supermarkets, condensing units offer a recognisable (ca. 4%), and split ACs and heat pumps marginal further contributions to the total reduction potential of HFC consumption. The further store categories with relatively low HFC reduction potential are analysed with more detail in the subsequent figure.

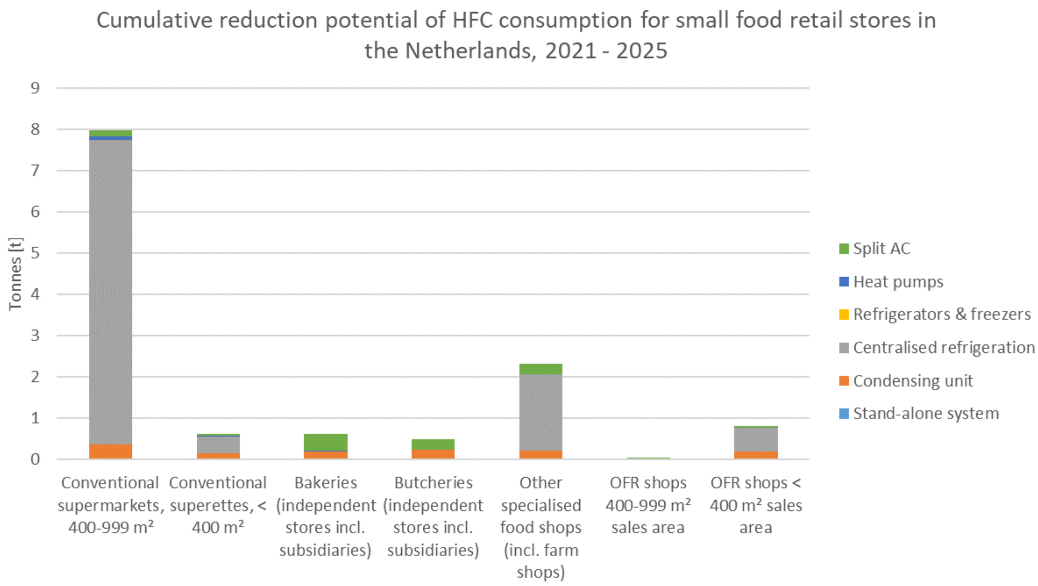

Figure 4-51: Projected cumulative reduction potential of HFC consumption for small food retail in the Netherlands by store and appliance type.

Figure 4-52 shows the projected cumulative reduction potential of HFC consumption for the closer selection of conventional superettes, bakeries, butcher stores, other specialised food shops (incl. farm shops) and OFR shops of both size categories. Besides the predominant share of centralised refrigeration systems of total HFC reduction potential (ca. 70%), conventional superettes exhibit most additional mitigation potential by condensing units (ca. 25%) and further shares of about 5% for both split ACs and heat pumps. Centralised refrigeration systems account for a share of around 80% within other specialised food shops, followed by condensing units and split ACs (each around 10%). Split ACs offer the largest reduction potential of HFC consumption for bakeries (ca. 65% of total) and butcher stores (ca. 50%), followed by condensing units (ca. 30% for bakeries, ca. 45% for butcher stores). Centralised refrigeration systems are most relevant for the HFC reduction potential in both OFR shop categories, with a share of around 90% for large OFR stores and 70% for small OFR stores. For the latter, condensing units offer significant further reduction potential (> 20% of total), followed by split ACs for both OFR store types (around 5% each) and marginal shares by heat pumps (3% in large OFR stores) and stand-alone units (both around 1%).

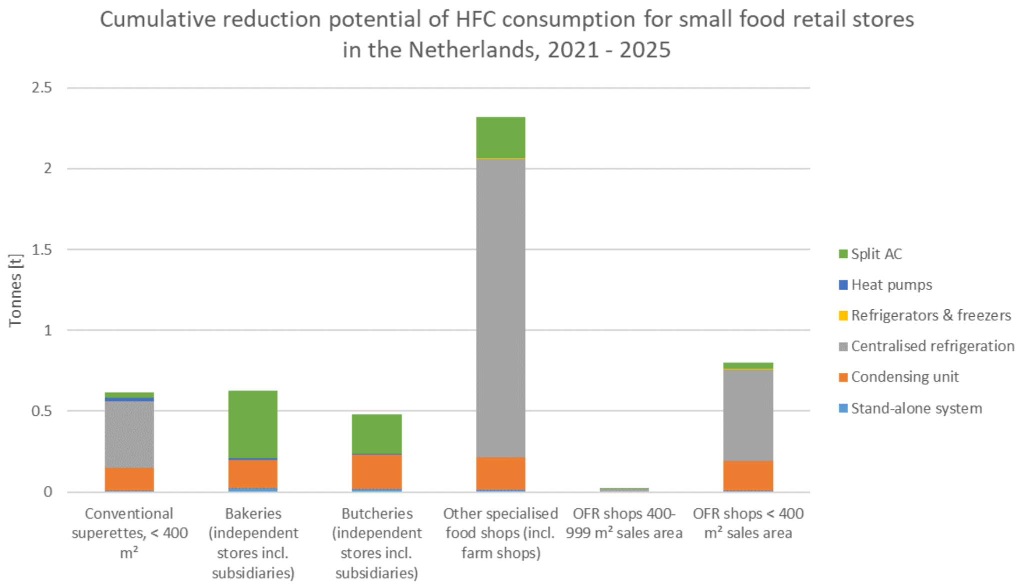

Figure 4-52: Projected cumulative reduction potential of HFC consumption for selected small food retail stores in the Netherlands from 2021 to 2025.

4.3.3.7 Portugal

4.3.3.7.1 RACHP-related GHG emissions

In Figure 4-53, the total GHG emissions of Portugal's small food retail per different shop types caused by the operation of RACHP appliances are shown for 2018. 57% of total RACHP emissions were caused by conventional small supermarkets, followed by conventional superettes with 30% and bakeries with 8%. Butcher stores were responsible for 4% of the emissions and OFR shops with a sales area below 400 m^2 had the lowest share with a contribution of less than 1%. No large OFR shops (sales area from 400 to 999 m²) were identified in Portugal. Moreover, other specialised food shops are not included for Portugal, due to limited availability of data for this store category.

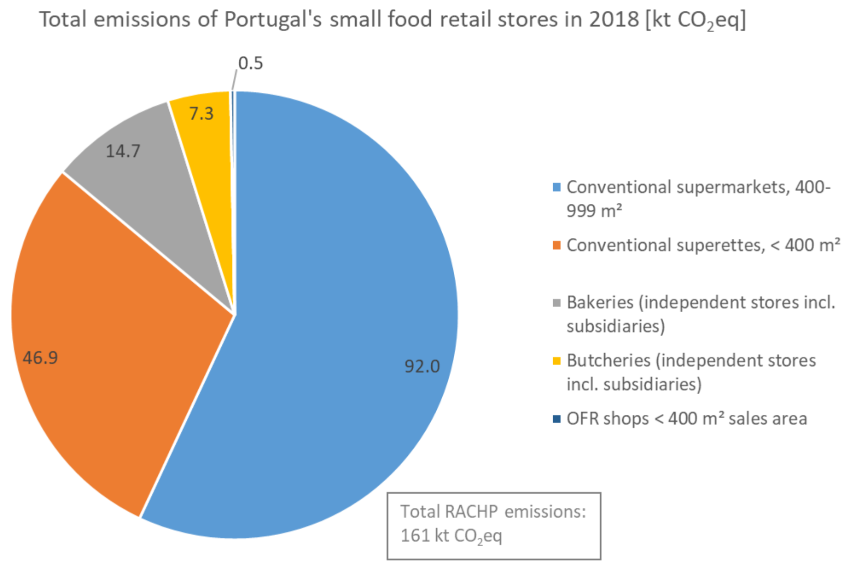

Figure 4-53: Total GHG emissions caused by operating RACHP equipment in small food retail stores in Portugal.

Figure 4-54 presents the total GHG emissions by store and RACHP appliance type in 2018, whereas the right column summarises the store types bakeries, butcher stores and OFR shops due to their relatively low shares of total RACHP emissions in total small food retail. The store types are displayed on the x-axis. Centralised refrigeration systems had by far the largest share of total emissions for conventional small supermarkets with a share of around 90% and for conventional superettes a share of 70%. For both store categories, stand-alone units were second largest emitters (ranging between 5 and 15% of total RACHP emissions per store type), followed by condensing units and split ACs in comparable ranges, holding relatively low shares. Refrigerators and freezers, heat pumps and split ACs had a marginal share of the total GHG emissions with less than 5% in total. Within the combined category bakeries, butcher stores and OFR shops, centralised refrigeration systems had only a marginal share of total emissions with around 1%. Here, stand-alone units had the largest share of emissions with around 35%, followed by split ACs, refrigerators and freezers and condensing units with comparable shares.

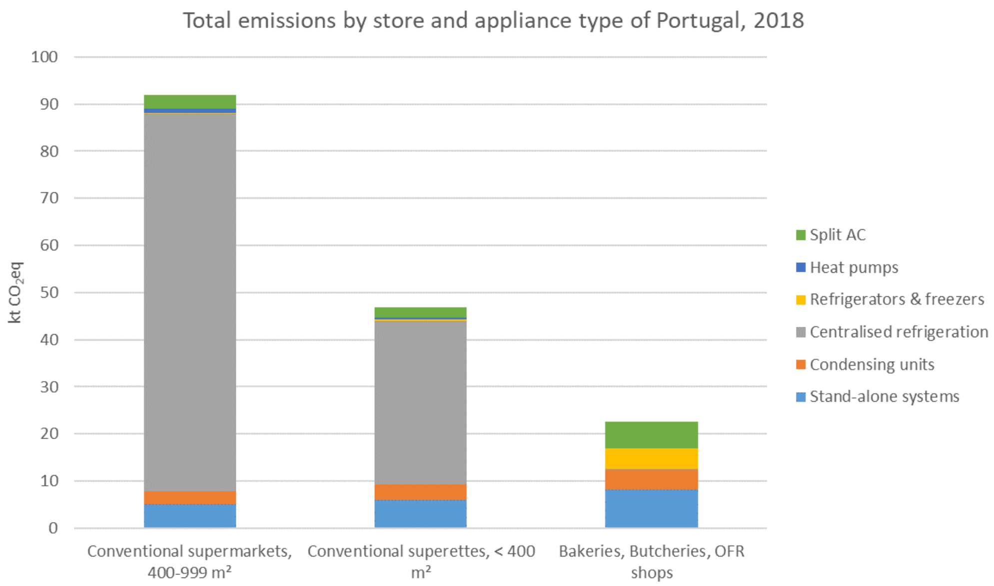

Figure 4-54: Total RACHP emissions by store and appliance type of Portuguese small food retail in 2018.

Figure 4-55 shows the total RACHP emissions of selected store types in small food retail (bakeries, butcher stores and OFR shops). Following the overall modelling assumptions, bakeries and butcher stores did not operate any centralised refrigeration systems. With around 35%, stand-alone systems had the largest share of the total emissions in bakeries and butcher stores. In bakeries, further contributions were split into shares by split ACs (around 25%), refrigerators and freezers (20%) and condensing units (15%). In butcher stores, condensing units and split ACs were the second largest GHG emission emitter with a share of around 20% each. Heat pumps caused the lowest amount of emission from bakeries and butcher stores (<1%). In OFR shops (sales area below 400 m^2), 55% of emissions were caused by centralised refrigeration systems, followed by stand-alone units (20%) and further contributions by condensing units and refrigerators and freezers causing around 10% of the total GHG emissions each. Heat pumps were not recognised to cause any emissions in Portuguese OFR shops.

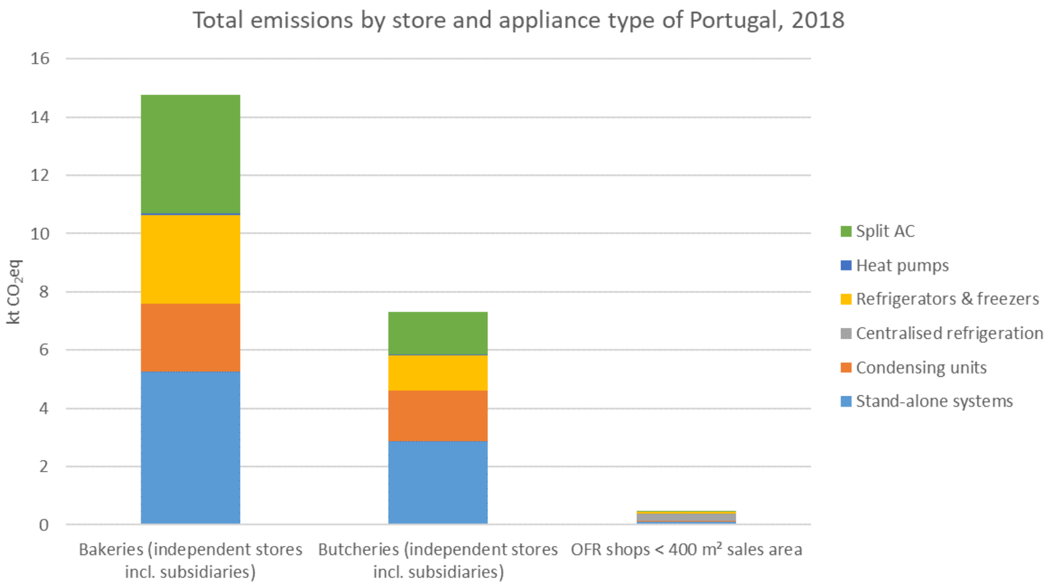

Figure 4-55: Total RACHP emissions of selected Portuguese small food retail stores by store and appliance type in 2018.

Figure 4-56 shows the cumulative emission reduction potential of small food retail in Portugal by store and appliance type from 2021 to 2025. Model predictions show the greatest potential for saving emissions in conventional superettes, followed from one to another at a significantly lower level by conventional small supermarkets, bakeries, butcher stores and ultimately OFR shops. Centralised refrigeration systems account for up to 80% of total emission reduction potential within conventional superettes, and for ca. 60% within conventional small supermarkets.

For bakeries and butcher stores, stand-alone systems offer the greatest emission reduction potential with a share of around 45% each (Figure 4-56). Second largest emission reduction potential within bakeries is represented by refrigerators and freezers and split ACs with a share of around 20% each. For butcher stores, refrigerators and freezers rank second together with condensing units, offering reduction potential with a share of around 12% each. Within OFR shops, centralised refrigeration systems account for the greatest share of total emission reduction potential (ca. 60%), followed by stand-alone units (20%) and refrigerators and freezers (10%), leaving minor shares to split ACs and condensing units. Due to data uncertainty in regard to the number of OFR stores, the potential for saving emissions might be underestimated.

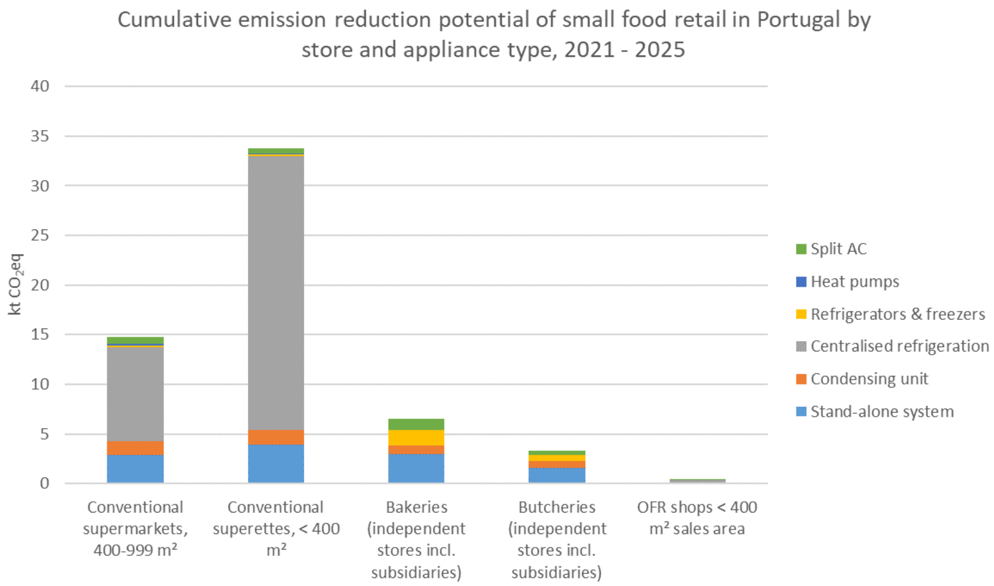

Figure 4-56: Projected cumulative RACHP emission reduction potential of small food retail in Portugal by store and appliance type from 2021 to 2025.

4.3.3.7.2 RACHP-related energy consumption

Figure 4-57 shows the total energy consumption of small food retail in Portugal by store and appliance type in 2018 associated with the operation of RACHP appliances. The x-axis shows the store types while colours within the columns indicate different appliance types. In 2018, the greatest amount of energy was consumed by conventional small supermarkets, followed by conventional superettes. Within these store types, centralised refrigeration systems were the main consumers with shares of total energy consumption of 75% for small supermarkets and 55% for superettes, respectively. Stand-alone units consumed shares of around 12% and 30%, respectively, while condensing units and split ACs accounted for minor shares of around 5% each.

Centralised refrigeration systems were assumed not to be used in bakeries and butcher stores. For these store types, most of the energy is consumed by stand-alone systems (around 45% each), followed by refrigerators and freezers (around 20% each), split ACs (around 20% each) and condensing units (around 5%). In OFR shops (sales area below 400 m²), stand-alone systems contributed over 40% to total RACHP energy consumption, and centralised refrigeration systems over 30%, followed by refrigerators and freezers (> 15%) and marginal shares of condensing units and split ACs (around 5% each) and heat pumps (< 1%).

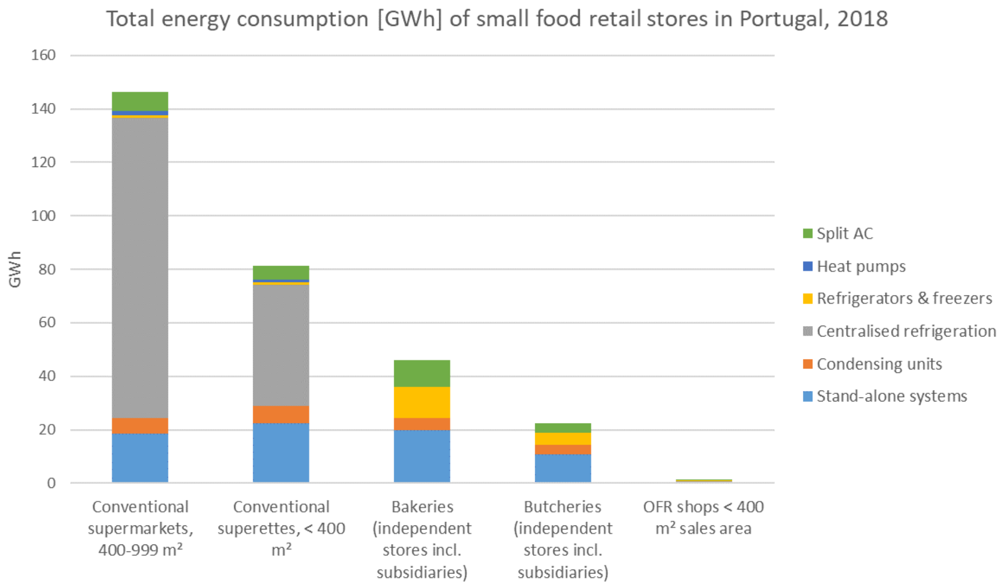

Figure 4-57: Total RACHP-related energy consumption of small food retail in Portugal by appliance and store type in 2018.

Figure 4-58 shows the cumulative RACHP energy reduction potential for the years 2021 to 2025 of Portuguese small food retail stores. Conventional superettes, small supermarkets and bakeries show the greatest energy saving potential. Most of this mitigation potential can be exploited by stand-alone systems, reaching shares above 70% for superettes and bakeries, and around 60% for conventional superettes and small supermarkets, and in between at approximately 60% shares for butcher stores and OFR shops (< 400 m^2). Refrigerators and freezers show the second largest energy saving potential for bakeries, butcher stores and OFR stores with a share of around 30% each. Centralised refrigeration systems offer energy saving potential shares around 30% for supermarkets and around 20% for superettes. Within all store categories, split ACs account for shares in the range of 5% of the total reduction potential, while condensing units and heat pumps only play a marginal role.

