Understanding the market need for skills in alternative refrigerants with low global warming potential in the EU region - A comprehensive survey on Refrigerant Emissions And Leakage (REAL) alternatives programme

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ABSTRACT

The widespread adoption of low GWP alternative refrigerants across Europe is critical to achieving long-term carbon reduction emissions from the Refrigeration, Air Conditioning and Heat Pump (RACHP) sector. The RACHP sector has been identified as being responsible for significant greenhouse gas emissions through direct emission (leakage of high GWP refrigerants) and indirect emissions (energy use). The changes to EU's Fluorinated greenhouse gases (F-gas) regulation No 517/2014, which came to force since 1st January 2015, has enacted restrictions on the use of halocarbon refrigerants in certain applications with the intent of reducing the F-gas associated emissions in the EU region. There are currently inconsistent levels of knowledge and awareness of how alternative refrigerants can be sustainably procured and utilised. This paper provides an understanding of the needs for skills in some European countries, specifically covering the general overview of the "as installed" RAC use, the current training provision, the potential use and status of alternative refrigerants and recommendations on procurement process. Furthermore, the paper discusses the availability of skills and existing training materials and template in specific European countries.

1. Introduction

The Refrigeration, Air Conditioning and Heat Pumps (RACHP) industry underpins most things in many areas that we all come across in our daily lives. For instance, without heat and cold, the food supply would still be seasonal and limited to non-consumables produced locally; data centres would not work; comfortable living conditions would be challenging; Zero carbon heating would not be an option, and some medical advances would be impossible. Trends show that the use of refrigeration will continue to overgrow in the future, especially in developing countries, where around 81% of the world's population is located [Ciconkov, 2018].

Over the years, the design of refrigeration system components and equipment, such as heat exchangers, compressors, fans, pumps, refrigerant, and expansion valves, has been significantly improved with extensive research and development work. However; as of the recent years, RACHP industry still represented more than 17% of world electricity consumption [Coulomb, 2016]. This is due to the fact that, the improvements being made are gradual as modern vapour compression cooling technology is already near to its basic energy efficiency limit. As the transition to a low carbon economy is being made, there are significant environmental and economic benefits to developing low GWP alternative refrigerants that reduce energy consumption and carbon emissions.

The REAL alternatives programme, which is part of the EU Leonardo lifelong learning programme for vocational education was set up with the aim of developing new blended learning material for European training providers to meet the need to address skills shortages and share resources in this area. It is a critical environmental objective for the refrigeration and air conditioning sectors to rapidly move to replace the undesired high GWP F-gas refrigerants with desired low GWP refrigerants to reduce the projected 70 Mt of CO_2 emissions from the sector by 2030 at an average cost of less than 20 Euro/t of CO_2 equivalent abated [European Commission, 2011].

It should be noted that there are varieties of different refrigerants, which are sub-categorised (as Chlorofluorocarbons (CFC), Hydrochlorofluorocarbons (HCFC), Hydrofluorocarbons (HFC), Unsaturated Hydrofluorocarbons (u-HFCs), Unsaturated Hydrofluorocarbons blends, Hydrocarbons (HC) and Natural refrigerants) due to their make-up. The presence of harmful substances such as CFCs and HCFCs in the lower atmosphere have increasingly threatened the environment, as well as human health and safety, over the past century [Kasaeian et al, 2018].

According to European Commission Report, 2016, safety levels must be maintained and risks minimised, but standards, codes and legislation must be adapted to technological progress and allow the use of more climate-friendly alternatives. Therefore, natural refrigerants such as ammonia, carbon dioxide and hydrocarbons, are the best suited alternatives for HFCs and HCFC, but there are some limitations (i.e. toxicity, flammability, and poor material compatibility) which can potentially be addressed through proper product design and adequate maintenance of the equipment.

Each refrigerant has different characteristics regarding operation abilities and environmental impacts. As the operational abilities limit refrigerants to particular uses, the environmental impacts have resulted in some refrigerants being outlawed while others are being restricted. Therefore, for some current HFC applications, alternative options are not readily available, and low flammable blends and u-HFCs are best proposed as a possible future development. However Environmental impacts of these refrigerants need to be considered to ensure environmentally friendliness and longevity of the systems. This is because, currently there are proven inconsistent levels of knowledge and awareness on how alternative refrigerants can be used sustainably [Ciconkov, 2018].

In order to understand the implications of the revised F-gas regulation on likelihood to drive the interests and use of alternative refrigerants, the local information on the current and likely use of the future alternative refrigerants in each specific country was collected and analysed. The collected information include standards and training, guidance materials, EU legislations and national legislation which are aligned with the applicable EC directives.

The survey results will continue supporting effective implementation of the EU F-gas Regulation requirements in order for information to be made available (by member states) to installation operatives on low GWP alternative refrigerant technologies. This will support the reduction of carbon emissions in line with the climate change policy, LIFE climate actions in governance and information, and climate change mitigation.

Therefore, this paper addresses knowledge, awareness and skills barriers to ensure rapid and widespread adoption of low GWP alternative refrigerants throughout Europe by providing recommendations on procurement process together with reliable, unbiased, consistent and up-to-date training materials linked to an extensive train the trainer programme.

2. Initial survey

This paper provides an understanding of the needs for the low GWP refrigerants handling skills in the partner countries which include Belgium, Germany, Italy, Poland, UK and the new designated stakeholders' countries including France, Portugal, Spain, Czech Republic, Slovakia, Romania, Croatia and Turkey as listed in Appendix 1.