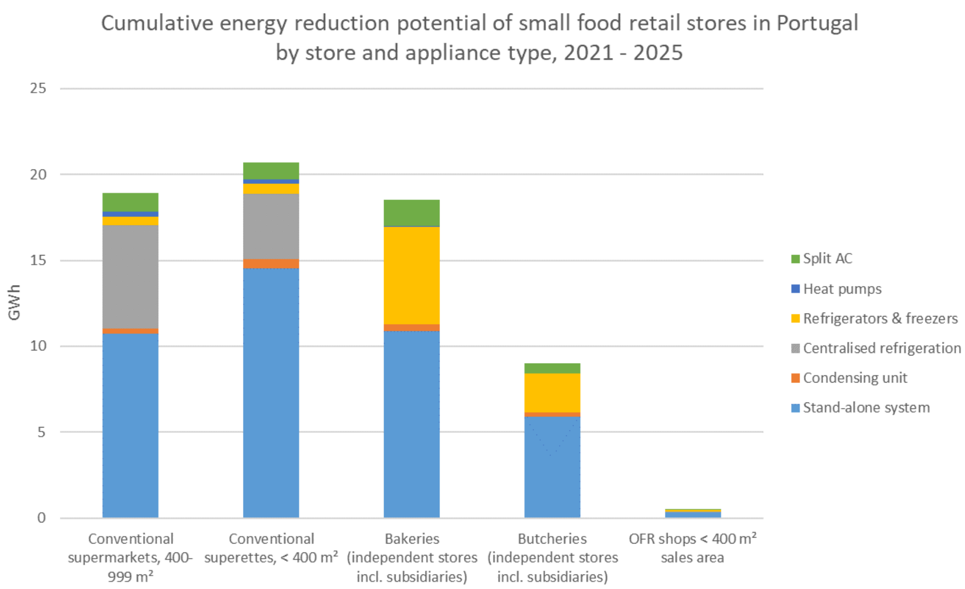

Figure 4-58: Projected cumulative RACHP-related energy reduction potential of small food retail in Portugal by store and appliance type from 2021 to 2025.

4.3.3.7.3 HFC consumption

Figure 4-59 shows the total HFC refrigerant consumption of small food retail in Portugal by store and appliance type in 2018. HFC consumption was dominated by conventional small supermarkets with almost 14 tonnes and conventional superettes with around 7 tonnes. In both store types, most of the HFC was consumed by centralised refrigeration systems with shares of around 90%, followed by split ACs and condensing units with a share of around 5% each. Stand-alone units and heat pumps only had a marginal share. HFC consumption within the further store categories is analysed in the subsequent figure.

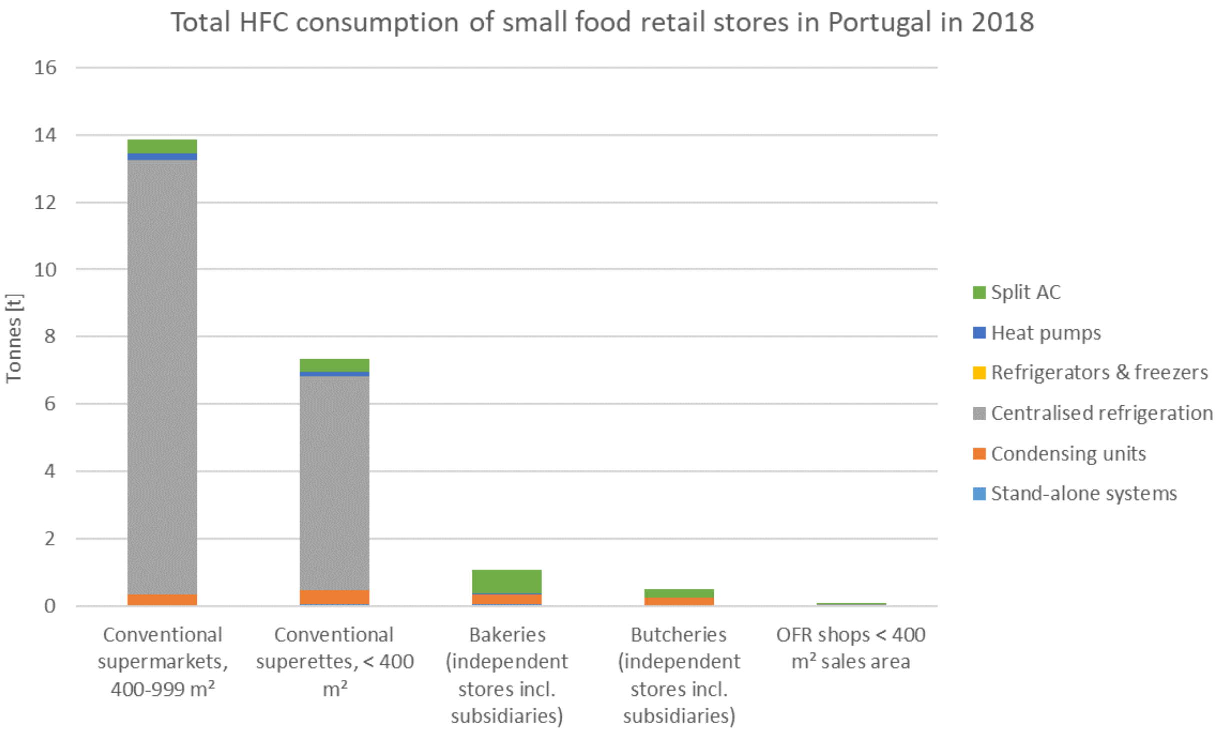

Figure 4-59: Total HFC consumption of small food retail in Portugal by store and appliance type in 2018.

Figure 4-60 gives a more detailed overview of the HFC consumption of bakeries, butcher stores and OFR shops (sales area below 400 m²) in 2018. Bakeries consumed around 1 tonne of HFC refrigerant, followed by butcher stores with around 500 kg. In both store types, the major share of refrigerant was used for split ACs (65% for bakeries, 50% for butcher stores), followed by condensing units (30% and 40%, respectively) and stand-alone units (less than 5% each), while refrigerators and freezers as well as heat pumps had a marginal share. OFR stores consumed less than 100 kg of HFC refrigerant which was mainly used by centralised refrigeration systems (ca. 90%), with minor share by split ACs and condensing units.

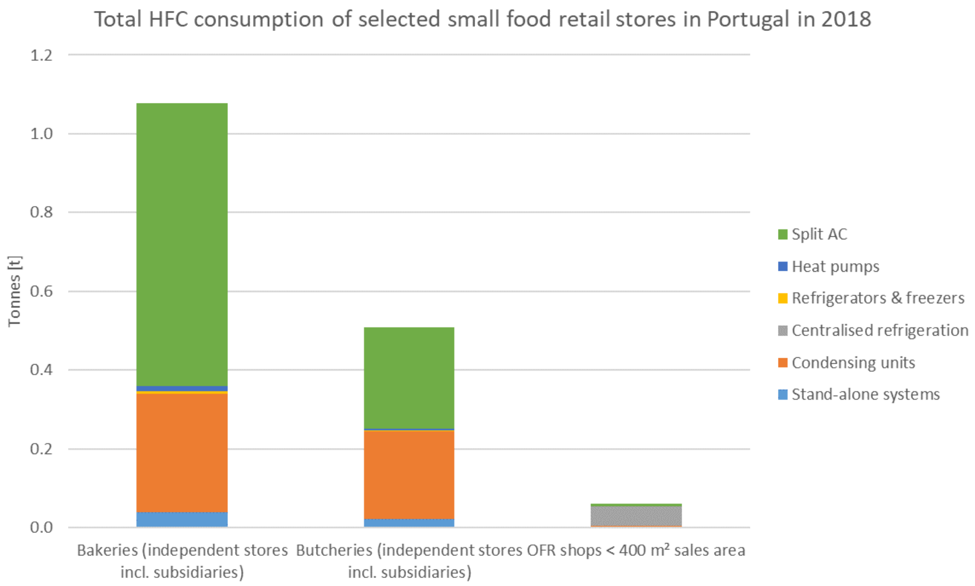

Figure 4-60: Total HFC consumption of selected small food store types in Portugal in 2018.

Figure 4-61 shows the cumulative reduction potential of HFC refrigerant consumption in Portugal's small food retail stores from 2021 to 2025. Conventional small supermarkets and superettes demonstrate by far the greatest potential to reduce their HFC consumption, followed by bakeries and butcher stores. In supermarkets, superettes and OFR shops, centralised refrigeration systems provide the greatest potential for reducing HFC consumption (around 90%), followed by split ACs and condensing units (around 3% each). The store categories which offer less reduction potential are discussed more in depth in the subsequent figure.

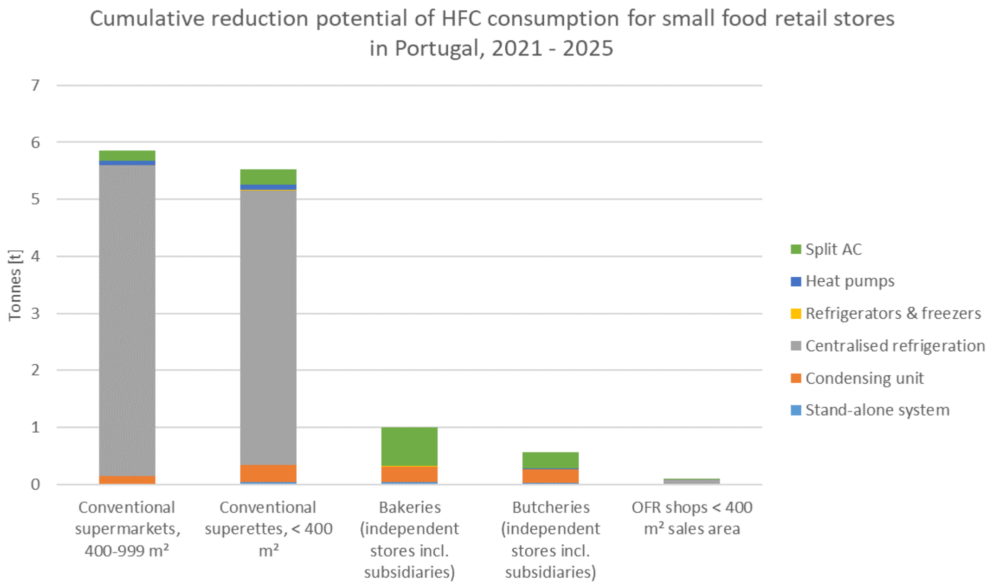

Figure 4-61: Projected cumulative reduction potential of HFC consumption for small food retail in Portugal by store and appliance type from 2021 to 2025.

Figure 4-62 shows the projected cumulative reduction potential of HFC refrigerant consumption for bakeries, butcher stores and OFR shops (sales area below 400 m²). Bakeries and butcher stores offer the greatest potential in reducing their HFC consumption in split ACs (65% and 50%, respectively), followed by condensing units (30% and 50%, respectively). Most relevant reduction potential for OFR shops is offered by centralised refrigeration systems (around 80%), while lower amounts of HFC could be saved by split ACs and condensing units (around 10% each).

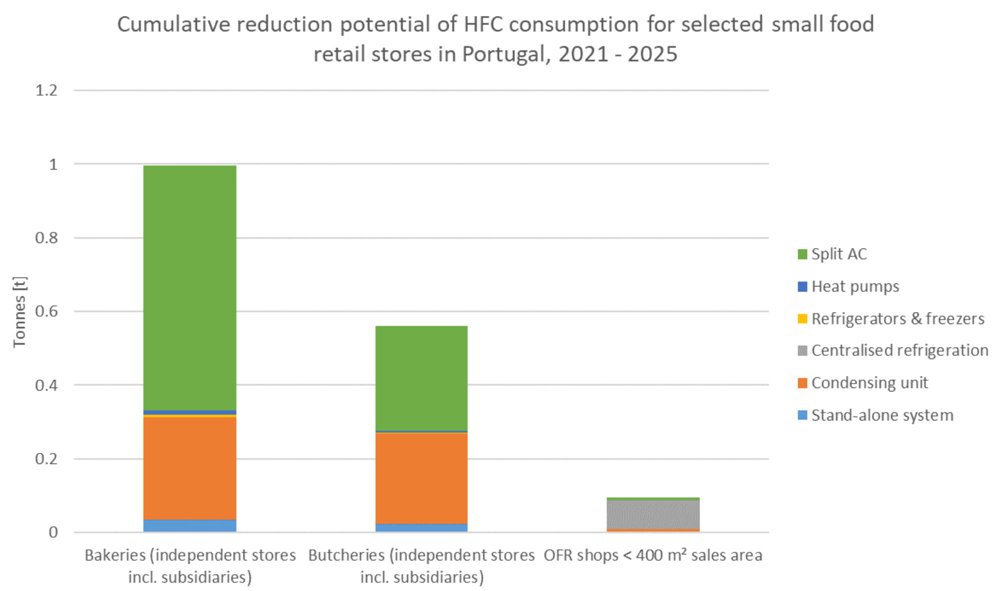

Figure 4-62: Projected cumulative reduction potential of HFC consumption for selected small food retail stores in Portugal from 2021 to 2025.

4.3.3.8 Spain

4.3.3.8.1 RACHP-related GHG emissions

Figure 4-63 shows the distribution per store type of Spain's GHG emissions caused by the operation of RACHP appliances in the small food retail sector in 2018. 52% of total RACHP emissions of this sector were produced by conventional small supermarkets, followed by conventional superettes (40%) and butcher stores (3%). Bakeries and OFR shops with a sales area below 400 m^2 had the lowest GHG emission shares, with contributions of about 2% each. No large OFR shops (sales area from 400 to 999 m^2) were identified in Spain. Moreover, other specialised food shops are not included for Spain, due to limited availability of data for this store category.

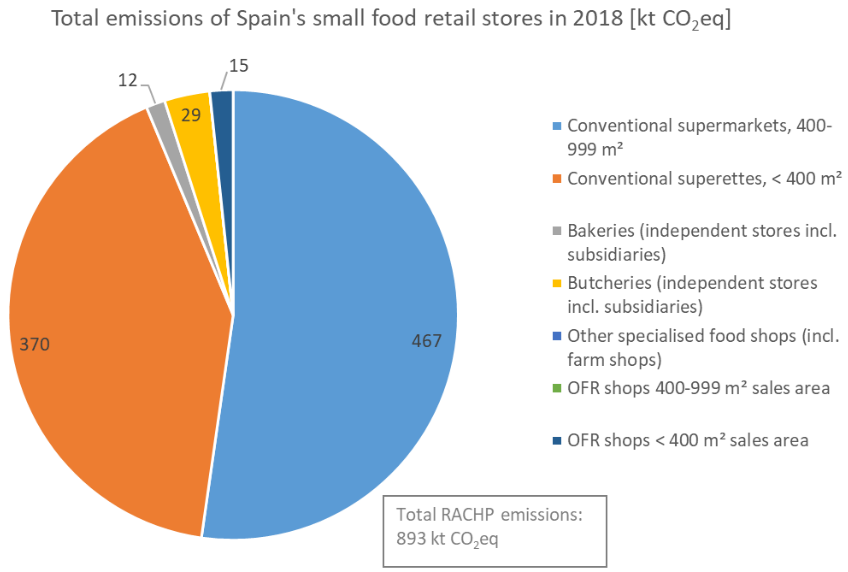

Figure 4-63: Total GHG emissions caused by operating RACHP equipment in small food retail stores in Spain.

Figure 4-64 presents total GHG emissions by RACHP appliances in 2018 for the selected small food retail store categories in Spain, whereas the column to the right summarises bakeries, butcher stores and OFR shops due to their relatively low shares of total RACHP emissions. These store categories are analysed with more detail in the subsequent figure. RACHP appliance types are distinguished by different colours within each column in the figure. The store types are displayed on the x-axis. Centralised refrigeration systems had by far the largest share of total emissions for conventional small supermarkets (around 90%) and conventional superettes (70%). For both store types, stand-alone units were second largest emitters (share of around 5% for conventional small supermarkets, around 10% for superettes), followed by condensing units and split ACs (both ca. 3% for conventional small supermarkets and ca. 5% for superettes). Refrigerators and freezers as well as heat pumps contributed marginal shares.

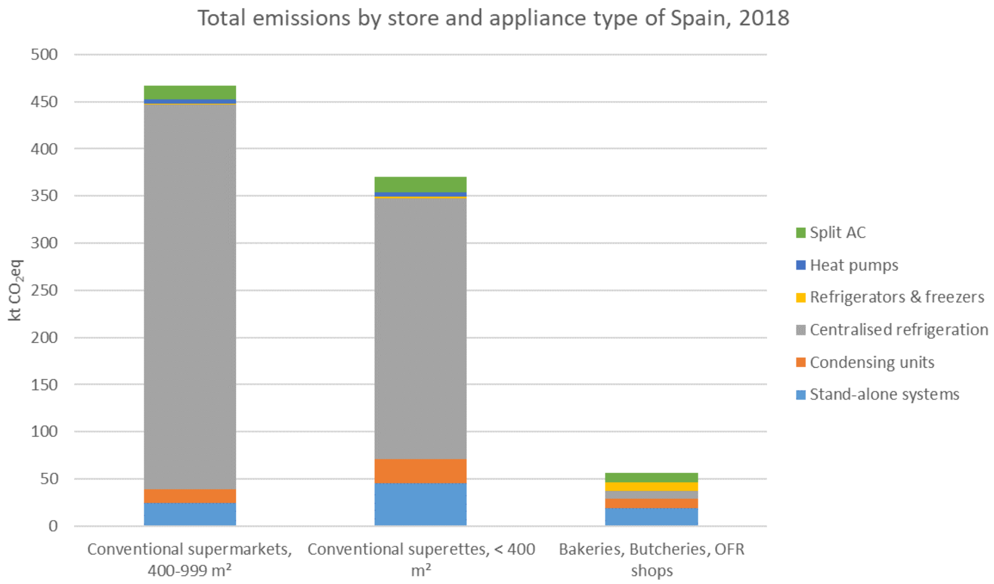

Figure 4-64: Total RACHP emissions by store and appliance type of Spain's small food retail sector in 2018.

Figure 4-65 shows the total RACHP-related emissions specifically for bakeries, butcher stores and OFR shops (sales area below 400 m²). Stand-alone systems contributed the largest share to the total emissions by bakeries and butcher stores with around 30%. In bakeries, further emission shares were attributed to split ACs (ca. 25%), refrigerators and freezers (ca. 20%), and condensing units (ca. 15%). In butcher stores, significant further shares were contributed by condensing units (ca. 25%), split ACs (ca. 20%) and refrigerators and freezers (ca. 15%). In OFR shops (sales area below 400 m^2), 57% of total RACHP emissions were caused by centralised refrigeration systems, with stand-alone units in the second place (ca. 20%), followed by low contributions by condensing units and refrigerators and freezers (around 10% each).

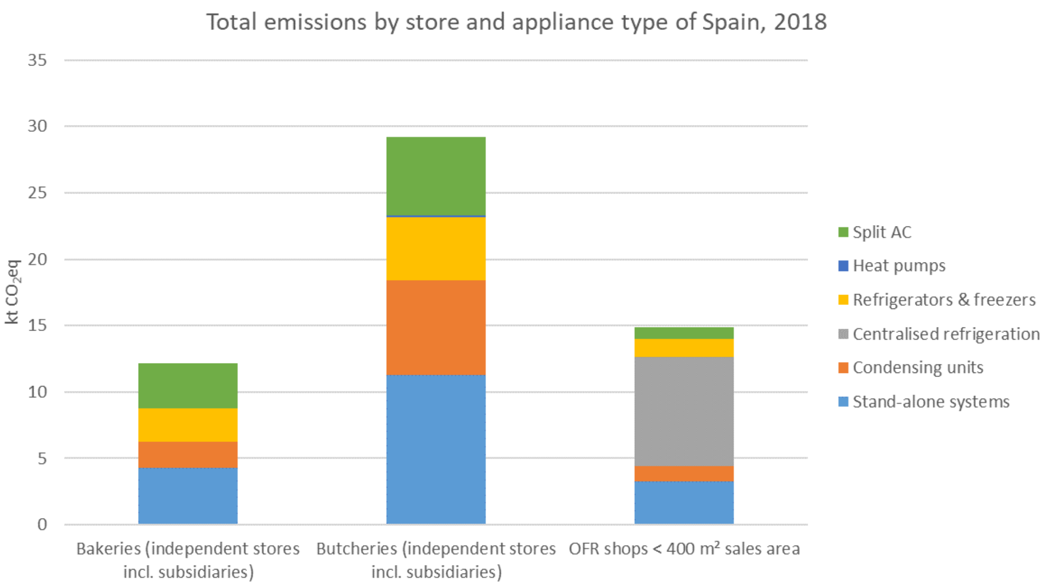

Figure 4-65: Total RACHP emissions of selected small food retail store types in Spain by store and appliance type in 2018.

Figure 4-66 shows the cumulative RACHP-related emission reduction potential of small food retail in Spain by store and appliance type from 2021 to 2025.

Model predictions show the greatest potential for saving RACHP emissions in conventional superettes by far, followed by conventional small supermarkets, with comparatively low emission mitigation potential by butcher stores, OFR shops (sales area below 400 m^2) and bakeries. Centralised refrigeration systems account for around 60% of the total RACHP emission reduction potential in conventional small supermarkets and within superettes for around 80%. For both store types, stand-alone systems offer most of the further emission mitigation potential (around 10% for conventional superettes, nearly 20% for small supermarkets), followed by condensing units, as well as marginal shares by split ACs and refrigerators and freezers. The shares within the remaining store categories with relatively lower emission reduction potential are analysed in the subsequent figure.

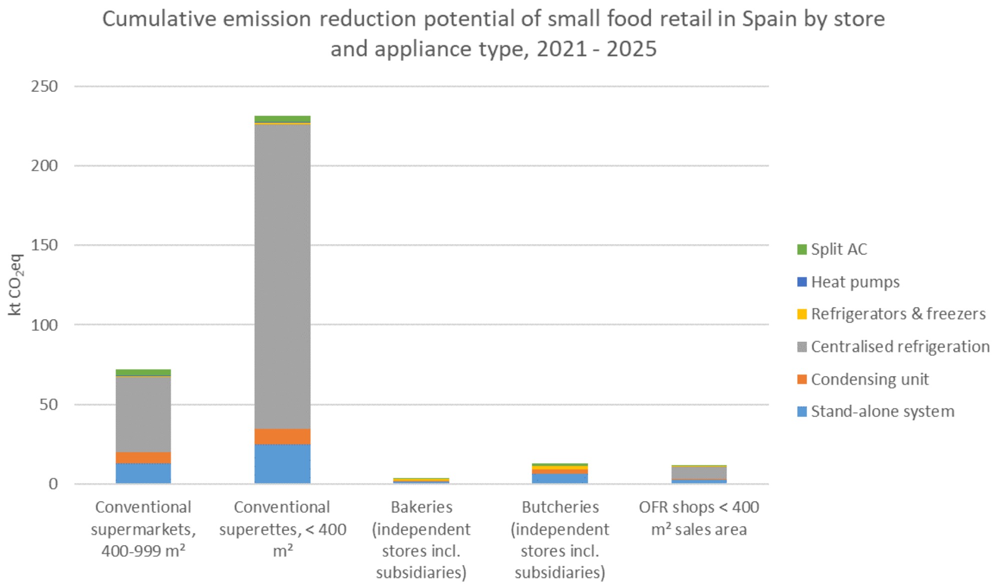

Figure 4-66: Projected cumulative RACHP-related emission reduction potential in Spain's small food retail by store and appliance type from 2021 to 2025.

Figure 4-67 shows the cumulative RACHP emission reduction potential for the closer selection of store types, consisting of bakeries, butcher stores and OFR shops (sales area below 400 m^2). Within bakeries and butcher stores, stand-alone systems have the greatest potential for emission reduction (shares of 45% and 50% of total reduction per store type, respectively). Within bakeries, refrigerators and freezers as well as split ACs (both around 20%) offer significant further emission reduction potential, followed by condensing units (ca. 15%). The most relevant additional reduction potential for butcher stores can be exploited by condensing units as well as by refrigerators and freezers (both around 20%), followed by split ACs (nearly 15 %). Within OFR shops, centralised refrigeration systems stand out for the greatest share of total RACHP emission reduction potential with a share of about 65%, followed by stand-alone systems (ca. 20%) and refrigerators and freezers (almost 10%). The remaining minor share is subdivided into split ACs and condensing units.

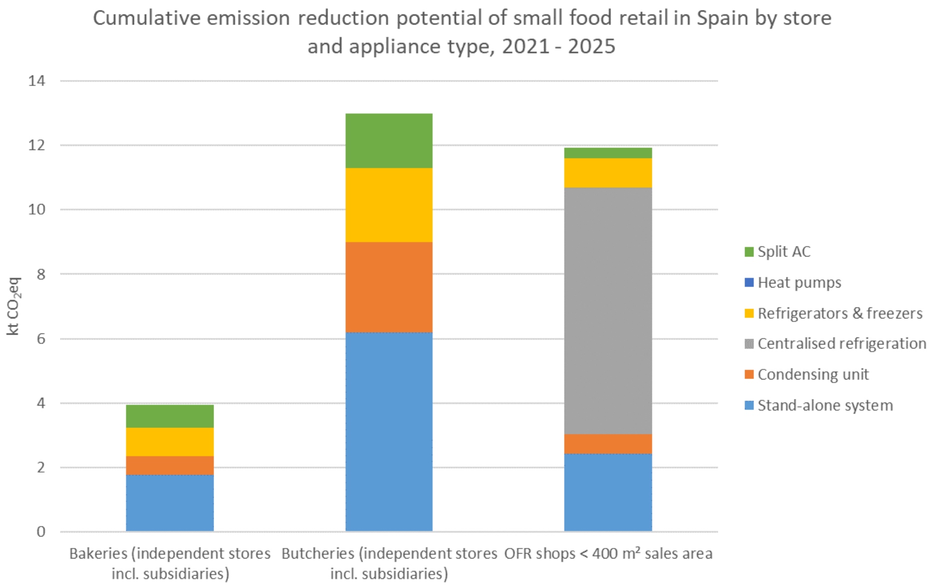

Figure 4-67: Projected cumulative RACHP emission reduction potential of selected small food retail store types in Spain by store and appliance type from 2021 to 2025.

4.3.3.8.2 RACHP-related energy consumption

Figure 4-68 illustrates the total energy consumption of small food retail in Spain associated with the operation of RACHP equipment by store and appliance type in 2018. The greatest amount of energy was consumed by conventional small supermarkets, followed by conventional superettes in a close range. Within these store types, centralised refrigeration systems were main energy consumers (share ca. 75% for small supermarkets, ca. 55% for superettes), followed by stand-alone systems (shares of around 12% and 30%, respectively). Condensing units and split ACs accounted for further recognisable shares of total RACHP energy consumption (ranging between 4 and 10% per store type each). The further store categories, accounting for significantly lower energy consumption levels, are analysed in depth in the subsequent figure.

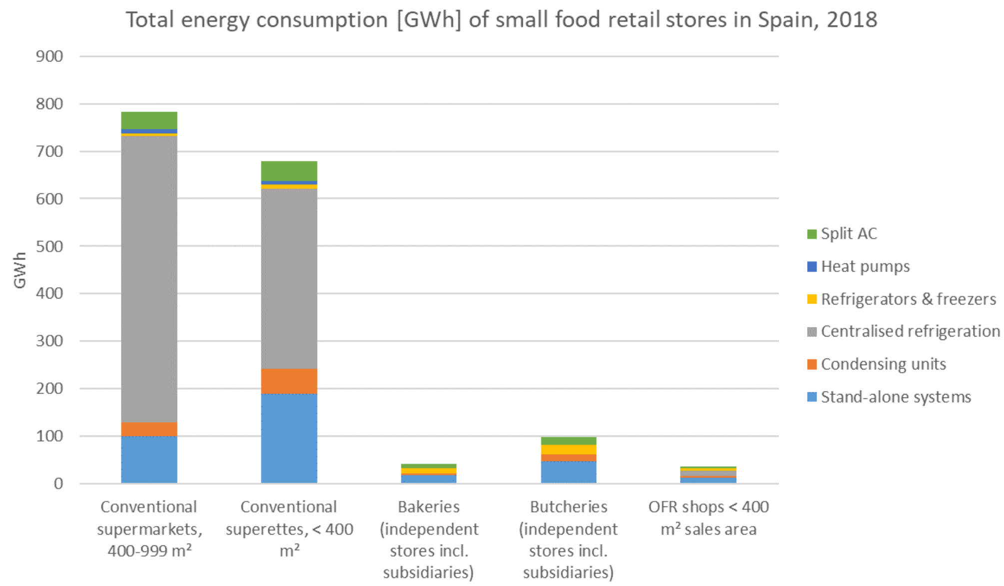

Figure 4-68: Total RACHP-related energy consumption of small food retail in Spain by appliance and store type in 2018.

Figure 4-69 shows the contributions made by the less energy consuming store types, consisting of bakeries, butcher stores and OFR shops (sales area below 400 m^2) in 2018. According to overall modelling assumptions, centralised refrigeration systems were not used by bakeries and butcher stores. Butcher stores stand out as predominant RACHP energy consumers, followed by bakeries and OFR shops at comparable levels. Within bakeries, butcher shops and OFR shops, most of the RACHP-related energy was consumed by stand-alone systems (both around 40% of total RACHP energy consumption). In bakeries and butcher stores, refrigerators and freezers ranked second (ca. 25 and 20% per store type, respectively), followed by split ACs (ca. 20% and 15%, respectively). In butcher shops, condensing units reached the same last-mentioned share (15%), while the appliance type accounted for around 10% of total RACHP energy consumption in bakeries. Besides the beforementioned contribution by stand-alone systems (40%), OFR shops noted significant share of total RACHP energy consumption by centralised refrigeration systems (about 35%), followed by refrigerators and freezers (over 15%), leaving marginal shares to condensing units and split ACs (around 5% each).

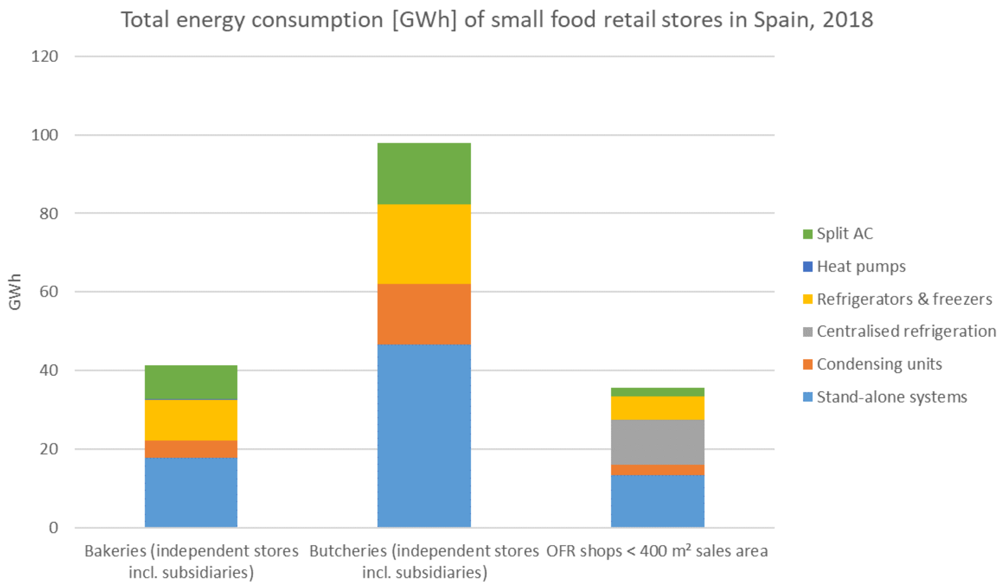

Figure 4-69: Total RACHP-related energy consumption of selected small food retail stores in Spain by store and appliance type in 2018.

Figure 4-70 shows the cumulative RACHP-related energy reduction potential of Spain's small food retail stores for the years 2021 to 2025. Conventional superettes and small supermarkets offer the greatest RACHP energy saving potential. For both store types, stand-alone systems account for the largest energy reduction potential, reaching 70% of the total saving potential for conventional superettes, and around 55% for small supermarkets. Centralised refrigeration systems contain significant further energy saving potential (around 20% and 30%, respectively). Energy savings at lower ranges can be achieved by split ACs (around 5% per store type), followed by refrigerators and freezers (3%), leaving marginal additional saving potentials to condensing units and heat pumps. The further store categories with less energy-saving potential are analysed in the subsequent figure.

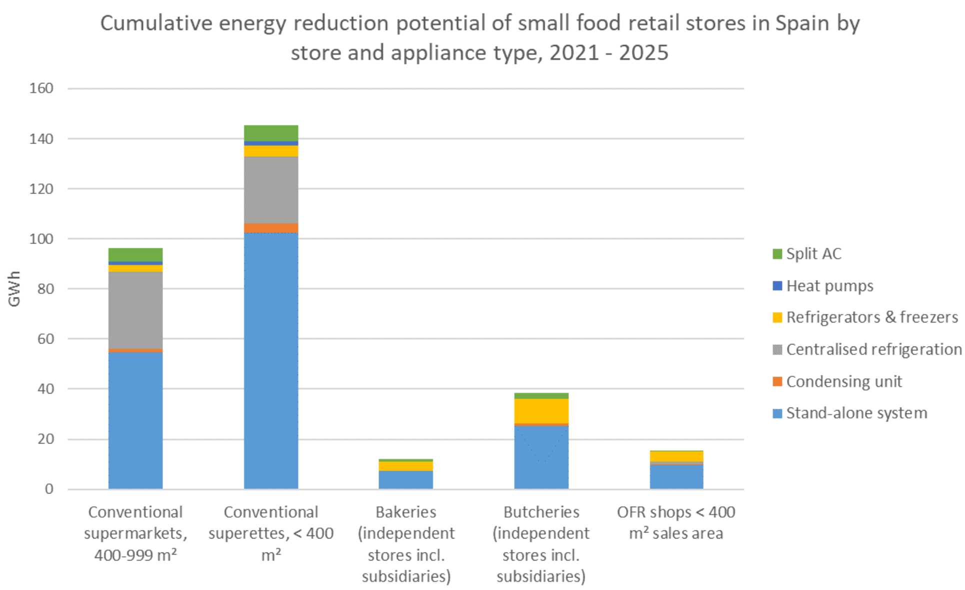

Figure 4-70: Projected cumulative RACHP-related energy reduction potential of small food retail in Spain by store and appliance type from 2021 to 2025.

Figure 4-71 presents the RACHP energy saving potential for the small, less energy-consuming store types, consisting of bakeries, butcher stores and OFR shops (sales area below 400 m²). Stand-alone systems offer the greatest saving potential with shares ranging from almost 60% (bakeries) to 65% (butcher shops and OFR stores) of total RACHP-related energy reduction potential per store type. All three store categories offer significant further energy savings potential by refrigerators and freezers (around 30% per store type). Exclusively for OFR shops, additional energy reduction potential exists in centralised refrigeration (8%), while comparable energy savings for bakeries and butcher stores can be achieved by split ACs. Condensing units contribute only marginally to the total energy reduction potential. This also applies to split ACs for OFR shops.

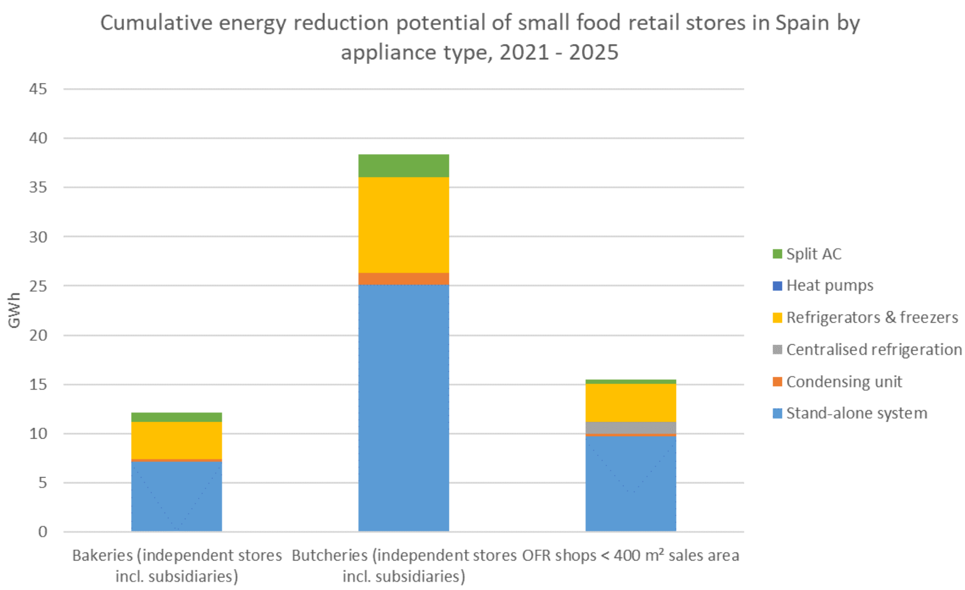

Figure 4-71: Projected cumulative RACHP-related energy reduction potential of selected small food retail stores in Spain from 2021 to 2025.

4.3.3.8.3 HFC consumption

Figure 4-72 shows the total HFC refrigerant consumption of small food retail in Spain by store and appliance type in 2018. As can be seen, HFC was predominantly consumed by conventional small supermarkets (over 70 tonnes) and superettes (around 60 tonnes). Within supermarkets and superettes, most HFC was consumed by centralised refrigeration systems with shares over 90% of total HFC consumption for each store type, followed by minor shares of split ACs (ca. 5 %) and marginal shares by condensing units and heat pumps (both less than 5% per store type). In comparison, the remaining store categories consumed minor amounts of HFC refrigerant. The distributions by these store categories are analysed in the subsequent figure.

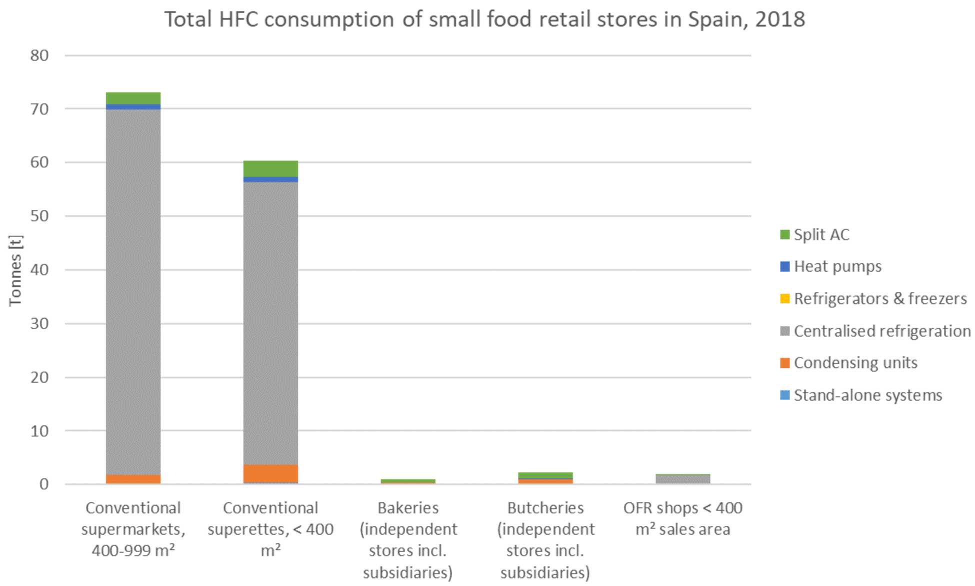

Figure 4-72: Total HFC consumption of small food retail in Spain by store and appliance type in 2018.