2.1 Description of the Initial Survey

In order to identify the skills gap, the survey was carried out to address the needs of specific target groups as listed; Equipment Manufacturers, Wholesalers, Designers, Consultants, Suppliers, Installers, Maintenance Companies, Owners, Operators, Educators and Training providers. The survey was translated into several languages for use by each stakeholder country, as indicated in Table 1 and "Survey Monkey" was the tool used to incorporate the questions into the survey. In total, 210 survey responses were obtained from all 12 stakeholders and 40 countries outside of the project as detailed in Table 1.

Table 1: Details of survey questionnaires

Type(s) of Business	SECTION(S)	COUNTRIES OF INTEREST	Languages Used	Number of Questionnaires Prepared	Number of Responses
Equipment Manufacturers and Wholesalers	**1**	UK Poland Belgium Italy Germany Czech Croatia Turkey Spain Slovakia France Denmark Portugal Romania	English Polish Czech Slovak Turkish Spanish Croatian	1 Questionnaire in 7 languages	**39**
Large scale (more than 250 employees) ○ **Designers** ○ **Consultants** ○ **Suppliers** ○ **Installers &** ○ **Maintenance Companies**	**2**			1 Questionnaire in 7 languages	**14**
Small to medium scale Suppliers / Installers both Individuals & Companies (1 - 249 employees)	**3**			1 Questionnaire in 7 languages	**109**
Owners / Operators of systems	**4**			1 Questionnaire in 7 languages	**4**
Training providers and Educators	**5**			1 Questionnaire in 7 languages	**44**
TOTAL				**5 Questionnaires in 7 languages**	**210**

The purpose of the survey was to achieve the following: -

- Understanding the compliance framework and training provision in each stakeholder country
- Identifying the carbon data baseline for the project for validation purposes
- Providing baselines for impact measurement & socio-economic indicators
- Establishing the baseline against which impact of our training activities can be evaluated as opposed to general market change.

- Identifying and clarifying national needs for inputting into- Trainingmaterials development, Train the trainer programmes, Key technical issues to be addressed and Gauging levels of training received and required
- Proposing measures for showing the project's effectiveness over its running period. This includes establishing and gauging: - The training impact, attitudes towards the use of low GWP refrigerants, the availability and level of training provisions, experience of applying new learning, changes to purchasing policies and changes in perceptions of barriers for using the low GWP refrigerants.
- Suggesting approaches to be used during the project in order to measure impact against needs.

2.2 Initial findings

The findings presented in this paper were obtained through analysing surveys from a wide selection of stakeholders, including the key partners. Based on locally obtained knowledge, an overview of the estimated number of systems was assessed. Table 2 includes a summary of the applications, types and numbers of "as installed" RAC (Refrigeration & Air Conditioning) systems/units for all HFCs and Low GWP refrigerants and typical refrigerant charge obtained from across stakeholder countries. It should be noted that, not all beneficiaries were able to provide information relating number of systems and respective total change for low GWP refrigerants based systems.

Table 2: Data established through the project beneficiaries

Business Sectors	Typical Refrigerant Charge (kg)	Estimated Number of Systems	Estimated Total Refrigerant Charge for Systems
		F-gas	F-gas (kt)
Integral retail cabinets	<3	70,810,333	133.6
Small Commercial	3-30		
Supermarket	30-300		
Industrial	>300		
Air conditioning	>30		
	<30		

On average, 80% of the systems in the partner and stakeholder countries are small systems, each with under 3 kg of refrigerant charge. This represents an increase of 5% from the report by Paurine and Maidment [2014]. There was growth in the number of low GWP systems being employed, but data were limited in availability. Based on this, typical leakage rates, baseline carbon data for the project is shown in Table 3 and further detailed in Appendix 2. The total emissions of 147.74 Mt represent approximately 3% of the total EU CO_{2eq} emissions, which is consistent with the report by Eurostat [2017].

Table 3: Baseline Data

Countries of Interest	Total Refrigerants Leakage (kt)	Emission leakages (kt CO_{2eq})
UK	2.87	10,056
France	2.61	9,132
Germany	3.29	11,521
Belgium	0.46	1,610
Italy	14.85	51,973
Spain	9.15	32,037
Poland	1.42	4,976
Croatia	0.34	1,185
Czech Republic	0.07	255
Slovakia	0.04	125
Romania	0.13	454
Turkey	6.98	24,416
Total Emissions	**42.21**	**147,739**

According to ETM [2016], there were 40 F-gas trained technicians and 10 certified companies per a population of 100,000 people. These figures were compared to the actual figures established from the survey as presented in Table 4.

Table 4: Certified Individuals & companies for working with F-gas & low GWP refrigerants

COUNTRIES	POPULATION	Estimated F-gas Trained Technicians as per ETM, 2016	Actual F-gas Trained Technicians as per Paurine nad Maidment [2018]	Low GWP Trained Technicians as per Paurine nad Maidment [2018]	Estimated F-gas Certified Companies as per ETM, 2016	Actual F-gas Certified Companies as per Paurine nad Maidment [2018]	Low GWP Certified Companies as per Paurine nad Maidment [2018]
UK	66,573,504	26,629	46,594	n/a	6,657	7,702	n/a
Poland	38,104,832	15,242	12,000	n/a	3,810	4,000	n/a
Belgium	11,498,519	4,599	3,000	200	1,150	350	n/a
Italy	60,656,000	24,262	80,000	1,000	6,066	45,000	n/a
Germany	82,293,457	32,917	35,000	n/a	8,229	10,000	n/a
Czech	10,625,250	4,250	3,000	n/a	1,063	n/a	n/a
Croatia	4,176,031	1,670	3,500	n/a	418	1,460	1460
Turkey	81,916,871	32,767	3,000	n/a	8,192	n/a	n/a
Spain	46,064,604	18,426	3,000	n/a	4,606	n/a	n/a
Slovakia	5,449,816	2,180	2,000	100	545	1,500	90
France	65,233,271	26,093	33,000	n/a	6,523	852	n/a
Romania	19,580,634	7,832	6,000	n/a	1,958	n/a	n/a

Using this approach on the figures established during the initial survey that was conducted, there were 47 F-gas trained technicians and 9 certified companies per a population of 100,000 people. With the exception of cases such as in the UK where training on Hydrocarbons, Ammonia, CO_2 had been in place for several years, in almost all the countries in which the survey was conducted, there were no reliable records of trained technicians and certified companies to implement low and lower GWP refrigerants based systems competently.

In order to gauge levels of training received and required, it was necessary to understand the percentage share of low and lower GWP refrigerants versus traditional HFCs in businesses. According to the survey, only 35% of businesses were prepared for these refrigerants, and if their market share was to grow, then the preparedness of all businesses needed to increase too. Of the 35% of businesses that were involved in low and lower GWP refrigerant-based systems, 50% of the companies provided training themselves, 10% provided training via train the trainer and 40% had no training ability for these refrigerants. Considering all businesses, including those not involved with low and lower GWP refrigerants, only 21% of businesses have training provision for low and lower GWP refrigerants. Of the 21% involved business, 45% do so by informally training service engineers who will service the newly installed systems after completion of the projects and 55% continually offer both practical and theoretical formal and informal training. This is a significant barrier to the development of low GWP capability and with it substantial scale reductions in carbon emissions

There was minimal preparedness in manufacturing and/or selling equipment or components that use low and lower GWP refrigerants, and this was consistent with a low percentage (%) of the workforce already trained on systems that use low and lower GWP refrigerants as illustrated in Figure 1.

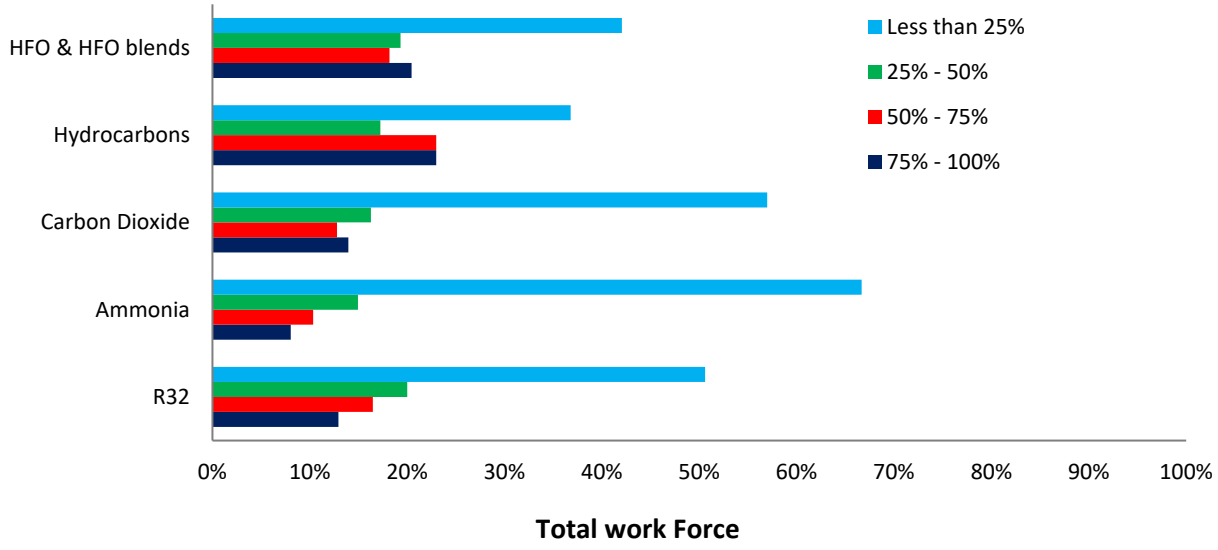

Figure 1: Percentage (%) of the workforce already trained on systems that use low and lower GWP refrigerants

Based on the above, the technical issues had to be identified, and those of utmost significance were established and weighed on the scale of 0 to 10, i.e. 0 for not and 10 for most significantly important and the result revealed the need to address them as indicated in Figure 2.