Figure 4-73 provides a more detailed overview of the HFC refrigerant consumption by bakeries, butcher stores and OFR shops (sales area below 400 m^2) in 2018. Bakeries consumed around 1 tonne of HFCs, butcher shops and OFR shops each around 2 tonnes. Split ACs were the main consumers of HFC refrigerants in bakeries (ca. 65% of total consumption by store type) and butcher stores (ca. 50%), followed by condensing units (ca. 30% and 40%, respectively), leaving minor share to stand-alone systems (less than 5% each). Stand-alone systems (most recognisable within butcher shops, ca. 3%), refrigerators and freezers as well as heat pumps contributed a marginal share on the total HFC consumption for all observed store categories. Within OFR shops, most HFC was consumed by centralised refrigeration systems with a share of 80%, complemented by minor shares by split ACs and condensing units (ca. 10% each).

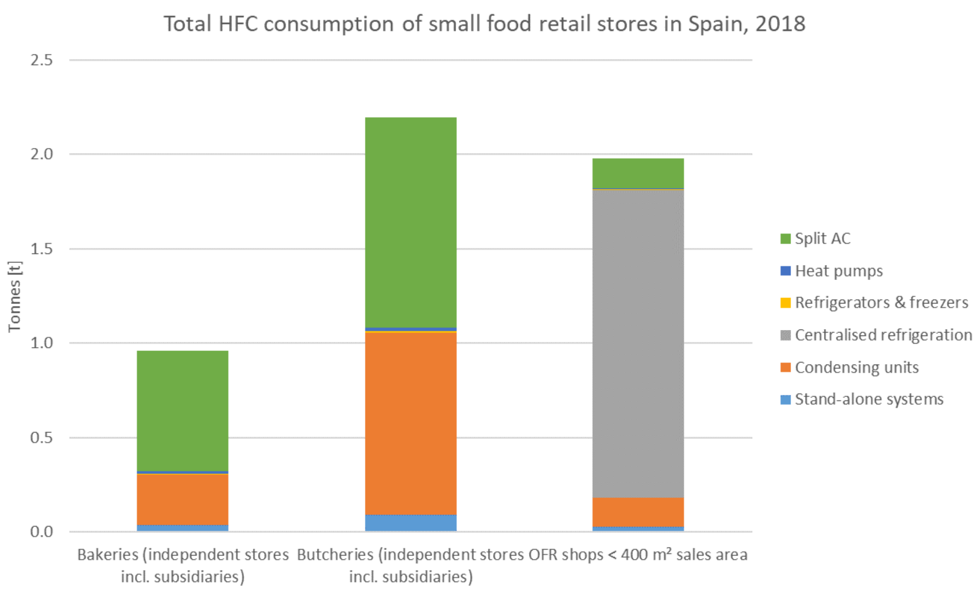

Figure 4-73: Total HFC consumption of selected small food store types in Spain in 2018.

Figure 4-74 shows the cumulative reduction potential of HFC refrigerant consumption within Spain's small food retail for each store and appliance type over the period 2021 to 2025. Conventional superettes offer the greatest potential to reduce their HFC consumption, followed at close range by conventional small supermarkets. Both store types have the greatest potential for reducing HFC consumption in centralised refrigeration systems with shares of about 90%, with remaining shares contributed mainly by split ACs and condensing units, leaving marginal shares to heat pumps and stand-alone systems. The remaining store categories present much lower HFC reduction potential and are analysed more in depth in the subsequent figure.

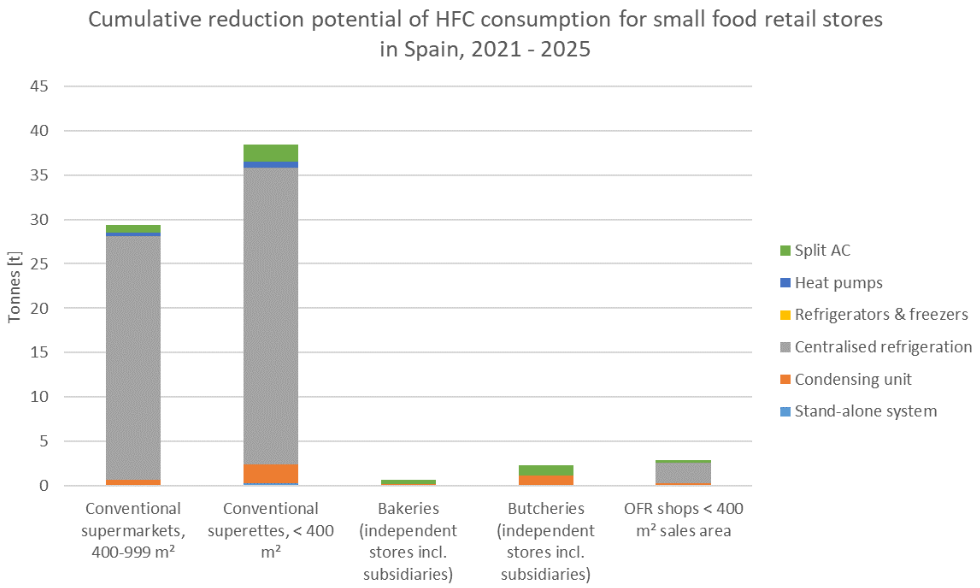

Figure 4-74: Projected cumulative reduction potential of HFC consumption for small food retail in Spain by store and appliance type from 2021 to 2025.

Figure 4-75 shows the cumulative reduction potential of HFC refrigerant consumption for bakeries, butcher stores and OFR shops from 2021 to 2025 in more detail. Split ACs demonstrate the greatest share of the total HFC reduction for bakeries (ca. 65%) and butcher shops (ca. 55%), followed by condensing units (ca. 30% and 40% by store type, respectively) and marginal shares by stand-alone systems, refrigerators and freezers and heat pumps. For OFR shops, the by far greatest reduction potential is offered by centralised refrigeration systems (around 80%). The remaining shares are mainly contributed by split ACs and condensing units (nearly 10% each), leaving marginal further shares to stand-alone systems as well as refrigerators and freezers.

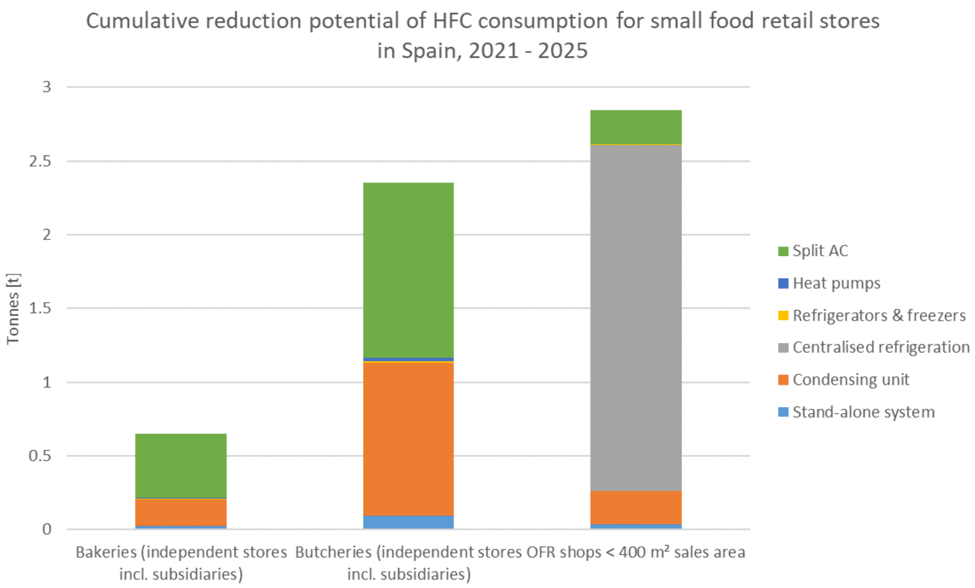

Figure 4-75: Projected cumulative reduction potential of HFC consumption for selected small food retail stores in Spain from 2021 to 2025.

5 Recommendations & Outlook

This report aims at assessing the market size of the small food retail sector, with a specific focus on the organic food retail (OFR) sector in Europe. It has to be noted though that in countries where organic products are well-established on the market, the largest share is typically commercialised through conventional food retail. The data basis established was used to develop a stock model to quantify the GHG emissions associated with refrigeration, air conditioning and heat pump (RACHP) equipment per store type, store size, and country. The performed desktop research took into account primary research and available secondary sources such as third-party studies. In addition, a survey among small store owners and the RACHP servicing sector was carried out, as well as personal interviews being conducted.

The result was a market overview for the small food retail sector (Chapter 2), the OFR sector (Chapter 3), as well as a more qualitative input on important questions regarding purchase decisions, the currently used RACHP stock, and the possible future willingness to opt for more sustainable RACHP solutions (Chapter 4.2). The Stock Model is presented in Chapter 4.3. Despite its data uncertainty (status quo numbers of stores estimated at an accuracy margin of +/-30%), the presented scope of data is unique in the small food retail market segment.

This chapter streamlines and synthesises main findings from the preceding chapters and uses them to provide recommendations. This is to facilitate an easy overview of key market and technology trends collected from research, as well as the interviews and surveys conducted. Moreover, it captures the main findings from the stock model data analysis. A summary table at the end of each sub-chapter provides a synthesis clustering the recommendations according to thematic categories market, technology, environment, financial and the stakeholders affected (store owners, RACHP contracting and servicing, policy makers, etc.). [122]

5.1 Market status and trends in the target sector: Europe's small food retail and OFR sector

A challenging climate for Europe's small food retail sector with high untapped potential

Europe's small food retail sector is diverse, making it challenging to capture the entirety of its market structure and involved actors. Today, markets such as the Netherlands have a low share of small food retail stores as compared to larger store types, whereas countries such as Germany have a more varied mix of small and larger food retail stores, and countries such as Spain, Belgium and Portugal still have a relatively high share of small food stores (see 4.3.3.2). In total, and despite the small food retail sector taking a sales

[122] Please note that for the entire report, all baseline scenarios and projections were based on data available before January 2020. It can be expected that due to the Covid-19 pandemic affecting all European countries, the economic outlook especially for the small food retail sector, including the organic food retail sector, might significantly differ from original projections. Presumably, the consolidation in the food retail sector will continue, making smaller independent shop owners suffer most from the economic recession following the crisis. This new situation, however, cannot be considered in this report as implications on national economies or individual market segments were not known in detail by the time this report was drafted. Forecasts of market growth rates for the entire food retail sector and its sub-categories must therefore be handled with particular care.

share of below 10% from the total food retail sector in most countries, the current contribution of small food retailers especially to Europe's employment rates and value added is high, making a deliberate focus of attention on this sector useful and necessary.

However, while Europe's food retail sector is expected to continue growing over the coming years as a whole, conflicting trends may favour or disfavour the sector's further spread when looking specifically at the future of small food retail in Europe: On one hand, convenience stores (neighbourhood stores, superettes, etc.) are among those store types expected to thrive in the coming years as opposed to large size supermarkets or hypermarkets. This trend is supported by a growing demand for a customised shopping experience and the need for convenience, fresh and regional food in combination with demographic changes favouring smaller urban store concepts (see 2.1.1). On the other hand, the existence of independent or family-led food retail stores will be threatened by competition from retail chains expected to further a consolidation of the European food retail market. In summary, one can expect a move towards less small independent stores run by single store owners or local chains with larger average sales area per store, co-existing next to convenience stores run by larger national or international food retail chains. This will affect general food retailers as well as specialised ones such as artisan bakeries and butcher stores (see 2.1.1, 2.2.1.2).

For all observed trends, however, the lack of reliable data and its ambiguity in terms of defining store types by different sources is a clear obstacle in further analysing and ultimately supporting the needs of small store owners and local chains in i) addressing future requirements related to climate friendly stores and involved cooling equipment and ii) effectively tracking GHG emissions in this sector to contribute to achieving the EU climate targets. Mostly data is available from private research organisations not working in unison, using different baselines, methodologies of data collection and definitions of food retail store types, marketing channels, or store size categories. The resulting gaps or overlaps lead to omissions in a reliable quantification of Europe's small food retail sector and/or its potential double counting (see 1.4.1, 4.3.2).

Close quantitative data gaps & harmonise categorisation of small food retail

R1

To enable a more reliable analysis, and ultimately better support small business owners, both European and national statistical offices, as well as public and private data collection entities, should work in better unison to capture data on Europe's small food retail sector in quantitative terms. The consistent use of categories across food retail sectors and geographic borders would constitute a significant contribution to analysing the small food retail sector, and enable a further sub-classification in terms of food types sold (conventional vs. organic) or marketing channels (bakeries, butcher stores, farm shops, etc.). Ambiguities should be avoided, as well as data overlaps and omissions. A central European database with clear definitions, combined with national reporting obligations, could be one possible implementation method to address the current lack of or inconsistencies in data sets. Another effective way to facilitate data collection is the concerted effort amongst national and European associations representing the interests of the food retail sector in general and each of its sub-categories (see also R2).

Europe's organic food retail market will grow and further consolidate

In the European Union, the market for organic food is constantly growing. Therefore, this sector should be addressing GHG emission reduction activities at the national and/or EU level. With more than one-third of the world's organic food sales occurring in the EU, which has had an average growth rate of 10%+ for sales over the last few years, this segment is expected to take away market shares from conventional food also in the future (see 0, 3.2). Today's organic food retail (OFR) market is mostly concentrated in four countries, among them the RefNat4LIFE project country Germany (3.1.1). Looking at the store types selling organic food, clear differences can be seen between EU countries: while some national markets such as Germany, Belgium and the Netherlands have a diverse mix of sales channels made up of conventional food retailers and specialised OFR channels; in other countries like Spain and Portugal still the smaller, specialised, independent OFR sector dominates. A third country group including Austria, Denmark and Sweden is dominated by large food retail groups selling mostly organic food (see 3.1.2). As visible in the stock model, not only do market shares by store type vary largely from one country to another, but the distribution of OFR stores by sales area also shows distinct differences. While large OFR stores (i.e. sales area > 400 m²) dominate the German OFR market[123] and continue gaining market shares, they have limited relevance in Belgium[124] and the Netherlands[125], and no relevance in Portugal and Spain where most OFR stores have less than 400 m² of sales area.

This difference in the national OFR set-up makes a comparative data analysis challenging, but more importantly, it affects the type and effectiveness of information and support needed per market player. As clear trends similar to the overall development in the small food retail sector show, it can be noted that 1) regional or national specialised OFR chains will increasingly compete with independent shop formats; and that 2) a move towards larger sales areas per store is going to continue. Trends such as the "store-in-store" concept of large hypermarket chains, where a closed thematic world around healthy and organic food can be created inside a larger facility, will also add competition to small food retailers.

As a pronounced drawback, and following on from the overall lack of reliable data on Europe's small food retail sector, the OFR sector is hardly quantifiable in most countries, with some exceptions like in Germany where more detailed statistics on OFR store types and sales areas are readily available. Given its comparatively recent emergence as a separate category, most available statistics do not distinguish between conventional and organic food retail formats. This has led to a situation where either 1) no national data is available on the sales share, the number of stores or the average store size in the OFR sector; and/or 2) available data on this currently small but fast growing sector is already showing distinct differences in the methodologies applied, categories assumed and trends projected. This is in spite of attempts to standardise OFR sales data among those entities collecting data on the OFR market development in leading markets such as Germany; or the existence of dedicated associations for the organic food sector in most European countries. As a result, and adding to the overall lack of clarity in data for the small food retail sector in general, the stock model showing emissions and the potential for reductions developed under the RefNat4LIFE project has to make certain assumptions as regards the

[123] This relation applies for the turnover of OFR stores. In number of stores, 70% of OFR stores had sales areas below 400 m² in 2019. The distribution of total sales area for both store categories is exactly reversed. Similar distributions were identified for France and Italy.
[124] Estimation: Currently 50 OFR stores > 400 m² of sales area, representing 7% of all OFR stores in Belgium.
[125] Estimation: Currently 10 OFR stores > 400 m² of sales area, representing 2% of all OFR stores in the Netherlands.

split between conventional and specialised organic food retail, and the growth rates per marketing channel (see 3.1.2, 4.3.2).

	Increase synergies between market actors to facilitate better data collection on the specialised OFR sector
R2	As a relatively new sub-sector to Europe's food retail sector, the specialised OFR sector, including organic supermarkets, specialised organic stores, organic farm shops and organic bakeries or butcher stores, should use available networks to strengthen data collection on sales and growth trends, the numbers of stores per type and the average sales area. This is basic information needed to quantify not only the entire sub-sector, but also deduce findings needed to improve the competitiveness of all market players. Possible tools to align efforts for data collection could include: 1. creating special organic food working groups inside existing associations (general food retail, bakeries, butcher stores, farm shops etc.); 2. creating a standardised methodology for data collection and categorisation among all European specialised organic food associations with annual concerted efforts to collect such data; 3. facilitating online or other easy-to-use interfaces to allow the specialised OFR sector to enter data on their business.

5.2 RACHP use in the small food retail and OFR sector

Data on the current and future use of refrigeration, air conditioning and heat pump (RACHP) equipment in the European small food retail sector, with a specific focus on the organic food retail, was collected via different sources. A survey, in combination with personal interviews and a literature review of previous studies, was conducted among small food retailers. Together with additional data provided by all project partners, a stock model was developed to quantify the current and projected GHG emissions from the current RACHP stock operated by small food retailers in all five project countries and other selected European markets. The following paragraphs distinguish the lessons learned and recommendations developed from these in the areas of technology, environment, and financing.

As a first overall conclusion, one may infer that differences in nearly all areas affecting the use of RACHP equipment exist if responses are separately analysed for stores with a sales area of below 400 m^2 and those occupying a space of 400-999 m^2. As outlined in more detail in the coming sections, questions surrounding the current and future choice of RACHP technology, familiarity with natural refrigerants and the use of energy efficiency measures differ between these two groups of store sizes. Another decisive difference in results exists between retailers operating a chain of stores, and those with only one or very few stores. This difference is especially pronounced when looking at conventional food retail chains operating convenience stores vs. those operating specialised OFR stores.

Technology: RACHP equipment choice varies by store size and operator. High projected GHG emissions are associated with Europe's small food retail sector

Regarding the RACHP technology currently used in the European small food retail sector, centralised refrigeration systems promise the greatest GHG emissions and related savings potentials (energy consumption and HFC refrigerant use). These centralized, tailor-designed systems for refrigeration (cabinets with various temperature levels), and eventually air conditioning function are used mainly in food retail with sales areas between 400 and 999 m^2. The large emissions savings potential is mainly due to large equipment size with the corresponding high energy consumption and large refrigerant charges, combined with an ongoing abundant use of HFC refrigerants.

Due to the long lifetimes of centralised refrigeration systems, technological transition is rather inert in this sector. To a somewhat reduced extent, the above-mentioned tendencies also apply for condensing units. Retailers operating a greater number of stores with a larger sales area are more likely to adopt centralized refrigeration systems and condensing units The larger category of small food retail stores (400-999 m^2, both conventional and OFR) and partly conventional superettes (sales area < 400 m^2) can also be associated with a wider use of centralised refrigeration systems, many of which also supply centralised air-conditioning. For centralised refrigeration systems, additional measures such as waste heat recovery as well as a heat pump function can also be used to allow for a significant increase in the overall energy efficiency. Moreover, operators with multiple stores adopt blueprinting programmes across the entire chain more easily or at least for certain national markets to roll out a test-and-tried refrigeration technology.

On the other hand, the smaller a food retail store, the more likely is the use of plug-in, stand-alone systems for refrigeration, where the adoption of units such as display cooling cabinets, serve-over counters, or island cases can cover all refrigeration needs (see chapters 4.2.1, and more particularly 4.3.3.4.2 and 4.3.3.5.2). Most new stand-alone systems on the market already use low-GWP refrigerants. Significant energy efficiency improvements are expected for this technology in the future. If space cooling is needed, those stores typically use single-split air conditioners.

However, the relevance of different RACHP appliances for each store category cannot be generalised. Two different approaches for large OFR stores were identified within the scope of the stock model. The first approach is observed in large OFR stores in Germany: These have increasingly been using stand-alone systems and thus alleviate the demand of centralised refrigeration systems and/or condensing units. Only recently, few pilot stores in the OFR market segment started using low-GWP refrigerants also in centralised refrigeration systems and thereby represent a combined approach. For instance, low-temperature refrigeration demands may rather be covered by stand-alone systems. This trend is also a popular strategy for several conventional small supermarkets with rather small sales areas.