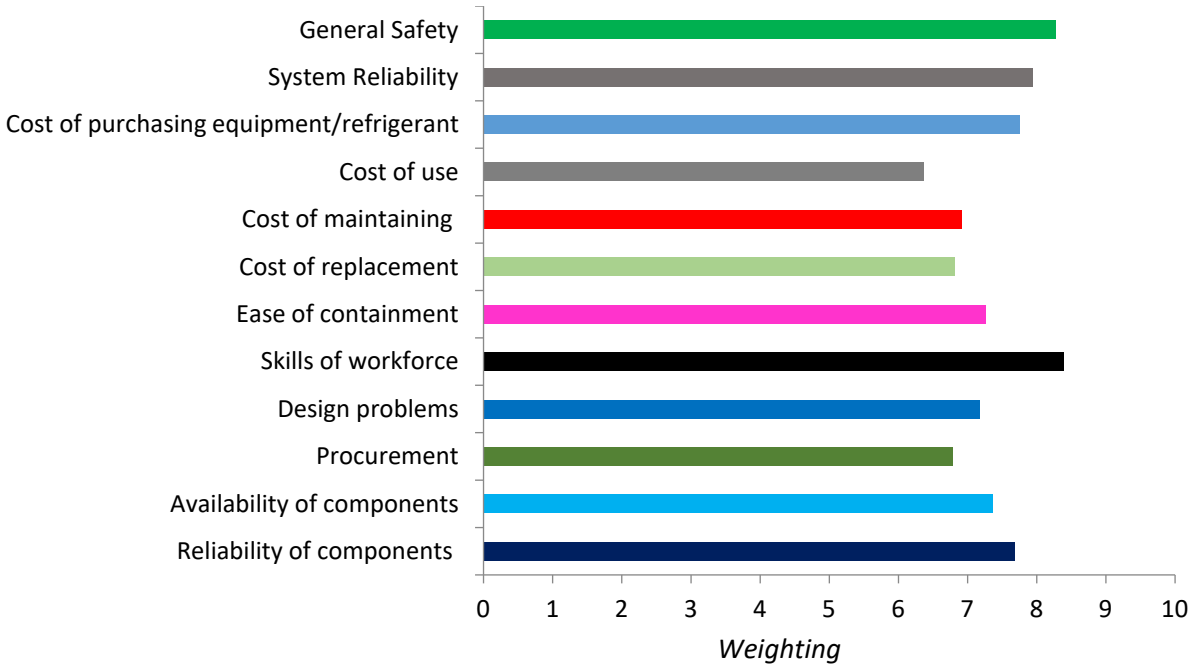

Figure 2: Significance (on a scale of 0 to 10) of the identified technical issues

Also, the survey identified the level of involvement in purchasing of equipment for refrigeration and air conditioning systems process. According to the survey, around 80% of all the respondents are involved in the purchasing process and out of which, 46% are directly responsible for procurement of equipment to the end-user whereas, 34% are only partly responsible. Although most companies are involved in the purchasing process, they are mainly guided by their respective policies and procedures for compliance, and the survey could not identify or establish a standardised set of purchasing policies to be used across the EU countries. There is a need for radical changes to be made for the purpose of enhancing the purchasing policies so as to facilitate more take up of low GWP based systems across the beneficiary and designated stakeholders' countries.

3. Interventions from 2018 to 2020

A low-cost, widely accessible multilingual (*i.e. Česky, Deutsch, Eesti, Español, Français, Hrvatski, Italiano, Nederlands, Polski, Português, Românesc, Slovenský, Suomi, Türkçe, Ελληνικά and Русскиӥ*) e-learning and a Train the Trainer CPD programme (https://www.realalternatives.eu/learning-platform) was developed in order to increase knowledge levels of the workforce on the safe use of low GWP alternative refrigerants, carbon dioxide, ammonia and hydrocarbons, and u-HFC blends. Amongst other topics, the programme covers the safety, efficiency, reliability and containment of low GWP alternative refrigerants.

Also, the project implemented a collaborative approach to identify and share best practice knowledge across member states with the aim to reach 85% of installers. The project produced training resources that can be replicated throughout the EU by licencing of materials – ensuring long-term sustainability. This addressed the inconsistencies in the skills levels across the EU in handling low GWP alternative refrigerants by providing training materials developed with input from a wide range of technical experts from 12 EU countries

Moreover, the project stakeholders have shared the best practice experience, case studies of success stories and by carrying out a comprehensive awareness-raising campaign across the EU (United Kingdom, Armenia, Belgium, Croatia, Cyprus, Czech Republic, Espana, Estonia, Greece, Germany, Italy, Netherland, New Zealand, Poland, Portugal, Romania, Slovakia and Turkey) through established training centres and providing free

guides, e-library, webinars, seminars and conferences. This has helped to overcome equipment user and distributor concerns over safety, reliability, containment, efficiency and standards compliance in low GWP refrigerant use.

4. Final Survey

The survey involved finding local information from each stakeholder's and beneficiary's country in terms of the changes in behaviour, knowledge, skills, awareness and policies towards the wider take-up and use of low GWP refrigerants based equipment.

4.1 Description of the Survey

The survey was developed and built upon baseline knowledge and experience gained from the report by Paurine and Maidment [2018] and other similar surveys and specifically that conducted by Colbourne [2011] on barriers to the uptake of low-GWP alternatives refrigerants in developing countries. This survey was set to evaluate the extent of the take up of equipment/components working with low GWP refrigerants as compared to the baseline by covering:

- The trend in business market share and the extent to which the equipment/components would be offered in the near future
- The extent to which the lack of training is considered to limit the wider take up of low GWP refrigerants
- How the demand for training provision in each stakeholder country has developed as compared to the baseline
- The effectiveness of the REAL alternatives training materials and programme in addressing critical technical issues
- Measuring the extent to which the workforce has been trained on the use of low GWP refrigerants in each stakeholder country, and
- Establishing the current and future trainers' capabilities of delivering low GWP refrigerants training

The information was collected from 193 respondents in 14 countries using 12 languages (i.e. English, Polish, Italian, Dutch, Czech, Croatian, Turkish, Spanish, Slovak, French, Portuguese and Romanian) and was analysed and compared to the baseline data as established in the previous needs review and impact report as detailed in Figure 3.

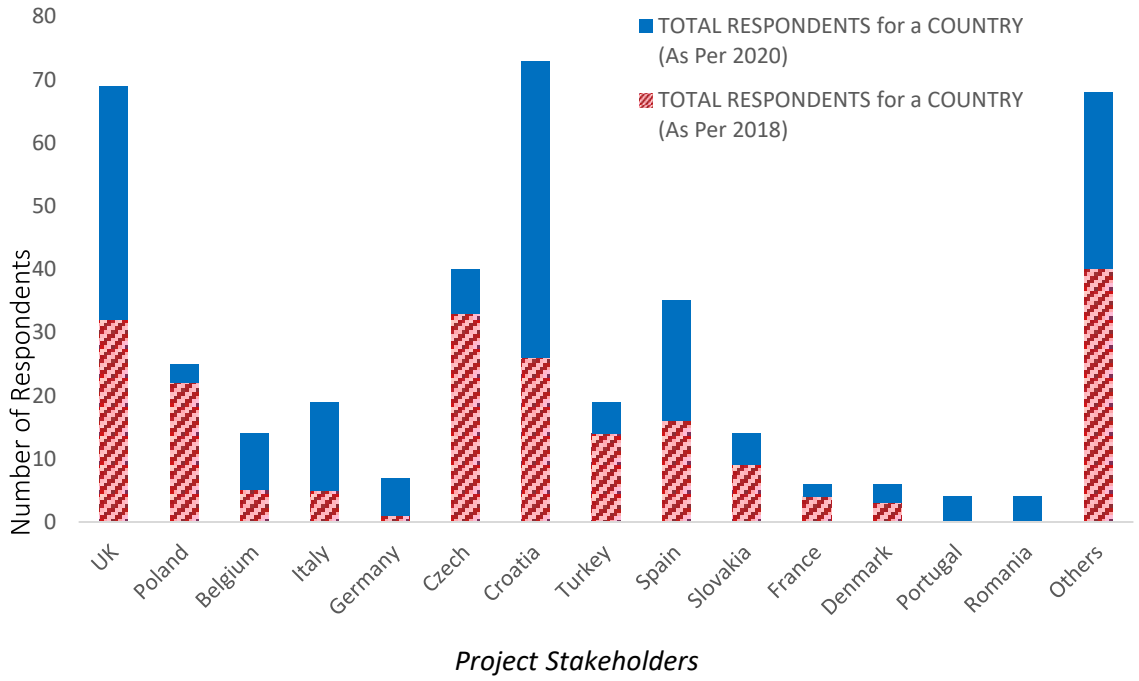

Figure 3: A statistical summary of questionnaire(s) responses from the Project Stakeholders

4.2 Final findings

The market scope in relation to the take up of equipment/components working with low GWP refrigerants as compared to the baseline was analysed. It should be noted that the survey was conducted by the help of the target groups in stakeholders' and beneficiaries' specific countries and detailed in Figure 4.

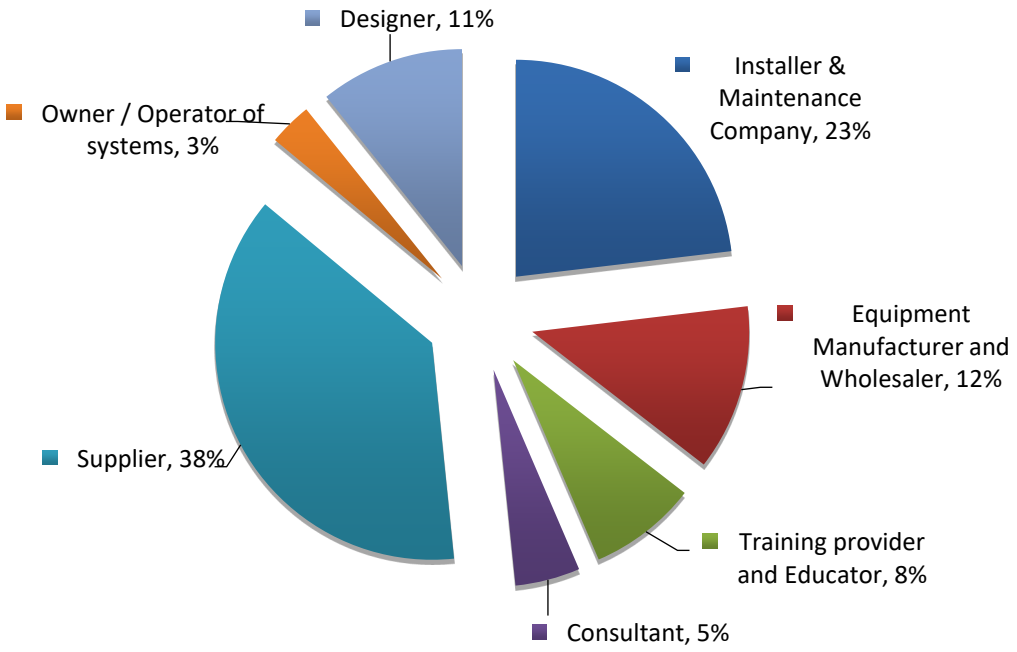

Figure 4: Break down of the survey respondents

Based on the survey; 38% of the respondents were suppliers of equipment and components, which was the highest followed by installation and maintenance companies. This trend above was consistently experienced in all countries in which the survey was conducted.

According to Paurine and Maidment [2018], it was established by then that only 35% of businesses were prepared for low GWP refrigerants and therefore, if their market shares were to grow, then the preparedness of all businesses needed to improve too. Based on the current trend in the business, 75% of the respondents in the recent survey did confirm that the take up of low GWP refrigerants based equipment was more than three years ago and therefore an increase of the market share was reported.