In contrast, the largest OFR stores in Belgium have rather focused on optimising the configurations and technical design of centralised refrigeration systems using low-GWP refrigerants. They have been avoiding new installations of stand-alone systems. Regarding other small food store categories, larger appliance types, particularly condensing units, were associated with bakeries, butcher stores and farm shops. This is usually the case if the store is attached to its own local small-size food production or processing facility.

These contrary trends are linked to the heating strategy of food retail stores. The technological focus on centralised refrigeration systems limits internal heat sources in the sales area, so that heating and cooling supplies are entirely controlled by centralised refrigeration systems. From a sustainability perspective with regards to energy consumption and GHG emissions, this configuration favors the use of heat recovery, and eventually an additional heat pump function for heat supply. On the other hand, although a minor effect, stand-alone systems reduce the heating demand and thus allow for a smaller dimensioning of heating systems. Stand-alone (plug-in) appliances are attractive because the store layout can easily be changed, and they entail significantly lower initial investments compared to centralised systems.

Distinguish training campaigns, support measures & technology choice by store size and food retail operator category

R3

For the smallest stores of up to 399 m^2 sales area, especially those operated by independent shop owners or regional (OFR, bakery, butcher store) chains, information should focus on the basic technology choice, the evaluation of installed RACHP units, and the impact of selecting a certain type of RACHP appliance especially from an energy efficiency point of view. The priority technology focus should be put on plug-in units operating in the smallest stores. Given the fact that those stand-alone systems available on the market today often already use low-GWP natural refrigerants, their energy consumption should be highlighted in educational and communication campaigns.

On the other hand, regional or national food retail chains (conventional and OFR / specific), should also be informed about the impact of a technology choice on the chain of stores with regards to GHG emissions and energy use to allow for blueprinting programmes. Given the impact of higher GHG emissions of centralised refrigeration systems, the focus in communication should be both on the direct (refrigerant charge and maintenance) as well as on the indirect (energy consumption) emissions associated with their use.

Technology: Slow adoption of natural refrigerants goes hand in hand with extended lifetime of RACHP equipment and reliance on contracting and servicing companies and distributors in the OFR sector

As regards the current and future adoption of sustainable refrigerants, this is thought to be in unison with the technology adoption rate in Europe's small food retail sector. Currently, fluorinated gases such as R404A, R134a and R410A are used in a majority of air conditioning and centralised refrigeration systems, as well as in older plug-in units. To understand adoption rates and related emissions scenarios, one needs to note that small independent food retailers, including most of the OFR sector, often rely on the extended maintenance of available refrigeration appliances, or even purchase second hand equipment with less sustainable refrigerants. Purchase of new appliances is often also influenced by the duration/renewal of tender contracts for the stores, and by the increasingly frequent changes in store layout. A delay in the adoption of RACHP units which use natural refrigerants is therefore to be expected. Even for regional or national OFR chains, the adoption of natural refrigerants is not as fast as is the case in conventional stores run by larger food retail chains, with only a few pilot projects on centralised refrigeration systems using natural refrigerants (CO_2, propane) having recently started in that sector (see 4.2.3, 4.2.6, 4.2.7). Underlying causes are the significantly higher investment for a centralized system, particularly with CO_2, a significant lack of competent contractors and personnel for such systems.

On the upside, survey results provide a first indication that there are no strong reservations against the use of natural refrigerants like propane (R290), carbon dioxide (CO_2) or isobutane (R600a). This can be partly explained by the lack of expertise on this subject among OFR store owners, but also by a focus on other decision factors such as the RACHP equipment's capital cost when selecting a new technology (see 4.2.7, 4.2.4).

Next to an extended lifetime of RACHP equipment, another reason for the slow adoption rate of more energy efficient RACHP equipment with non-fluorinated gases is the OFR and small food retailers' reliance on external contracting and servicing companies. Most survey respondents use local, often family owned, RACHP contracting and servicing companies for the installation and maintenance of their equipment. A lack of expert knowledge on technology and refrigerant choice, or on the legislative pressure on the energy efficiency and use of non-fluorinated gases in RACHP equipment, will directly translate into a lock-in for the shop owners if inefficient systems using high-GWP substances installed are operated for an above-average lifetime. As a general finding, the more structured a company is in terms of operating a chain of stores the higher the awareness of technology choice, the more likely a roll-out of in-house piloting programmes (see 4.2.3, 1.2.4).

Moreover, in many cases, the larger and more advanced RACHP system manufacturers do not have a direct relationship with the final customer in the case of small independent shop owners, as they use small local contractors or distributors as intermediaries to work with those local RACHP contracting companies.

As a result, the group of RACHP contracting and servicing companies, as well as distributors offering them this technology, are crucial in influencing the future adoption of more sustainable refrigeration and cooling choices in the small specialised food retail sector. While the group of contracting and servicing partners is trusted by store owners to recommend future-proof, energy-efficient RACHP solutions, distributors would need to serve as a two-way communication channel to communicate new technology choices and sustainability features to the RACHP contractor, and provide feedback from the final customer back to the RACHP manufacturer. Given this supply chain and a lack of feedback options, the result is that most RACHP manufacturers do not offer tailored refrigeration and cooling systems for the needs of OFR/small food retail store owners. This does not only affect the design of system types, the choice of materials and other environmental and technical features, but, most importantly, poses a strong barrier in terms of offering preferential financial schemes that could support small food retailers in keeping their competitiveness in a consolidating market (see also section on Finances below).

	Address local RACHP contracting and servicing companies to effectively reach the small shop owners
R4	To effectively reach small, independent shop owners, a dedicated communication, education and engagement campaign with local RACHP contracting and servicing companies which have direct contact with the final client should be initiated. Communication should centre around questions of technology and refrigerant choice available based on cooling and heating needs, the advantages and challenges of using natural refrigerants, legislative requirements regarding energy efficiency and a phase-out of fluorinated gases, and a best-practice maintenance and disposal for RACHP systems. Possible formats include physical workshops, MOOC training courses, short guidance documents and checklists supplied by the RefNat4LIFE project.
	Provide low-entry information and support tools to shop owners on RACHP economic and environmental impact
R5	The second important group to reach for a more effective uptake of energy-efficient low-GWP RACHP systems are the store owners themselves. Given their lack of interest, time and/or expertise in the details of RACHP equipment installed, communication should focus on the most important economic and legal implications of choosing the “wrong” system. This includes a focus on topics such as a comparison of capital cost vs. lifecycle cost and the relevance of energy efficiency as the decisive cost driver for any store owner over an equipment’s normal lifetime. The lifetime, reliability and durability of RACHP systems, in combination with the impact of best-practice maintenance schedules on efficiency and costs, should be mentioned. A focus on the details of natural refrigerants might be less effective, as knowledge and interest in this topic is rather low. Here, basic information on the characteristics and implications could work best. Possible tools to reach small food retailers include: guidance documents on how to choose RACHP technology; case studies to provide examples of similar store formats and the best technology choice available, articles in relevant journals and press; MOOC short tutorials on legislative requirements; and contacts to expert platforms or networks among associations (see R2). In combination, R3 and R4 could activate a pull strategy if small business owners demand more energy-efficient, less harmful RACHP systems, while contractors and

servicing companies could bring systems with a better lifecycle-cost performance ratio to store owners.

Environment: Inefficiencies in RACHP technology choice, maintenance and monitoring impact small food retailers' emissions and competitiveness

Connected to all previous findings, the current climate impact of RACHP equipment in Europe's small food retail sector is significant. Due to great variations in population and food retail structure, the emission shares caused by RACHP appliances per store category are heterogenous across countries. The analysis of RACHP-related emissions across supermarket categories of all sizes (hypermarkets, large and small supermarkets and superettes) emphasises the relevance of the market segment small food retail (sales area below 1000 m²). Together, small supermarkets and superettes contributed approximately 67% of the total RACHP-related GHG emissions of more than 18 Mt CO_2eq contributed by all supermarket store categories including superettes in 19 European countries in 2015. Due to their relatively delayed technological transition and a rather fragmented owner structure, it is expected that the estimated 27% share of RACHP-related GHG emissions caused by superettes in particular contains a significant amount of unexploited emission mitigation potential.

Total GHG emissions caused by operating RACHP equipment in small food retail[126] in the five project countries Belgium, Germany, the Netherlands, Portugal and Spain were estimated to amount to 4.3 Mt CO_2eq in 2015.

If no aimed measures are taken, the total GHG emissions contributed by RACHP equipment in small food retail in the five project countries could still amount to 2.6 Mt CO_2eq in 2025. In any case, RACHP emissions are expected to decrease based on the underlying baseline assumption that all stores must comply with the F-gas regulation, besides minor energy efficiency improvements of RACHP appliances. On the upside, the estimated RACHP-related emissions saving potential is in the range of 0.4 Mt CO_2eq by 2025, corresponding to a cumulative emission reduction of about 1.1 Mt CO_2eq from 2021 to 2025. Most of the emissions saving potential is associated with centralised refrigeration systems, followed by stand-alone systems, as outlined in the report.

As the survey among the small food retail sector indicates, a regular energy efficiency assessment is not currently being carried out in most small stores. This means that an opportunity is being missed in terms of 1) establishing a solid baseline on the European level as regards the current stock of models and their associated energy performance; and 2) supporting store owners in making an informed choice for or against a new RACHP system and the best fitting type for its needs. As a result, many opportunities in increasing energy efficiency by specific features in stores have been missed, with operators of larger stores having invested more into measures such as doors on refrigeration equipment or heat recovery (4.2.5). In general, food retail chains and larger OFR chains mentioned more often that they take a holistic approach on the choice and operation of RAC equipment, where waste heat from refrigeration cycles is recovered and used for heating the store or adjoining offices, or a heat pump function is added to the RAC equipment.

The on-site use of renewable energies, another measure which would reduce the carbon footprint caused by operating RACHP equipment, is not practiced by the majority of survey

[126] Store types below 1,000 m² of sales area including further store types: bakery and butcher shops, other specialised food shops (farm shops, fish shops, cheese/delicatessen shops, poultry shops)

respondents and interviewees. This could be attributed to the fact that small store owners are often tenants in a multi-storey building where the installation of solar panels or wind turbines is not within their influence.

Finally, and as mentioned previously, the extended operation of existing old fashioned RACHP equipment, or the purchase of second hand equipment, could contribute to currently high GHG emissions in the small individual store sector. As examples from personal interviews showed, systems are often operated significantly beyond the lifetime originally projected by the RACHP system manufacturer (4.2.3). While this could be beneficial in terms of avoiding an early disposal and therefore a loss of raw materials, it has a negative impact on the average energy efficiency levels of the currently operating stock. As was analysed by third party studies before, energy efficiency improvements in plug-in refrigeration units could by far outweigh higher costs on the initial purchase (4.2.2). As a result from this lack of data on the average lifetime of equipment in current small food retail stores, the variation in the age of equipment could be significant, making projections in a stock model challenging and prone to large deviations from reality.

As a positive sign, most survey respondents confirmed that their RACHP equipment is maintained every 1-2 years and for some respondents within the larger stores (>400 m²) even more often (4.2.3). This is important to note since a regular maintenance of RACHP equipment constitutes a valid opportunity to 1) gather more data on the existing environmental impact of RACHP equipment; and 2) raise awareness on the implications of choosing a new technology and/or extending the operation of existing equipment. As one German OFR chain confirms, higher investments into a more frequent maintenance of their stand-alone systems has financially paid off via the significantly improved energy performance of their RACHP units.

	Engage with contracting and servicing companies for best-practice maintenance, data collection, reporting & awareness-raising in small stores
R6	Given their important role as a trusted partner for most individual store operators (see also R4), RACHP contracting and servicing companies should be a major focus group of attention to improve the environmental performance on various levels: 1. Technology choice: Contracting and servicing companies could effectively evaluate the (decreasing, low) energy performance and use of high-GWP refrigerants in existing RACHP equipment and recommend a replacement of end of life units to the shop owner. 2. Maintenance for better energy efficiency: Educational measures for servicing companies should also be directed towards best practices in terms of maintenance to improve the energy performance of existing units. 3. Monitoring & reporting: Contracting and servicing companies with regular access to the RACHP equipment are theoretically best placed to record and report back data about the layout and performance of installed units. Data could go to associations and working groups to derive sector-specific and national data sets or benefit the store owner in terms of directly reporting back to such entities. Such data should be used for an update of the developed stock model, and ultimately for a sustainability monitoring system to quantify and improve the environmental impact from cooling and heating. As the administrative requirements for these companies are already significant strong incentives would need to be provided to cover for this additional work. 4. Awareness-raising: Finally, the RACHP servicing company has an important role to play in terms of turning the store owner's attention towards environmental and legal concerns and financial losses associated with the RACHP equipment operation. In this regard, the company can also distribute or advertise guidance

documents, tutorials and other information tools provided specifically for shop owners, such as the ones developed under RefNat4LIFE.

	Focus on chain stores first for a fast replication and scalability of sustainable RACHP concepts and zero-carbon stores
R7	Given the contribution of superettes (convenience stores) and small supermarkets to the current and projected GHG emissions, a first focus to achieve significant emission reductions should be put on those stores operated by local, regional or national chains. To achieve fast replication and scalability, those companies operating multiple OFR stores or supermarkets, bakeries or butcher stores and conventional chain stores should be encouraged to take early measures to achieve a considerable decrease of GHG emissions from operating RACHP equipment. The adoption of renewable energy supply, using doors and remote controls on equipment, the selection of stand-alone and remote refrigeration systems with natural refrigerants, or the use of heat recovery especially in larger stores or those with bordering facilities, are among the topics that should be discussed first. Similarly, if maintenance cycles for RACHP equipment are harmonised and shortened for companies operating multiple stores, the potential for economies of scale can by optimised by improving the energy performance of existing appliances and by replacing poorly performing equipment.

Finances: Reduce upfront cost and maintenance efforts for RACHP equipment with innovative financing schemes optimised for small store owners

As the survey and personal interviews indicate, the initial investment in new RACHP equipment is taking precedence over the consideration of its lifecycle costs in a majority of small food retail stores (see 4.2.2). This is because small business owners are especially competitively challenged by larger retail groups. The latter are often more capable due to a stronger cash flow position, access to specialist resources and applying a long-term perspective on strategic business decisions, including the purchase of equipment for a chain of stores. Economies of scale from higher amounts of RACHP systems bought and maintained, the integration of heating and cooling solutions in a holistic system, or a more direct influence on renewable energy generation if the building is owned by the food retailer, are some of the benefits usually available to operators of larger size and/or chain stores. The focus on the initial cost of purchase, however, might be disadvantageous especially for smaller stores if RACHP units bought at a lower price as this may lead to significantly higher costs over the system's lifetime. This is especially the case when such equipment is operated beyond the usual lifespan as often occurs in small food retail stores. As a secondary factor influencing the decision for energy efficient equipment, high energy costs play a decisive role as an incentivising factor in choosing a low energy-consuming RACHP system.

As a concrete support measure, some, mostly large, RACHP suppliers are now considering the introduction of leasing models for their units to ease this burden of faster replacement of RACHP technology especially in smaller stores. Small business owners would thus be able to pay monthly instalments towards the full price of these systems without the need to obtain bank loans to cover the initial investment.

Models like energy contracting or Cooling as a Service (CaaS; CAAS Initiative, 2020) where the use of cooling is paid instead of the unit providing it are not yet established in the industry but are slowly being considered by RACHP suppliers. In this sort of model, the provision of cooling and heating would be paid by the user via a fixed monthly fee. The monthly fee covers the financing of the cooling system as well as the supplier's servicing and operating costs and margin. The price also includes, when applicable, the premium for the payment guarantee to reduce the risk of payment default. In such a system, the RACHP supplier is tasked with estimating the cooling need and supplying the units providing it. The supplier maintains and optimises the systems to increase its profit margins, benefiting from a regular income stream while minimising operational costs and establishing more solid, long-term relationships with its customers. The supplier can be recapitalised by banks and other investors through innovative mechanisms such as sale-leaseback or dedicated special purpose vehicle (SPV) structures. In its essence, CaaS can create a clear win-win situation where high initial capital costs are replaced by a model to lower the entry burden for small business owners, while promoting more efficient models to cover all cooling needs.

The basis for implementing such strategies include easy monitoring and reporting tools so that small business owners can minimise the effort for collecting the data, while still being able to compare their financial performance in particular with shops of similar sizes and set-ups (see also R6).

	Use leasing schemes, cooling as a service, or other financial models to alleviate financial pressure from small business owners
R8	RACHP system suppliers, servicing and contracting companies should be involved in dedicated initiatives to work on sustainable financing models tailored to the financial capabilities of small business owners. Such models might include leasing schemes, Cooling as a Service (CaaS), or other innovative financial schemes to take away the financial pressure from the initial investment. Special credit schemes or loans for energy efficient RACHP do exist in some European countries but should be reviewed for their effectivity in supporting small food retailers. In addition, RACHP system suppliers and contractors should base their quotations to their customers on the basis of total cost of ownership or life cycle cost, and demonstrate to the small shop owner that an early investment in a more efficient system offsets higher energy costs from a continued use of existing RACHP systems. This message should also be transmitted by any intermediary involved, such as small local contracting companies or energy consultants and auditors in direct contact with the final client.

Bibliography

Agence BIO. (2017). *La Bio dans l'Union Européenne. Edition 2017.* http://www.agencebio.org/sites/default/files/upload/documents/4_Chiffres/BrochureCC/Carnet_UE_2017.pdf

AIBI. (2011). European Bread Market Report 2010. ASSOCIATION INTERNATIONALE DE LA BOULANGERIE INDUSTRIELLE. https://www.aibi.eu/wp-content/uploads/AIBI-Bread-Market-report-2010.pdf

AIBI. (2015). European Bread Market Report 2013. ASSOCIATION INTERNATIONALE DE LA BOULANGERIE INDUSTRIELLE. https://www.aibi.eu/wp-content/uploads/draft-AIBI-Bread-Market-report-2013.pdf

AMI. (2018). *AMI Markt Bilanz Öko-Landbau.* AMI. Bonn. https://www.ami-informiert.de/ami-maerkte/maerkte/ami-maerkte-oekolandbau/meldungen

Beaudelot, A., & Mailleux, M. (2019). *Les chiffres du bio 2018*. https://mk0biowalloniejo431r.kinstacdn.com/wp-content/uploads/2019/05/Le-bio-en-chiffre-2018-final3.pdf

Bionext. (2018). *Trendrapport 2018. Ontwikkelingen in de Biologische Sector.* Ede 2018. https://files.smart.pr/f1/176a685def40eb83f93864f9ccfbce/TRENDRAPPORT-BIOLOGISCHE-SECTOR-2018.pdf

Biowallonie. (2019). *Chiffres du Bio*. https://www.biowallonie.com/chiffres-du-bio/

BMEL. (2013). *Einkaufen direkt auf dem Bauernhof*. https://www.bmel.de/DE/Laendliche-Raeume/Freizeit_Kultur/Direktvermarktung/_texte/EinkaufenBauernhof.html

BNN. (2018). *Bio-Facheinzelhandel. Spezielle Anforderungen an die Kälte.* DUH Fachgespräch, 19.04.2018

BNN. (2020). *Specialized Organic Retail Shops in Germany*. eChillventa. 13.-15.10.2020

BÖLW (2019). *Zahlen.Daten.Fakten. Die Bio-Branche 2019*. https://www.boelw.de/themen/zahlen-fakten/handel/

BÖLW (2020). Branchenreport 2020 Ökologische Lebensmittelwirtschaft. https://www.boelw.de/fileadmin/user_upload/Dokumente/Zahlen_und_Fakten/Brosch%C3%BCre_2020/B%C3%96LW_Branchenreport_2020_web.pdf

Bulwiengesa. (2017). *Marktstudie Lebensmitteleinzelhandel in Deutschland – Marktstrukturdaten 2016.* https://www.bulwiengesa.de/de/studien/lebensmitteleinzelhandel-deutschland-marktstrukturdaten-2016

CAAS (2020). Cooling as a Service Initiative. https://www.caas-initiative.org/

DFV. (2019). Aktuelle Branchendaten – Jahrbuch 2019. Deutscher Fleischer-Verband e.V. https://www.fleischerhandwerk.de/presse/jahrbuch-zahlen-und-fakten.html

DH NET. (2019). *Le nombre de boulangeries wallonnes en recul constant*. https://www.dhnet.be/actu/belgique/le-nombre-de-boulangeries-wallonnes-en-recul-constant-5d11f3e59978e215c700bd7f

District food dynamics. (2020). Online data for Ekoplaza stores. https://distrifooddynamics.nl/

EC (2014). *Bakery and Bake-off. Market Study: Low Energy Ovens. European Commission.* https://issuu.com/fp7leo/docs/bakery_and_bakeoff_market_study

Ecological. (2018). *El Sector Ecológico en España 2018*. https://www.ecological.bio/es/sectorbio2018/

EHI Retail Institute. (2011). *Top 10 der Bio-Bäckereien für Frischbackwaren in Deutschland nach Zahl der eigenen Verkaufsstellen im Jahr 2011*. https://www.handelsdaten.de/lebensmittelhandel/groesste-bio-baeckereien-deutschland-nach-zahl-der-eigenen-verkaufsstellen-2011

EHI Retail Institute. (2018a). *Lebensmittelhandel in Deutschland*. https://www.handelsdaten.de/branchen/lebensmittelhandel

EHI Retail Institute. (2018b). *Nettoumsatz der Lebensmittelgeschäfte in Deutschland 2018 im Vergleich zu 2008 nach Betriebsformen (in Milliarden Euro)*. https://www.handelsdaten.de/lebensmittelhandel/lebensmittelhandel-umsatz-der-lebensmittelgeschaefte-deutschland-nach-0

EHI Retail Institute. (2018c). *Ranking der Backwarenfilialisten in Deutschland nach der Gesamtzahl der Verkaufsstellen in den Jahren 2017 und 2018*. https://www.handelsdaten.de/baeckereien/zahl-verkaufsstellen-groessten-backwarenfilialisten-deutschland-ranking-2018

EHI Retail Institute. (2019a). *Anzahl der Betriebe, Filialen und Bäckereifachgeschäfte im Bäckerhandwerk in Deutschland in den Jahren 2009 bis 2019*. https://www.handelsdaten.de/baeckereien/anzahl-der-baeckereien-deutschland-zeitreihe

EHI Retail Institute. (2019b). *Das Fleischerhandwerk in Deutschland*. https://www.handelsdaten.de/branchen/fleischereien

EHI Retail Institute. (2019c). Forschungsergebnisse zum Energiemanagement im Einzelhandel. Supermarkt-Symposium Webinar. https://www.zvkkw.de/fileadmin/user_upload/01-Chini_EHI2020.pdf

Enova. (2007). Statistics on energy use in Norwegian buildings.