In addition, the study needed to establish the expected trend in business market share for low GWP refrigerants over the next 3-5 years compared to traditional HFC refrigerants, and the outcome was as follows in Figure 5:

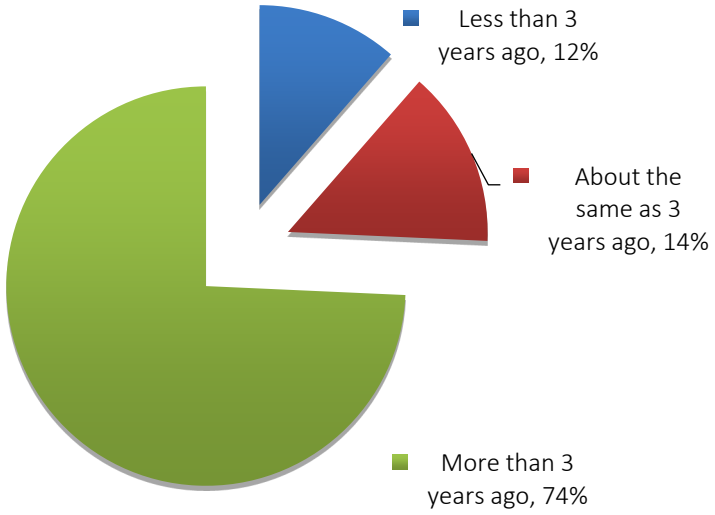

Figure 5: Perception of Share of low GWP refrigerants

The most recent survey confirmed that, although there have been significant improvements in awareness and training provision, to a greater extent (i.e. 6.2 out of 10), the respondents identified and reported the lack of training as still being the main barrier to the wider take up of low GWP refrigerants in respective countries. Also, to some extent (i.e. 5.3 out of 10) the respondents did estimate that the lack of training will remain as a barrier to the wider take up of low GWP refrigerants in respective countries in the next 3-5 years.

Therefore, the new survey investigated the status of this barrier, and it was established that only 32% of all the respondents do believe with certainty that, there are enough trainers capable of delivering low GWP refrigerant training in the market at the moment and thus suggesting the need for continuing to train the trainers.

According to the recent survey, the majority (71%) of the respondents confirmed that the demand for training on low GWP refrigerants based systems over the past three years has increased. However, this majority is only 37% of all participants in the survey and suggesting minimal improvements in the take up of the new low GWP refrigerants based systems. Also, 79% (which is equal to 42% of all participants in the survey) of those who responded to the question, did expect that the demand for training in the next 3-5 years will increase due to sensitisation efforts in these specific countries.

Lastly, based on the recent survey, it was established that the REAL alternatives training material (to a great extent) do address the technical issues and there is room for improvement in the training material as 95%

of the participants did technically agree that the REAL alternatives 4 LIFE training material do not fully address the listed issues. The highest weighted aspect was General Safety (i.e. 7.46 out of 10) as detailed in Figure 6.