EU. (2009). *Directive 2009/125/EC of the European Parliament and of the Council of 21.October 2009 establishing a framework for the setting of ecodesign requirements for energy related products*. https://eur-lex.europa.eu/legal-content/EN/ALL/?uri=CELEX%3A32009L0125

EU. (2017a). *An overview of harmonized standards used by the Ecodesign Directive and the Energy Labelling Directive*. https://ec.europa.eu/growth/single-market/european-standards/harmonised-standards/ecodesign_en

EU. (2017b). *Regulation (EU) 2017/1369 of 4 July 2017 setting a framework for energy labeling and repealing Directive 2010/30/EU.* https://eur-lex.europa.eu/eli/reg/2017/1369/oj

EU. (2018). *Directive (EU) 2018/2002 of the European Parliament and of the Council of 11 December 2018 amending Directive 2012/27/EU on energy efficiency*. https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=uriserv%3AOJ.L_.2018.328.01.0210.01.ENG

EY, Cambridge Econometrics Ltd., & Arcadia International. (2014). *The economic impact of modern retail choice innovation EU food sector*. https://ec.europa.eu/competition/sectors/agriculture/retail_study_report_en.pdf

Ferreira, Duarte Pinheiro, de Brito, Mateus (2020). *Relating carbon and energy intensity of best-performing retailers with policy, strategy and building practice.* https://link.springer.com/article/10.1007/s12053-020-09840-0?shared-article-renderer

FiBL (2016). *Organic in Europe: Prospects and developments 2016*. https://shop.fibl.org/chde/mwdownloads/download/link/id/767/

FiBL (2020) Data set for European organic retail sales. https://statistics.fibl.org/europe/retail-sales-europe.html

FiBl & IFOAM. (2020) *The World of Organic Agriculture. Statistics and Emerging Trends 2020*. https://www.fibl.org/fileadmin/documents/shop/5011-organic-world-2020.pdf

Food & Drinks (2018). *Data & Trends EU Food & Drink Industry 2018*. https://www.fooddrinkeurope.eu/uploads/publications_documents/FoodDrinkEurope_Data_and_Trends_2018_FINAL.pdf

Forte, F. (2019). *Leading organic supermarket chains in Spain as of June 2019, by quantity of stores*. https://www.statista.com/statistics/729573/leading-enterprises-of-organic-goods-in-spain-by-stores/

Fraunhofer ISI. (2013). *Energieverbrauch des Sektors Gewerbe, Handel, Dienstleistungen (GHD)*. https://www.bmwi.de/Redaktion/DE/Publikationen/Studien/sondererhebung-zur-nutzung-erneuerbarer-energien-im-gdh-sektor-2010.pdf?__blob=publicationFile&v=7

GHG Protocol and Carbon Trust Team (2013). *Technical Guidance for Calculating Scope 3 Emissions (version 1.0).* https://ghgprotocol.org/sites/default/files/standards/Scope3_Calculation_Guidance_0.pdf

GIZ/HEAT (2018). *Non-state action towards climate-friendly and energy-efficient cooling.* https://newclimate.org/wp-content/uploads/2018/08/GIZ_C4_non_state_action_green_cooling.pdf

Gondola. (2017a). *Nielsen: Les supermarchés de taille moyenne (F2) grappillent des parts de marché aux F1 et hard discounters*. https://www.gondola.be/fr/news/nielsen-les-supermarches-de-taille-moyenne-f2-grappillent-des-parts-de-marche-aux-f1-et-hard

HDE. (2019). *Zahlenspiegel 2019.* Handelsverband Deutschland. August 2019. https://einzelhandel.de/publikationen-hde/zahlenspiegel

Henrich, P. (2019). *Statistiken zu Lebensmittel-Discountern*. https://de.statista.com/themen/1291/lebensmittel-discounter/

Heubes, J. and Papst, I. (2014) NAMAs in the refrigeration, air conditioning and foam sectors. A technical handbook Module 1 - Inventory. https://mia.giz.de/qlink/ID=245486000

IEA, 2020, Data and statistics: Electricity and heat. International Energy Agency. https://www.iea.org/data-and-statistics/data-tables?country=WORLD

IFI. (2019). GHG Accounting for Grid Connected Renewable Energy Projects. International Financial Institutions Technical Working Group on Greenhouse Gas Accounting. https://unfccc.int/sites/default/files/resource/Renewable%20Energy_GHG%20accounting%20approach.pdf

IGD. (2018). *European grocery retail market to be worth €2,289 billion by 2022*. https://www.igd.com/articles/article-viewer/t/european-grocery-retail-market-to-be-worth-2289-billion-by-2022/i/18614

INE. (2016). Instituto Nacional de Estatística, Portugal.

Kantar. (2018). *El Gran Consumo crece un 1,3% en 2017*. https://www.kantarworldpanel.com/es/Noticias/el-gran-consumo-crece-un-13-en-2017

Karamour. Sawalha, Arias (2016). Eco-friendly supermarkets - an overview. SuperSmart project, Report 2. http://www.supersmart-supermarket.info/s/2-eco-friendly-supermarkets-an-overview.pdf

MAPA (2018a). Datos Estadísticos de la Producción Ecológica. Informe del Consumo Alimentario en España en 2018. Ministerio de Agricultura, Pesca y Alimentación de España. https://www.mapa.gob.es/es/alimentacion/temas/produccion-eco/Copia_de_default.aspx

MAPA (2018b). Informe del Consumo Alimentario en España en 2018. Ministerio de Agricultura, Pesca y Alimentación de España. https://www.mapa.gob.es/es/alimentacion/temas/produccion-eco/Copia_de_default.aspx

Mercasa. (2016). Alimentación en España – Estructura del comercio minorista. http://mercasa-ediciones.es/alimentacion_2016/pdfs/Datos%20Basicos/Estructura_del_comercio_minorista.pdf

Ministerio de agricultura. (2019). *Agricultura ecológica estadísticas 2018*. https://www.agroecologia.net/wp-content/uploads/2019/10/estadisticaspe2018_tcm30-513741.pdf

Mordor Intelligence. (2020). Air Conditioner Market – Growth, Trends, and Forecast (2020-2025). https://www.mordorintelligence.com/industry-reports/air-conditioner-market

Myhre, Shindell, Bréon, Collins, Fuglestvedt, Huang, Koch, Lamarque, Lee, Mendoza, Nakajima, Robock, Stephens, Takemura, Zhang (2013). *Anthropogenic and Natural Radiative Forcing*. In: Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA. https://www.ipcc.ch/site/assets/uploads/2018/02/WG1AR5_Chapter08_FINAL.pdf

Natex Bio. (2016). La distribution des produits naturels et bio en Belgique. https://www.natexbio.com/distribution-produits-naturels-bio-belgique/

NHH (2018). *Food Research Project.* NHH NORWEGIAN SCHOOL OF ECONOMICS. https://www.nhh.no/en/research-centres/food/food-news/2018/march/strong-european-grocery-growth/

Nielsen. (2014). *Grocery Universe 2014 – Belgium.*

Nielsen. (2017). *Grocery Universe 2017 – Belgium*. (Report includes Europe-wide set of data). https://www.nielsen.com/be/en/insights/report/2017/nielsen-grocery-universe-2017/

Norwegian Environment Agency. (2017). *Study on environmental and health effects of HFO refrigerants*. https://www.miljodirektoratet.no/globalassets/publikasjoner/M917/M917.pdf

Penman, J., Gytarsky, M., Hiraishi, T., Irving, W. and Krug, T. (2006). *2006 IPCC Guidelines for National Greenhouse Gas Inventories - Chapter 7 Emissions of Fluorinated substitutes for ozone depleting substances*. http://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/0_Overview/V0_1_Overview.pdf

Planet Retail RNG. (2017). *Store of the Future*. https://lp.planetretail.net/rs/895-ENN-359/images/SOTF%20Final%2011%2010%202017.pdf

Retail Detail. (2019). *Le marché bio belge poursuit sa croissance*. https://www.retaildetail.be/fr/news/food/le-marché-bio-belge-poursuit-sa-croissance

Retail Insiders. (2020). Food specialty shops. https://www.retailinsiders.nl/branches/foodspeciaalzaken/

Ritchie, Roser. (2017). *Meat and Dairy Production.* Our World in Data, last revision in 2019. https://ourworldindata.org/meat-production

RTBF. (2019a). *L'offre d'enseignes bio explose, la production belge peut-elle suivre?* https://www.rtbf.be/info/economie/detail_l-offre-d-enseignes-bio-explose-la-production-belge-peut-elle-suivre?id=10246109

RTBF. (2019b). *Magasins bio à Bruxelles: Y a-t-il de la place pour tout le monde?* https://www.rtbf.be/info/regions/bruxelles/detail_magasins-bio-a-bruxelles-y-a-t-il-de-la-place-pour-tout-le-monde?id=10271440

Schönberger, H., Martos, J. L. G., & Styles, D. (2013). Best environmental management practice in the retail trade sector learning from frontrunners. https://doi.org/10.2791/1775

shecco (2018). *Technical report on energy efficiency in HFC-free supermarket refrigeration.* https://eia-international.org/wp-content/uploads/EIA-report-Energy-efficiency-in-HFC-free-supermarket-refrig-single-pages-for-print.pdf

SPW. (2019). Consommation d'aliments issus de l'agriculture biologique. http://etat.environnement.wallonie.be/contents/indicatorsheets/MEN%206.html

SNI NET (2019). *Chaque semaine, une boucherie ferme en Belgique!* https://www.sninet.be/fr/archives-de-presse/detail/chaque-semaine-une-boucherie-ferme-en-belgique

Steinmaßl, J. (2014). *Plug-in refrigerated cabinets in food retail: Stock-power consumption-potential savings*. https://steinmaszl.com/studie-1/vorschau?path=studie_na_EN.pdf

SuperSmart project. (2016). *Eco-friendly supermarkets – an overview. Report 2.* October 2016. https://www.supersmart-supermarket.info/s/2-eco-friendly-supermarkets-an-overview.pdf

Tassou, S.A., Ge, Y., Hadawey, A., Marriott, D (2011). *Energy consumption and conservation in food retailing.* https://hal.archives-ouvertes.fr/hal-00692330/document

UN (2019). CDM Methodology Booklet https://cdm.unfccc.int/methodologies/documentation/2003/CDM-Methodology-Booklet_fullversion.pdf

Wunsch, N.-G. (2019). *Organic retail sales value in the European Union and Europe from 2004 to 2017*. https://www.statista.com/statistics/541536/organic-retail-sales-value-european-union-europe-statistic/

ZDB. (2020). Bäckerhandwerk in Deutschland: Strukturzahlen 2012 bis 2019. Zentralverband des Deutschen Bäckerhandwerks e. V. https://www.baeckerhandwerk.de/baeckerhandwerk/zahlen-fakten/

Zion Market Research (2019). *Air Conditioning Market By Product (Room/Unitary Air Conditioners, Chillers, VRF Systems, Coolers, and Others), By Component (Compressor, Evaporator, Fan, and Condenser Coil), By Technology (Automatic Air Conditioning, Manual/Semi-Automatic Air Conditioning, Invertor, Split A/C, and Others), and By End-User (Commercial, Residential, Industrial, and Others): Global Industry Perspective, Comprehensive Analysis, and Forecast, 2018–2025,* https://www.zionmarketresearch.com/sample/the-air-conditioning-market

Extended explanation of Methodology and assumptions

The modelled GHG emissions for the stock model result from indirect emissions (electricity consumption of RACHP appliances, multiplied by a national grid emission factor for the carbon intensity of power production) as well as from direct emissions. The latter is the product of leakage of refrigerant gases and their respective Global Warming Potential (GWP). The stock model exclusively accounts direct emissions in use which occur during operation and servicing. Potential emissions during installation and at the end of life of the RACHP appliances are not included. The GWP values are taken from the 5th IPCC Assessment Report (Myhre et al., 2013).

The calculation of GHG emissions is in conformity with the methodology of GHG Protocol Scope 3. Particularly, the calculation method adheres to the relevant Category 11 – Emissions concerning the use of sold products. The GHG Protocol methodology does not contain requirements regarding the formulation of a MIT scenario. The GHG emission calculations also are broadly consistent[127] with the methodology established by the UNFCCC Clean Development Mechanism (CDM) (UN, 2019). As the project scope focuses on the RACHP appliance level operated in food retail stores, the transmission and distribution losses in the electricity supply grid remain unconsidered in the GHG emission modelling, other than within the scope of the CDM methodology. In contrast, the IPCC Tier 2 methodology from 2006 with the concepts outlined by Heubes et al. (2014) and Penman et al. (2006) includes the entire appliance lifecycle, accounting direct GHG emissions from installation (initial emissions) through operation (in-use/servicing emissions) until decommissioning (end of life emissions) the appliances.

In order to assess the GHG emission reductions in the relevant RACHP sub-sectors, a business-as-usual (BAU) scenario was defined and compared with a mitigation (MIT) scenario that includes the assumptions related to a technically feasible market uptake of best available technology. The total mitigation potential is the difference between the calculated GHG emissions of both scenarios.

In order to develop realistic scenarios, a profound inventory process to collect appliance-based primary and secondary data was carried out. Within this scope, desk research, expert consultations and interviews (including inputs by country partners, branch-specific umbrella organisations, leading OFR retailers, manufacturers, trade fair contacts) and a comprehensive data survey for small retailers with focus on OFR and for RACHP contracting and servicing companies were conducted. The stock model is based on a profound market analysis with the result of characteristic values concerning stores (sizes and typical appliances), stock of appliances by store type, technical specifications of appliances with different energy efficiency performance levels, refrigerant use and market trends. Ultimately, the stock model allows future projections by forming a BAU scenario feeding input into a dynamic database to calculate emissions. Underlying the mitigation (MIT) scenario, higher energy efficiencies and faster uptake of low-GWP, natural refrigerants are assumed after year 2020, resulting in reduced GHG emissions. A comprehensive GHG emission stock model for the relevant RACHP sub-sectors was developed for the RefNat partner countries Belgium, Germany, Netherlands, Portugal and

[127] In the referenced Tool 29, the CDM methodology requests very stringent baseline benchmarks. By applying this highly limiting benchmark precondition, only marginal mitigation potential of indirect emissions will remain. For these reasons, the baseline benchmarking in the present_GHG emission calculations follow the previouslymentioned option to adjust the EE assumptions according to the MEPS, although in reality the 90th percentile is much higher and would therefore be the required approach for complying with the CDM methodology on indirect emission modelling.

Spain, and additionally for France and Italy which represent important further markets. An extended overview of basic store categories (general food retail) is provided for a selection of 16 major EU countries plus Norway, Switzerland and the United Kingdom, denominated as “EU 16 + 3”.

Following a bottom-up approach, data of the appliance numbers was gathered in order to account for direct and indirect emissions of the RACHP appliances stock during their use. GHG emissions occurring during installation and at end of life are not covered within this stock model.

The direct and indirect GHG emissions derived from market and appliance-based data describe the total emissions associated with small food retail and are distinguished by specific store type within the scope of the stock model. On an appliance level, the annual GHG emissions for a single RACHP unit can be calculated as follows:

Emissions due to electricity consumption (indirect emissions)[128]:

$$Annual\ Indirect\ GHG\ Emissions = \frac{Cooling\ Capacity}{Energy\ Efficiency} \times Load\ factor \times Annual\ Runtime\ Hours \times Grid\ Emission\ Factor = \frac{CC}{EER} \times \beta \times t \times GEF$$

<u>Input parameters:</u>

$CC: Cooling\ Capacity\ [kW]$

$EER: Energy\ Efficiency\ Ratio\ \left[\frac{kW}{kW}\right]$

$\beta: Load\ factor\ [-]$

$t: Annual\ Runtime\ Hours\ \left[\frac{h}{a}\right]$

$GEF: Grid\ Emission\ Factor\ \left[\frac{kg_{CO2eq}}{kWh}\right]$

<u>Output:</u>

$Annual\ Indirect\ GHG\ Emissions\ \left[\frac{kg_{CO2eq}}{a}\right]$

Emissions due to the leakage of refrigerant (direct emissions)[129]:

$$Annual\ Direct\ GHG\ Emissions = Initial\ Charge\ Size \times Refrigerant\ Leakage \times Global\ Warming\ Potential\ of\ Refrigerant = m \times EF_{Operation} \times GWP$$

[128] Excluding transmission and distribution losses of the electricity grid

[129] Excluding emissions occurring during the installation and after end of useful life

Input parameters:

$m: Initital\ Charge\ Size\ [kg]$

$EF_{Operation}: Annual\ Leakage\ Rate\ during\ operation\ based\ on\ initial\ charge\ \left[\frac{\%}{a}\right]$

$GWP: Global\ Warming\ Potential\ \left[\frac{kg_{CO2eq}}{kg}\right]$

Output:

$Annual\ Direct\ GHG\ Emissions\ \left[\frac{kg_{CO2eq}}{a}\right]$

Based on these two principle equations, market-wide GHG emissions can be calculated under given conditions and a defined time period using a dynamic data-processing model.

Assumed sector parameters

The following table shows the quantified stores by country and store category including their projection until 2025 for selected years.

Table A-1: Number of stores in small food retail used in the stock model by store type and country for the years 2015, 2018, 2020, 2022 and 2025.[130]

Country	Store type	2015	2018	2020	2022	2025
Belgium	Conventional supermarkets, 400-999 m²	2,047	2,131	2,195	2,262	2,313
	Conventional superettes (< 400 m²)	1,069	976	938	901	874
	Bakeries	3,733	4,632	5,163	5,556	6,200
	Butcher stores	3,645	3,441	3,344	3,280	3,188
	Other specialised food shops (incl. farm shops)	5,939	5,706	5,592	5,518	5,409
	OFR shops 400-999 m² sales area	32	42	50	55	63

[130] Sources: Conventional supermarkets and superettes: INE, 2016 (Portugal), Mercasa, 2016 (Spain), Nielsen, 2017 (all others); Bakery stores: DH Net, 2019 (Belgium), ZDB, 2020 (Germany), Retail Insiders, 2020 (Netherlands), EC, 2014 (all others); Butcher stores: SNI Net, 2019 (Belgium), DFV, 2019 (Germany), Retail Insiders, 2020 (Netherlands), Estimation based on butcher stores per habitant in other project countries (all others); Other specialised food shops: Shecco, 2020 and Nielsen, 2017 (Belgium), BNN, 2020 (Germany), Retail Insiders, 2020 (Netherlands); OFR: Natex Bio, 2016 and survey within this project (Belgium), BNN, 2020 (Germany), Bionext, 2018 and District food dynamics, 2020 (Netherlands), Agrobio, 2020 (Portugal), SEAE, 2020 (Spain)

Country	Store type	2015	2018	2020	2022	2025
	OFR shops < 400 m² sales area	399	524	625	684	782
Germany	Conventional supermarkets, 400-999 m²	19,305	18,960	18,771	18,583	18,444
	Conventional superettes (< 400 m²)	1,703	1,313	1,136	982	883
	Bakeries	44,154	46,000	46,940	47,579	48,553
	Butcher stores	20,039	19,667	19,483	19,361	19,180
	Other specialised food shops (incl. farm shops)	35,704	36,785	37,339	37,713	38,282
	OFR shops 400-999 m² sales area	543	718	806	905	988
	OFR shops < 400 m² sales area	1,884	1,812	1,761	1,711	1,674
Netherlands	Conventional supermarkets, 400-999 m²	2,873	2,810	2,782	2,754	2,734
	Conventional superettes (< 400 m²)	299	293	290	287	285
	Bakeries	3,943	3,838	3,787	3,753	3,703
	Butcher stores	1,711	1,780	1,816	1,840	1,877
	Other specialised food shops (incl. farm shops)	2,296	2,285	2,280	2,277	2,272
	OFR shops 400-999 m² sales area	9	10	10	10	11
	OFR shops < 400 m² sales area	380	403	415	423	435
Portugal	Conventional supermarkets, 400-999 m²	1,117	1,083	1,072	1,062	1,054
	Conventional superettes (< 400 m²)	1,097	1,159	1,206	1,254	1,292
	Bakeries	6,330	6,142	6,050	5,990	5,901
	Butcher stores	2,311	2,242	2,209	2,187	2,154
	Other specialised food shops (incl. farm shops)					
	OFR shops 400-999 m² sales area	0	0	0	0	0
	OFR shops < 400 m² sales area	32	42	49	54	63
Spain	Conventional supermarkets, 400-999 m²	6,114	5,707	5,537	5,372	5,252

Country	Store type	2015	2018	2020	2022	2025
	Conventional superettes (< 400 m²)	10,209	9,528	9,245	8,970	8,769
	Bakeries	7,505	5,471	4,678	4,222	3,620
	Butcher stores	10,163	9,654	9,409	9,250	9,016
	Other specialised food shops (incl. farm shops)	0	0	0	0	0
	OFR shops 400-999 m² sales area	0	0	0	0	0
	OFR shops < 400 m² sales area	1,120	1,394	1,553	1,664	1,846

The following table shows the quantified RACHP appliances by country, store category and appliance type including their projection until 2025 for selected years. These numbers are the result of the numbers of stores (table above) multiplied by the appliances attributed to each store (see Table 4-5).

Notes:

- Central refrigeration systems: Based on the default cooling capacity of 20 kW, and also reflecting the corresponding refrigerant initial charge, the numbers of central refrigeration systems per store type and country were scaled to this unit size.
- Refrigerators and freezers are usually designed with non-transparent openings and are, besides households, typically found in storage areas of commercial businesses with no customer access.

Table A-2: Number of RACHP appliances in small food retail used in the stock model by country, store type and appliance type for the years 2015, 2018, 2020, 2022 and 2025.

Coun-try	Store type	Appl. type	2015	2018	2020	2022	2025
Belgium	Conv. supermarkets, 400-999 m²	Stand-alone systems	14,739	15,342	15,806	16,284	16,653
	Conventional superettes (< 400 m²)		8,014	7,323	7,033	6,755	6,554
	Bakeries		4,193	5,203	5,799	6,240	6,964
	Butcher stores		6,059	5,720	5,558	5,453	5,299
	Other specialised food shops (incl. farm shops)		5,939	5,706	5,592	5,518	5,409
	OFR shops 400-999 m² sales area		36	48	57	62	71
	OFR shops < 400 m² sales area		1,326	1,740	2,074	2,269	2,596
Germany	Conv. supermarkets, 400-999 m²	Stand-alone	138,999	136,510	135,148	133,800	132,799

Coun-try	Store type	Appl. type	2015	2018	2020	2022	2025
	Conventional superettes (< 400 m²)		12,772	9,849	8,518	7,367	6,621
	Bakeries		49,592	51,666	52,722	53,439	54,533
	Butcher stores		33,308	32,691	32,384	32,182	31,881
	Other specialised food shops (incl. farm shops)		35,704	36,785	37,339	37,713	38,282
	OFR shops 400-999 m² sales area		6,491	8,593	9,645	10,826	11,820
	OFR shops < 400 m² sales area		9,072	8,724	8,477	8,237	8,062
Netherlands	Conv. supermarkets, 400-999 m²	Stand-alone systems	17,181	16,806	16,638	16,472	16,349
	Conventional superettes (< 400 m²)		1,853	1,812	1,794	1,776	1,763
	Bakeries		4,428	4,311	4,253	4,215	4,159
	Butcher stores		2,843	2,959	3,019	3,059	3,120
	Other specialised food shops (incl. farm shops)		2,296	2,285	2,280	2,277	2,272
	OFR shops 400-999 m² sales area		38	40	41	42	43
	OFR shops < 400 m² sales area		1,521	1,612	1,659	1,691	1,740
Portugal	Conv. supermarkets, 400-999 m²	Stand-alone systems	8,043	7,798	7,720	7,643	7,586
	Conventional superettes (< 400 m²)		8,230	8,691	9,042	9,407	9,692
	Bakeries		7,110	6,899	6,796	6,728	6,627
	Butcher stores		3,841	3,727	3,672	3,635	3,581
	Other specialised food shops (incl. farm shops)		0	0	0	0	0
	OFR shops 400-999 m² sales area		0	0	0	0	0
	OFR shops < 400 m² sales area		106	140	164	181	210
Spain	Conv. supermarkets, 400-999 m²	Stand-alone systems	44,021	41,087	39,864	38,677	37,813
	Conventional superettes (< 400 m²)		76,566	71,464	69,336	67,271	65,769
	Bakeries		8,429	6,145	5,254	4,742	4,065

Coun-try	Store type	Appl. type	2015	2018	2020	2022	2025
	Butcher stores		16,894	16,047	15,640	15,375	14,986
	Other specialised food shops (incl. farm shops)		0	0	0	0	0
	OFR shops 400-999 m² sales area		0	0	0	0	0
	OFR shops < 400 m² sales area		3,718	4,628	5,154	5,523	6,127
Belgium	Conv. supermarkets, 400-999 m²	Condensing units	2,047	2,131	2,195	2,262	2,313
	Conventional superettes (< 400 m²)		1,069	976	938	901	874
	Bakeries		485	602	671	722	806
	Butcher stores		984	929	903	886	861
	Other specialised food shops (incl. farm shops)		1,485	1,426	1,398	1,380	1,352
	OFR shops 400-999 m² sales area		0	0	1	1	1
	OFR shops < 400 m² sales area		121	159	189	207	237
Germany	Conv. supermarkets, 400-999 m²	Condensing units	19,305	18,960	18,771	18,583	18,444
	Conventional superettes (< 400 m²)		1,703	1,313	1,136	982	883
	Bakeries		5,740	5,980	6,102	6,185	6,312
	Butcher stores		5,410	5,310	5,260	5,227	5,179
	Other specialised food shops (incl. farm shops)		8,926	9,196	9,335	9,428	9,570
	OFR shops 400-999 m² sales area		173	229	257	288	315
	OFR shops < 400 m² sales area		1,256	1,208	1,174	1,140	1,116
Netherlands	Conv. supermarkets, 400-999 m²	Condensing units	2,864	2,801	2,773	2,745	2,725
	Conventional superettes (< 400 m²)		618	604	598	592	588
	Bakeries		513	499	492	488	481
	Butcher stores		462	481	490	497	507
	Other specialised food shops (incl. farm shops)		574	571	570	569	568

Coun-try	Store type	Appl. type	2015	2018	2020	2022	2025
	OFR shops 400-999 m² sales area		0	0	0	0	0
	OFR shops < 400 m² sales area		380	403	415	423	435
Portugal	Conv. supermarkets, 400-999 m²	Condensing units	1,117	1,083	1,072	1,062	1,054
	Conventional superettes (< 400 m²)		1,097	1,159	1,206	1,254	1,292
	Bakeries		823	798	787	779	767
	Butcher stores		624	605	596	590	582
	Other specialised food shops (incl. farm shops)		0	0	0	0	0
	OFR shops 400-999 m² sales area		0	0	0	0	0
	OFR shops < 400 m² sales area		10	13	15	17	19
Spain	Conv. supermarkets, 400-999 m²	Condensing units	6,114	5,707	5,537	5,372	5,252
	Conventional superettes (< 400 m²)		10,209	9,528	9,245	8,970	8,769
	Bakeries		976	711	608	549	471
	Butcher stores		2,744	2,607	2,540	2,497	2,434
	Other specialised food shops (incl. farm shops)		0	0	0	0	0
	OFR shops 400-999 m² sales area		0	0	0	0	0
	OFR shops < 400 m² sales area		339	423	471	504	559
Belgium	Conv. supermarkets, 400-999 m²	Centralised refrigeration	9,791	10,192	10,500	10,817	11,063
	Conventional superettes (< 400 m²)		1,870	1,709	1,641	1,576	1,529
	Bakeries		0	0	0	0	0
	Butcher stores		0	0	0	0	0
	Other specialised food shops (incl. farm shops)		1,485	1,426	1,398	1,380	1,352
	OFR shops 400-999 m² sales area		46	60	72	79	90
	OFR shops < 400 m² sales area		140	184	220	240	275

Coun-try	Store type	Appl. type	2015	2018	2020	2022	2025
Germany	Conv. supermarkets, 400-999 m²	Centralised refrigeration	92,337	90,683	89,778	88,883	88,218
	Conventional superettes (< 400 m²)		2,980	2,298	1,988	1,719	1,545
	Bakeries		0	0	0	0	0
	Butcher stores		0	0	0	0	0
	Other specialised food shops (incl. farm shops)		8,926	9,196	9,335	9,428	9,570
	OFR shops 400-999 m² sales area		653	865	971	1,090	1,190
	OFR shops < 400 m² sales area		558	537	522	507	496
Netherlands	Conv. supermarkets, 400-999 m²	Centralised refrigeration	7,159	7,002	6,933	6,863	6,812
	Conventional superettes (< 400 m²)		201	196	194	192	191
	Bakeries		0	0	0	0	0
	Butcher stores		0	0	0	0	0
	Other specialised food shops (incl. farm shops)		574	571	570	569	568
	OFR shops 400-999 m² sales area		12	13	13	13	13
	OFR shops < 400 m² sales area		133	141	145	148	152
Portugal	Conv. supermarkets, 400-999 m²	Centralised refrigeration	5,343	5,180	5,128	5,077	5,039
	Conventional superettes (< 400 m²)		1,920	1,947	2,110	2,195	2,261
	Bakeries		0	0	0	0	0
	Butcher stores		0	0	0	0	0
	Other specialised food shops (incl. farm shops)		0	0	0	0	0
	OFR shops 400-999 m² sales area		0	0	0	0	0
	OFR shops < 400 m² sales area		11	12	17	19	22
Spain	Conv. supermarkets, 400-999 m²	Centralised refrig	29,243	27,294	26,481	25,693	25,119

Country	Store type	Appl. type	2015	2018	2020	2022	2025
	Conventional superettes (< 400 m²)		17,865	16,675	16,178	15,697	15,346
	Bakeries		0	0	0	0	0
	Butcher stores		0	0	0	0	0
	Other specialised food shops (incl. farm shops)		0	0	0	0	0
	OFR shops 400-999 m² sales area		0	0	0	0	0
	OFR shops < 400 m² sales area		394	490	546	585	649
Belgium	Conv. supermarkets, 400-999 m²	Refrigerators & freezers	2,047	2,131	2,195	2,262	2,313
Belgium	Conventional superettes (< 400 m²)	Refrigerators & freezers	1,069	976	938	901	874
Belgium	Bakeries	Refrigerators & freezers	7,213	8,950	9,976	10,733	11,979
Belgium	Butcher stores	Refrigerators & freezers	7,659	7,230	7,025	6,892	6,698
Belgium	Other specialised food shops (incl. farm shops)	Refrigerators & freezers	14,848	14,264	13,981	13,796	13,523
Belgium	OFR shops 400-999 m² sales area	Refrigerators & freezers	224	294	350	383	438
Belgium	OFR shops < 400 m² sales area	Refrigerators & freezers	1,709	2,243	2,674	2,925	3,347
Germany	Conv. supermarkets, 400-999 m²	Refrigerators & freezers	19,305	18,960	18,771	18,583	18,444
Germany	Conventional superettes (< 400 m²)	Refrigerators & freezers	1,703	1,313	1,136	982	883
Germany	Bakeries	Refrigerators & freezers	85,305	88,872	90,688	91,922	93,804
Germany	Butcher stores	Refrigerators & freezers	42,101	41,320	40,933	40,678	40,297
Germany	Other specialised food shops (incl. farm shops)	Refrigerators & freezers	89,259	91,963	93,347	94,283	95,705
Germany	OFR shops 400-999 m² sales area	Refrigerators & freezers	2,557	3,386	3,800	4,265	4,657
Germany	OFR shops < 400 m² sales area	Refrigerators & freezers	5,862	5,637	5,477	5,322	5,209
Netherlands	Conv. supermarkets, 400-999 m²	Refrigerators & f	5,727	5,602	5,546	5,491	5,450

Coun-try	Store type	Appl. type	2015	2018	2020	2022	2025
	Conventional superettes (< 400 m²)		3	3	3	3	3
	Bakeries		7,617	7,416	7,316	7,251	7,154
	Butcher stores		3,594	3,741	3,815	3,866	3,944
	Other specialised food shops (incl. farm shops)		5,740	5,714	5,701	5,692	5,679
	OFR shops 400-999 m² sales area		19	20	21	21	22
	OFR shops < 400 m² sales area		1,141	1,209	1,244	1,268	1,305
Portugal	Conv. supermarkets, 400-999 m²	Refrigerators & freezers	1,117	1,083	1,072	1,062	1,054
	Conventional superettes (< 400 m²)		1,097	1,159	1,206	1,254	1,292
	Bakeries		12,230	11,867	11,689	11,573	11,400
	Butcher stores		4,856	4,711	4,641	4,595	4,526
	Other specialised food shops (incl. farm shops)		0	0	0	0	0
	OFR shops 400-999 m² sales area		0	0	0	0	0
	OFR shops < 400 m² sales area		137	181	211	233	270
Spain	Conv. supermarkets, 400-999 m²	Refrigerators & freezers	6,114	5,707	5,537	5,372	5,252
	Conventional superettes (< 400 m²)		10,209	9,528	9,245	8,970	8,769
	Bakeries		14,500	10,570	9,038	8,156	6,993
	Butcher stores		21,353	20,283	19,768	19,434	18,942
	Other specialised food shops (incl. farm shops)		0	0	0	0	0
	OFR shops 400-999 m² sales area		0	0	0	0	0
	OFR shops < 400 m² sales area		4,793	5,966	6,644	7,120	7,899
Belgium	Conv. supermarkets, 400-999 m²	Heat pumps	4,094	4,262	4,391	4,523	4,626
	Conventional superettes (< 400 m²)		1,069	976	938	901	874
	Bakeries		68	84	94	101	113

Coun-try	Store type	Appl. type	2015	2018	2020	2022	2025
	Butcher stores		66	63	61	60	58
	Other specialised food shops (incl. farm shops)		108	104	102	100	98
	OFR shops 400-999 m² sales area		3	4	5	5	6
	OFR shops < 400 m² sales area		7	10	11	12	14
Germany	Conv. supermarkets, 400-999 m²	Heat pumps	38,611	37,919	37,541	37,167	36,889
	Conventional superettes (< 400 m²)		1,703	1,313	1,136	982	883
	Bakeries		803	836	853	865	883
	Butcher stores		364	358	354	352	349
	Other specialised food shops (incl. farm shops)		649	669	679	686	696
	OFR shops 400-999 m² sales area		1,085	1,437	1,612	1,810	1,976
	OFR shops < 400 m² sales area		140	134	130	127	124
Netherlands	Conv. supermarkets, 400-999 m²	Heat pumps	2,864	2,801	2,773	2,745	2,725
	Conventional superettes (< 400 m²)		309	302	299	296	294
	Bakeries		72	70	69	68	67
	Butcher stores		31	32	33	33	34
	Other specialised food shops (incl. farm shops)		42	42	41	41	41
	OFR shops 400-999 m² sales area		9	10	10	10	11
	OFR shops < 400 m² sales area		7	7	8	8	8
Portugal	Conv. supermarkets, 400-999 m²	Heat pumps	2,234	2,166	2,144	2,123	2,107
	Conventional superettes (< 400 m²)		1,097	1,159	1,206	1,254	1,292
	Bakeries		115	112	110	109	107
	Butcher stores		42	41	40	40	39
	Other specialised food shops (incl. farm shops)		0	0	0	0	0

Coun-try	Store type	Appl. type	2015	2018	2020	2022	2025
	OFR shops 400-999 m² sales area		0	0	0	0	0
	OFR shops < 400 m² sales area		1	1	1	1	1
Spain	Conv. supermarkets, 400-999 m²	Heat pumps	12,228	11,413	11,073	10,744	10,504
	Conventional superettes (< 400 m²)		10,209	9,528	9,245	8,970	8,769
	Bakeries		136	99	85	77	66
	Butcher stores		185	176	171	168	164
	Other specialised food shops (incl. farm shops)		0	0	0	0	0
	OFR shops 400-999 m² sales area		0	0	0	0	0
	OFR shops < 400 m² sales area		20	25	28	30	34
Belgium	Conv. supermarkets, 400-999 m²	Split AC	6,141	6,393	6,586	6,785	6,939
	Conventional superettes (< 400 m²)		2,137	1,953	1,875	1,801	1,748
	Bakeries		2,579	3,200	3,567	3,838	4,283
	Butcher stores		2,518	2,377	2,310	2,266	2,202
	Other specialised food shops (incl. farm shops)		4,103	3,942	3,863	3,812	3,737
	OFR shops 400-999 m² sales area		0	0	1	1	1
	OFR shops < 400 m² sales area		276	362	432	472	540
Germany	Conv. supermarkets, 400-999 m²	Split AC	57,916	56,879	56,312	55,750	55,333
	Conventional superettes (< 400 m²)		3,406	2,626	2,272	1,965	1,766
	Bakeries		30,503	31,778	32,428	32,869	33,542
	Butcher stores		13,843	13,587	13,459	13,375	13,250
	Other specialised food shops (incl. farm shops)		24,665	25,413	25,795	26,054	26,446
	OFR shops 400-999 m² sales area		1,628	2,155	2,419	2,715	2,964
	OFR shops < 400 m² sales area		837	804	782	760	743

Coun-try	Store type	Appl. type	2015	2018	2020	2022	2025
Netherlands	Conv. supermarkets, 400-999 m²	Split AC	2,864	2,801	2,773	2,745	2,725
	Conventional superettes (< 400 m²)		309	302	299	296	294
	Bakeries		2,724	2,652	2,616	2,593	2,558
	Butcher stores		1,182	1,230	1,255	1,271	1,297
	Other specialised food shops (incl. farm shops)		1,586	1,579	1,575	1,573	1,569
	OFR shops 400-999 m² sales area		9	10	10	10	11
	OFR shops < 400 m² sales area		190	202	207	211	217
Portugal	Conv. supermarkets, 400-999 m²	Split AC	3,351	3,249	3,217	3,185	3,161
	Conventional superettes (< 400 m²)		2,195	2,317	2,411	2,509	2,585
	Bakeries		4,373	4,243	4,180	4,138	4,076
	Butcher stores		1,597	1,549	1,526	1,511	1,488
	Other specialised food shops (incl. farm shops)		0	0	0	0	0
	OFR shops 400-999 m² sales area		0	0	0	0	0
	OFR shops < 400 m² sales area		22	29	34	38	44
Spain	Conv. supermarkets, 400-999 m²	Split AC	18,342	17,120	16,610	16,115	15,755
	Conventional superettes (< 400 m²)		20,418	19,057	18,490	17,939	17,538
	Bakeries		5,185	3,780	3,232	2,917	2,501
	Butcher stores		7,021	6,669	6,500	6,390	6,229
	Other specialised food shops (incl. farm shops)		0	0	0	0	0
	OFR shops 400-999 m² sales area		0	0	0	0	0
	OFR shops < 400 m² sales area		774	963	1,073	1,150	1,275

Based on the specific categorising of stores for each country, the growth of stores has been assumed as presented in the following table. As far as the available data would allow, the compound annual growth rates were calculated from the total number in two different years in order to increase the representation of the resulting growth trend. When no absolute data was available, market indicators from statistics or sector studies were used. To avoid exaggerations of sector growth, harmonised rates were used in several cases, or a combined approach between historic growth and market indicators was applied. A phased approach is used for the years 2020 onward by assuming two reductions of annual growth rates by 50%.