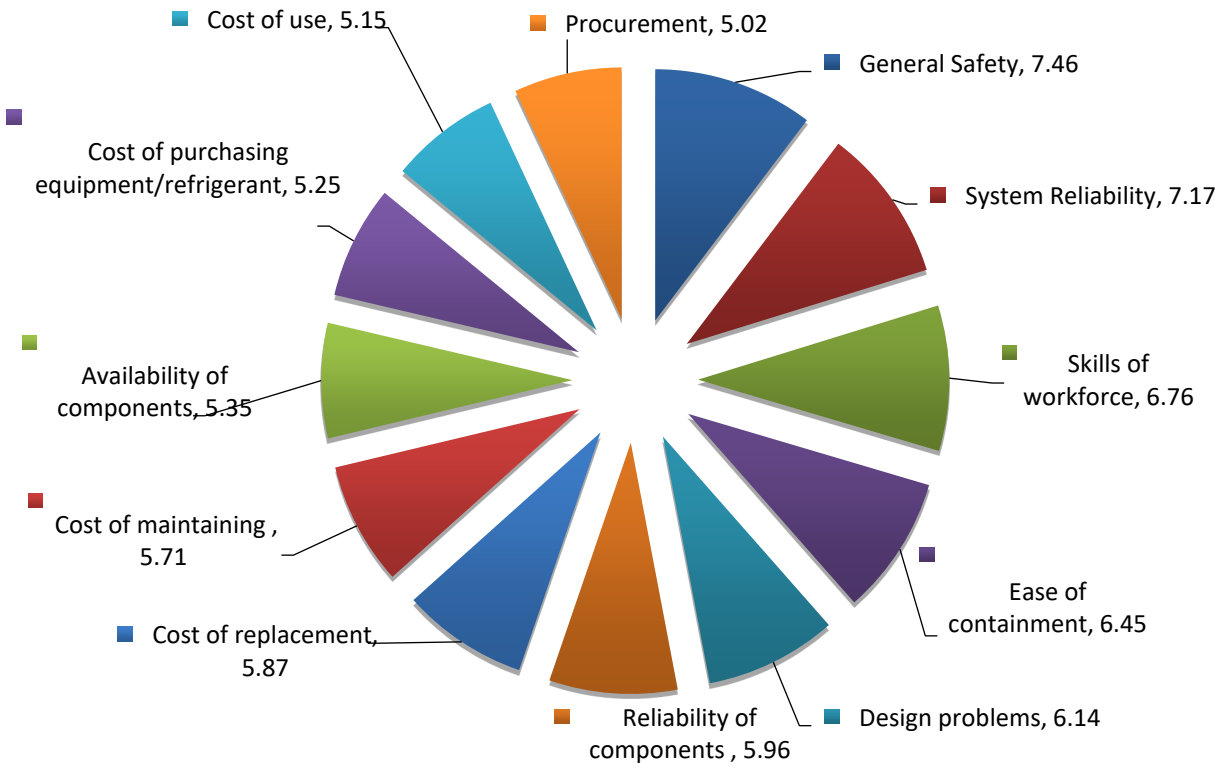

Figure 6: Significance of the identified technical issues

4.3 Recommendations for procurement of RACHP equipment using low GWP alternatives

Based on Paurine and Maidment [2018]; the level of involvement in purchasing of equipment for refrigeration and air conditioning systems was established. The level of stakeholders/businesses involved in the purchasing process was around 80% of all 210 respondents, out of which 46% were directly responsible for procurement of equipment to the end-user whereas, 34% were only partly responsible (through a third party). Although most companies are involved in the purchasing process, they are mainly guided by their respective policies and procedures for compliance, and the survey could not identify or establish a standardised set of purchasing policies to be used across the EU countries. It is for this reason, several recommendations are made to enhance the procurement and therefore facilitating more take up of low GWP alternatives based RACHP equipment across the beneficiary and designated stakeholders' countries.

With due consideration for sustainability, systems efficiency and cost-effectiveness, the REAL alternatives project hereby recommend on the quality of equipment/components and quality of delivery, installation and operational services at the most competitive available market prices. This gives due regard to the process of defining and identifying needs, Sourcing relevant supplier(s), negotiating terms and contracts, building and maintaining relationships with suppliers, performing quality assurance, analysing and reporting on cost savings and profit margins of the products.

The procurement process should comply with EU Minimum Energy Performance Standards (MEPS) to ensure certain low-efficiency equipment/components are not utilised in air conditioning systems. The raising of the minimum MEP threshold will encourage the use of higher efficiency equipment using natural refrigerants like ammonia and therefore driving purchasing.

Due to the importance and far-reaching environmental, social and economic effects of procurement processes in all businesses, each end-user should employ or seek the help of procurement consultant(s) to help with technicalities that are associated with:

- Selecting of the most suitable suppliers who are able to deliver high-quality RACHP equipment using low GWP alternatives at competitive prices.
- Negotiating with suppliers on lead-time, cost and quality so as to obtain the maximum benefit for the end-user.
- Managing suppliers to meet objectives related to cost, delivery performance, schedule and quality standards.
- Developing purchasing strategies based on market analyses and preferred supplier's preferences.
- Developing, implementing and driving the procurement strategies in order to meet carbon and cost savings targets.
- Performing regular performance review with equipment suppliers in order to drive continuous improvements.
- Ensuring RACHP equipment/components are meeting conformance and performance ISO standards.
- Ensuring compliances in all the procurement transactions.
- Periodic training on effective procurement processes and strategy.
- Communicating and ensuring alignment of specific projects and expectations of the stakeholders.
- Risk identification and mitigation and anticipating supply chain challenges

The low GWP alternative refrigerants must be listed in ISO 817 which is detailed by ISO Standards [2020]. Moreover, the procurement of low GWP alternative refrigerants based RACHP equipment shall comply with some of the existing relevant standards and statutory requirements in each specific stakeholder country. These standards include but not limited to; ISO 50001, ISO 5149-1:2014, ISO 5149 2:2014, ISO 5149 3:2014, and ISO 5149 4:2014 [ISO Standards, 2020]. Others include EN 378-1:2016, EN 378-2:2016, EN 378-3:2016, EN 378-4:2016 and ISO 26000:2010 as summarised in Figure 7.