Table A-3: Assumed compound annual growth rates of small food stores by store category and country[131]

Country	Store type	2010-2016	2017-2019	2020-2022	2023-2025
Belgium	Conventional supermarkets, 400-999 m²	1.0%	1.5%	1.5%	0.8%
	Conventional supermarkets < 400 m²	-4.9%	-2.0%	-2.0%	-1.0%
	Organic food retail	9.2%	9.2%	4.6%	4.6%
	Bakeries	7.5%	7.5%	3.7%	3.7%
	Butcher stores	-1.9%	-1.9%	-1.0%	-1.0%
	Other special. food shops (incl. farm shops)	-1.3%	-1.3%	-0.7%	-0.7%
Germany	Conventional supermarkets, 400-999 m²	-0.8%	-0.5%	-0.5%	-0.3%
	Conventional supermarkets < 400 m²	-10.8%	-7.0%	-7.0%	-3.5%
	Organic food retail, 400-999 m²	10.5%	5.9%	5.9%	3.0%
	Organic food retail < 400 m²	-1.2%	-1.4%	-1.4%	-0.7%
	Bakeries	1.4%	1.4%	0.7%	0.7%
	Butcher stores	-0.6%	-0.6%	-0.3%	-0.3%
	Other special. food shops (incl. farm shops)	1.0%	1.0%	0.5%	0.5%
Netherlands	Conventional supermarkets, 400-999 m²	-1.2%	-0.5%	-0.5%	-0.3%
	Conventional supermarkets < 400 m²	-1,2%	-0.5%	-0.5%	-0.3%
	Organic food retail, 400-999 m²	1.9%	1.9%	1.0%	1.0%
	Organic food retail < 400 m²	1.9%	1.9%	1.0%	1.0%
	Bakeries	-0.9%	-0.9%	-0.4%	-0.4%
	Butcher stores	1.3%	1.3%	0.7%	0.7%
	Other special. food shops (incl. farm shops)	-0.2%	-0.2%	-0.1%	-0.1%
Portugal	Conventional supermarkets, 400-999 m²	-0.8%	-0.5%	-0.5%	-0.3%
	Conventional supermarkets < 400 m²	1.5%	2.0%	2.0%	1.0%
	Organic food retail	10.1%	10.1%	5.0%	5.0%
	Bakeries	-1.0%	-1.0%	-0.5%	-0.5%
	Butcher stores	-1.0%	-1.0%	-0.5%	-0.5%

[131] Sources: 2010 to 2016: CAGR calculated over the largest time span of years with available data; Germany's bakeries and butcher stores based on sales numbers; 2017-2019: conventional supermarkets of both size categories assumed on NHH (2018), other store categories assumed to remain constant until 2019, OFR shops with one data only were assumed from indicators for organic retail growth by (FiBL, 2020a), multiplied with organic sales channel share; 2020-2022: 50% reduction of prior annual growth rate assumed for all store categories except conventional supermarkets; 2023-2025: 50% reduction of prior annual growth rate assumed for conventional supermarkets only.

Country	Store type	2010-2016	2017-2019	2020-2022	2023-2025
Spain	Conventional supermarkets, 400-999 m²	-3.8%	-1.5%	-1.5%	-0.8%
	Conventional supermarkets < 400 m²	-3.8%	-1.5%	-1.5%	-0.8%
	Organic food retail	7.0%	7.0%	3.5%	3.5%
	Bakeries	-10.0%	-10.0%	-5.0%	-5.0%
	Butcher stores	-1.7%	-1.7%	-0.9%	-0.9%
France	Conventional supermarkets, 400-999 m²	-1.5%	-0.2%	-0.2%	-0.1%
	Conventional supermarkets < 400 m²	-1.5%	-0.2%	-0.2%	-0.1%
	Organic food retail	5.3%	5.3%	2.6%	2.6%
	Bakeries	0%	0%	0%	0%
	Butcher stores	-1.0%	-1.0%	-0.5%	-0.5%
Italy	Conventional supermarkets, 400-999 m²	-4.9%	-2.2%	-2.2%	-1.1%
	Conventional supermarkets < 400 m²	-4.9%	-2.2%	-2.2%	-1.1%
	Organic food retail	2.1%	2.1%	1.1%	1.1%
	Bakeries	2.7%	2.7%	1.4%	1.4%
	Butcher stores	-0.5%	-0.5%	-0.2%	-0.2%

Energy efficiency ratios (EER) were assumed as shown in the following table for the appliance and store types of each country, presented in 5-year increments with the assumptions in the MIT scenario on the right side. The model was established based on a market study of typical products in 2019. For the development of the future projection, the presented energy efficiency (EE) characteristics up until 2025 are assumed to increase its EE classification in the range of C to D for the BAU scenario, and to EE class A for the MIT scenario. For stand-alone systems, refrigerators and freezers, the energy modelling was based on total energy consumption instead of EER values (see subsequent table), in conformity with the common declaration of appliance data and reference values in the EU regulations. For simplification reasons and given the limited data available, these assumptions were made for all countries.

Table A-4: Energy efficiency ratio (EER) parameters for the RACHP appliance stock in BAU and MIT scenarios [Watt per Watt][132]

Appliance type	Store type(s)	BAU scenario				MIT
		2015	2019	2020	2025	2025
Condensing unit	Conventional Supermarkets 400-999 m²	3.33	3.49	3.53	3.81	3.91
	Conventional superettes (< 400 m²)	3.17	3.29	3.32	3.55	3.68
	Bakeries, butcher stores, other specialised food shops (incl. farm shops)	3.01	3.09	3.11	3.29	3.42
	OFR shops 400-999 m² sales area	3.17	3.29	3.32	3.55	3.68

[132] Source: Assumptions based on EU regulative framework (minimum energy performance standards, energy labelling)

	OFR shops < 400 m² sales area	3.01	3.09	3.11	3.29	3.42
Centralised refrigeration	Conventional Supermarkets 400-999 m²	3.19	3.35	3.39	3.67	3.77
	Conventional superettes (< 400 m²)	3.13	3.25	3.28	3.51	3.64
	Bakeries, butcher stores, other specialised food shops (incl. farm shops)	3.07	3.15	3.17	3.35	3.48
	OFR shops 400-999 m² sales area	3.13	3.25	3.28	3.51	3.64
	OFR shops < 400 m² sales area	3.07	3.15	3.17	3.35	3.48
Heat pumps	Conventional Supermarkets 400-999 m²	2.72	2.80	2.82	2.92	3.22
	Conventional superettes (< 400 m²)	2.54	2.60	2.62	2.70	3.01
	Bakeries. Butcher stores. other specialised food shops (incl. farm shops)	2.46	2.50	2.51	2.59	2.83
	OFR shops 400-999 m² sales area	2.54	2.60	2.62	2.70	3.01
	OFR shops < 400 m² sales area	2.46	2.50	2.51	2.59	2.83
Split AC	Conventional Supermarkets 400-999 m²	3.80	3.90	3.93	4.05	4.34
	Conventional superettes (< 400 m²)	3.72	3.80	3.82	3.92	4.22
	Bakeries. Butcher stores. other specialised food shops (incl. farm shops)	3.66	3.70	3.71	3.76	4.03
	OFR shops 400-999 m² sales area	3.72	3.80	3.82	3.92	4.22
	OFR shops < 400 m² sales area	3.66	3.70	3.71	3.76	4.03

Table A-5: Energy consumption parameters for the RACHP appliance stock in BAU and MIT scenarios [kWh/a][133]

Appliance type	Store type(s)	BAU scenario				MIT
		2015	2019	2020	2025	2025
Stand-alone system	Conv. Supermarkets 400-999 m²	2,548	2,284	2,226	1,920	1,408
	Conventional superettes (< 400 m²)	2,704	2,500	2,454	2,119	1,567

[133] Source: Assumptions based on EU regulative framework (minimum energy performance standards, energy labelling)

	Bakeries, butcher stores, other specialised food shops (incl. farm shops)	2,945	2,761	2,718	2,345	1,748
	OFR shops 400-999 m^2 sales area	2,704	2,500	2,454	2,119	1,567
	OFR shops < 400 m^2 sales area	2,945	2,761	2,718	2,345	1,748
Refrigerators and freezers	Conv. Supermarkets 400-999 m^2	946	892	880	808	626
	Conventional superettes (< 400 m^2)	960	914	903	844	654
	Bakeries, butcher stores, other specialised food shops (incl. farm shops)	1,001	960	950	896	703
	OFR shops 400-999 m^2 sales area	960	914	903	844	654
	OFR shops < 400 m^2 sales area	1,001	960	950	896	703

The following table shows the assumed distribution of relevant refrigerant types among the total appliance stock for each appliance and store category, assumed equally across all five partner countries. A progressive ongoing transition to low-GWP refrigerants was assumed for conventional supermarkets and for large OFR stores, leaving relatively low potential for additional emission mitigation effects in the MIT scenario. For the remaining store categories, significant differences between BAU and MIT were assumed for the point in time when the remaining store categories will tackle a comprehensive transition to low-GWP refrigerants and thus offer notable mitigation potential per unit (kg) of refrigerant charge. Therefore, the BAU scenario was aligned with the requirements by the EU F-gas regulation. However, refrigerators and freezers have already largely converted to the low-GWP refrigerant R600a. For simplification reasons and given the limited data available, these assumptions were made equally for all countries.

Table A-6: Assumed refrigerant distribution for the RACHP appliance stock in BAU and MIT scenarios[134]

Appliance type	Store type(s)	Refrigerant	BAU scenario			MIT
			2015	2019	2025	2025
Stand-alone systems	Conventional Supermarkets 400-999 m^2	R134a	40%	20%	2%	0%
		R404A	51%	35%	8%	0%
		R290	5%	25%	66%	70%
		R600a	2%	12%	14%	17%
		R744	2%	8%	10%	13%
		R134a	20%	17%	10%	5%

[134] Sources: Survey within this project, HEAT database, STEK/KNVvK, own judgement

Appliance type	Store type(s)	Refrigerant	BAU scenario			MIT
			2015	2019	2025	2025
Condensing units	Conventional Supermarkets 400-999 m^2	R404A	79%	75%	40%	15%
		R290	0%	3%	15%	33%
		R744	1%	5%	35%	47%
Centralised refrigeration	Conventional Supermarkets 400-999 m^2	R134a	28%	27%	15%	3%
		R404A	65%	64%	51%	14%
		R407C	2%	2%	2%	1%
		R507A	5%	5%	5%	2%
		R290	0%	0%	2%	15%
		R744	0%	2%	25%	65%
Refrigerators & freezers	Conv. Supermarkets 400-999 m^2	R600a	100%	100%	100%	100%
Heat pumps	Conventional Supermarkets 400-999 m^2	R410A	100%	98%	90%	45%
		R290	0%	0%	1%	12%
		R744	0%	1%	5%	38%
		R32	0%	1%	4%	5%
Split AC	Conventional Supermarkets 400-999 m^2	R407C	15%	20%	22%	7%
		R410A	85%	80%	68%	25%
		R290	0%	0%	0%	30%
		R744A	0%	0%	0%	3%
		R32	0%	0%	10%	35%
Stand-alone systems	Conventional superettes (< 400 m^2)	R134a	44%	30%	10%	5%
		R404A	55%	50%	25%	10%
		R290	1%	12%	45%	60%
		R600a	0%	5%	15%	15%
		R744	0%	3%	5%	10%
Condensing units	Conventional superettes (< 400 m^2)	R134a	20%	20%	15%	10%
		R404A	80%	79%	60%	40%
		R290	0%	0%	7%	20%
		R744	0%	1%	18%	30%
		R134a	28%	25%	18%	12%

Appliance type	Store type(s)	Refrigerant	BAU scenario			MIT
			2015	2019	2025	2025
Centralised refrigeration	Conventional superettes (< 400 m²)	R404A	65%	65%	60%	36%
		R407C	2%	0%	0%	0%
		R507A	5%	5%	4%	2%
		R290	0%	0%	3%	10%
		R744	0%	5%	15%	40%
Refrigerators & freezers	Conventional superettes (< 400 m²)	R134a	5%	1%	0%	0%
		R404A	10%	3%	0%	0%
		R600a	85%	96%	100%	100%
Heat pumps	Conventional superettes (< 400 m²)	R410A	100%	100%	98%	56%
		R290	0%	0%	0%	3%
		R744	0%	0%	1%	35%
		R32	0%	0%	1%	6%
Split AC	Conventional superettes (< 400 m²)	R407C	10%	10%	8%	7%
		R410A	90%	89%	52%	45%
		R290	0%	0%	7%	20%
		R32	0%	1%	33%	28%
Stand-alone systems	Bakeries, other specialised food shops (incl. farm shops)	R134a	60%	55%	27%	15%
		R404A	40%	35%	23%	5%
		R290	0%	7%	34%	60%
		R600a	0%	2%	12%	12%
		R744	0%	1%	4%	8%
Condensing units	Bakeries, other specialised food shops (incl. farm shops)	R134a	20%	20%	15%	10%
		R404A	80%	79%	60%	40%
		R290	0%	0%	7%	20%
		R744	0%	1%	18%	30%
Centralised refrigeration	Bakeries, other specialised food shops (incl. farm shops)	R134a	28%	25%	18%	12%
		R404A	65%	65%	60%	36%
		R407C	2%	0%	0%	0%
		R507A	5%	5%	4%	2%
		R290	0%	0%	3%	10%

Appliance type	Store type(s)	Refrigerant	BAU scenario			MIT
			2015	2019	2025	2025
		R744	0%	5%	15%	40%
Refrigerators & freezers	Bakeries, other specialised food shops (incl. farm shops)	R134a	1%	0%	0%	0%
		R404A	3%	0%	0%	0%
		R600a	96%	100%	100%	100%
Heat pumps	Bakeries, other specialised food shops (incl. farm shops)	R410A	100%	98%	62%	56%
		R290	0%	0%	1%	3%
		R744	0%	1%	30%	35%
		R32	0%	1%	7%	6%
Split AC	Bakeries, other specialised food shops (incl. farm shops)	R407C	10%	10%	7%	6%
		R410A	90%	89%	70%	54%
		R290	0%	0%	3%	22%
		R744	0%	0%	0%	0%
		R32	0%	1%	20%	18%
Stand-alone systems	Butcher stores	R134a	44%	40%	20%	5%
		R404A	55%	48%	30%	10%
		R290	1%	8%	40%	60%
		R600a	0%	3%	7%	15%
		R744	0%	1%	3%	10%
Condensing units	Butcher stores	R134a	20%	20%	15%	10%
		R404A	80%	79%	60%	40%
		R290	0%	0%	7%	20%
		R744	0%	1%	18%	30%
Centralised refrigeration	Butcher stores	R134a	28%	25%	18%	12%
		R404A	65%	65%	60%	36%
		R407C	2%	0%	0%	0%
		R507A	5%	5%	4%	2%
		R290	0%	0%	3%	10%
		R744	0%	5%	15%	40%
Refrigerators & freezers	Butcher stores	R134a	1%	0%	0%	0%
		R404A	3%	0%	0%	0%

Appliance type	Store type(s)	Refrigerant	BAU scenario			MIT
			2015	2019	2025	2025
		R600a	96%	100%	100%	100%
Heat pumps	Butcher stores	R410A	100%	98%	62%	56%
		R290	0%	0%	1%	3%
		R744	0%	1%	30%	35%
		R32	0%	1%	7%	6%
Split AC	Butcher stores	R407C	10%	10%	7%	6%
		R410A	90%	89%	70%	54%
		R290	0%	0%	3%	22%
		R32	0%	1%	20%	18%
Stand-alone systems	OFR shops 400-999 m² sales area	R134a	44%	30%	10%	3%
		R404A	55%	45%	15%	7%
		R290	1%	15%	50%	65%
		R600a	0%	7%	15%	15%
		R744	0%	3%	10%	10%
Condensing units	OFR shops 400-999 m² sales area	R134a	20%	17%	10%	5%
		R404A	80%	75%	40%	15%
		R290	0%	3%	15%	30%
		R744	0%	5%	35%	50%
Centralised refrigeration	OFR shops 400-999 m² sales area	R134a	28%	23%	16%	15%
		R404A	65%	60%	50%	25%
		R407C	2%	0%	0%	0%
		R507A	5%	5%	4%	0%
		R290	0%	2%	5%	12%
		R744	0%	10%	25%	48%
Refrigerators & freezers	OFR shops 400-999 m² sales area	R600a	100%	100%	100%	100%
Heat pumps	OFR shops 400-999 m² sales area	R410A	100%	98%	62%	50%
		R290	0%	0%	1%	8%
		R744	0%	1%	30%	36%
		R32	0%	1%	7%	6%

Appliance type	Store type(s)	Refrigerant	BAU scenario			MIT
			2015	2019	2025	2025
Split AC	OFR shops 400-999 m^2 sales area	R407C	10%	10%	8%	5%
		R410A	90%	89%	52%	40%
		R290	0%	0%	7%	27%
		R744	0%	0%	0%	1%
		R32	0%	1%	33%	27%
Stand-alone systems	OFR shops < 400 m^2 sales area	R134a	44%	40%	20%	0%
		R404A	55%	48%	30%	5%
		R290	1%	8%	40%	40%
		R600a	0%	3%	7%	27%
		R744	0%	1%	3%	1%
Condensing units	OFR shops < 400 m^2 sales area	R134a	20%	20%	15%	5%
		R404A	80%	79%	60%	10%
		R290	0%	0%	7%	60%
		R600a	0%	0%	0%	15%
		R744	0%	1%	18%	10%
Centralised refrigeration	OFR shops < 400 m^2 sales area	R134a	28%	25%	18%	12%
		R404A	65%	65%	60%	36%
		R407C	2%	0%	0%	0%
		R507A	5%	5%	4%	2%
		R290	0%	0%	3%	10%
		R744	0%	5%	15%	40%
Refrigerators & freezers	OFR shops < 400 m^2 sales area	R134a	1%	0%	0%	0%
		R404A	3%	0%	0%	0%
		R600a	96%	100%	100%	100%
Heat pumps	OFR shops < 400 m^2 sales area	R410A	100%	98%	62%	56%
		R290	0%	0%	1%	3%
		R744	0%	1%	30%	35%
		R32	0%	1%	7%	6%
Split AC		R407C	10%	10%	7%	6%
		R410A	90%	89%	70%	54%

Appliance type	Store type(s)	Refrigerant	BAU scenario			MIT
			2015	2019	2025	2025
	OFR shops < 400 m² sales area	R290	0%	0%	3%	22%
		R32	0%	1%	20%	18%

Get in touch
www.refnat4life.eu
#RefNat4LIFE
info@refnat4life.eu

The Refrigerants, Naturally! for LIFE project has received funding from the LIFE Programme of the European Union, project number: LIFE18 GIC/DE/001104