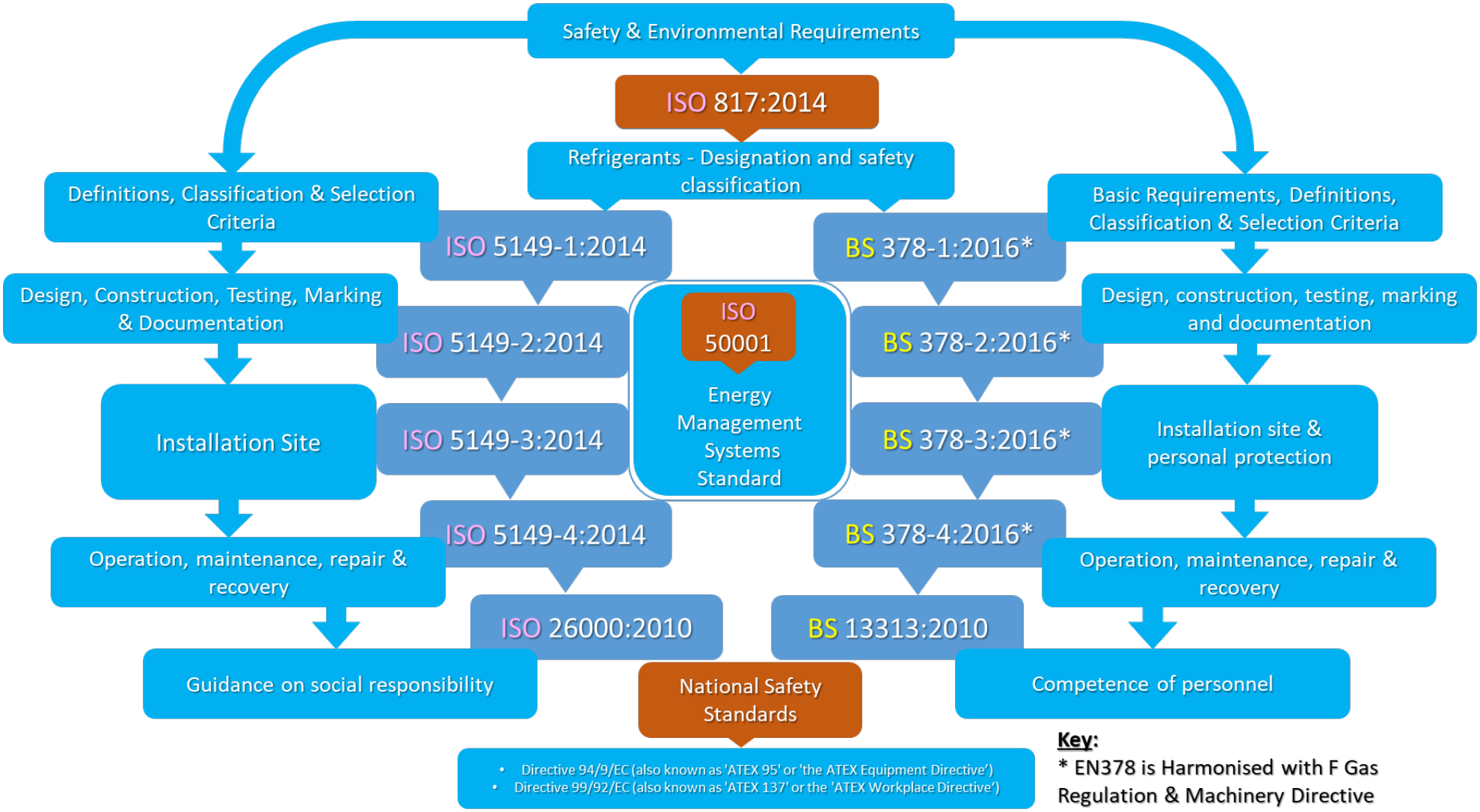

Figure 7: Recommended Standards for procurement of low GWP refrigerating heating systems and heat pumps.

It should be noted that the above standards do address most of the following aspects: conformance and performance specifications, services and system quality, pay-pack periods, functionality, risk assessment and management, general safety, components and systems reliability, skills of the workforce, design problems, ease of containment, cost of replacements, cost of maintaining, cost of purchase and use of equipment, health and safety, choosing manufactures/suppliers and procurement training to increase knowledge and awareness of good business practice.

Moreover, a cities cooling initiative through the cool coalition, the global covenant of mayors and mission innovation is striving to establish better procurement practices in 10,000 cities worldwide for sustainable cooling and consequently driving the need for high-efficiency natural refrigerants. It should be noted that, as we decarbonise the electricity supply, in use energy/carbon will become much less significant and embodied emissions will start to dominate. Therefore, we recommend that; future practices should focus on this aspect in order to encourage more use of zero/low GWP refrigerants based systems.

5. Conclusions and future work

- Based on the review, there are many systems in place in the EU region, and those in the surveyed countries are responsible for approximately 3% of CO_{2eq} emissions.
- The project has ensured that users of cooling equipment and those employed in the sectors across EU member states have had improved knowledge, skills and awareness of how to use low GWP refrigerants safely and minimise the environmental impact of systems.
- The use of low GWP refrigerants is growing in response to demand.
- The sector is now more prepared for a rapid and safe transition to climate-friendly for low GWP refrigerants in new refrigeration and air conditioning equipment and to the adaptation of existing systems.
- If the EU is to reduce its emissions to achieve its targets, then the increased use of low GWP refrigerants based systems is urgently needed.
- There is limited technical information available and some compliance in some countries.
- There is still little technical capability for low GWP refrigerants at the moment, and this must be improved.
- The survey also concluded that there was limited capacity and capability for training for low GWP refrigerants, and this was essential.
- There was no clear preference in the method of delivering training for individuals; however, trainers do prefer a blended learning approach.
- The survey identified that diverse technical skills were needed and these included general safety, system reliability, cost of purchasing equipment and refrigerant, cost of use, cost of maintaining, cost of replacement, ease of containment, skills of the workforce, design problems, procurement, availability and reliability of components.
- Clear need for improved skills - especially for Carbon dioxide and u-HFC / low flammable refrigerants
- High awareness of retraining to address safety, reliability and containment issues
- Strong emphasis on assessed and certificated training, with supporting online technical information

- High-interest levels and commitment by smaller businesses
- There is a need for changes to purchasing policies to facilitate more take up of low GWP based systems.
- Continued demand to improve the containment of existing HFC systems as refrigerant becomes scarcer
- Compliance has not been demonstrated in most countries and therefore suggesting lack of it, which necessitates the need for training and awareness

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Appendices

Appendix 1: Key partners and stakeholders

Stakeholders' and Key Partners' Information		
UK/LSBU	Key Partners	LSBU – London South Bank University
& IoR		IoR – Institute of Refrigeration
Germany/IKKE		IKKE – Informationszentrum für Kälte-, Klima- und Energietechnik
Belgium/KHLIM		KHLIM – Katholieke Hogeschool Limburg
Italy/ATF		ATF – Associazione Tecnici del Freddo
Poland/Prozon		Prozon – The Foundation for climate protection
IIR/France		IIR – International Institute of Refrigeration
APIRAC/Portugal	Stakeholders	APIRAC – Portuguese Association for RAC Industry
CNI/Spain		CNI – National Confederation of RAC Installers
SCHKT/Czech Republic		SCHKT – Czech RAC Technical Group
SZCHKT/Slovakian Republic		SZCHKT – Slovakian RAC Technical Group
AGFR/Romania		AGFR – Romania General Association of Refrigeration
HRKT/Croatia		HRKT – Croatian Refrigeration air conditioning & heat pump association
SOSIAD/Turkey		SOSIAD – Turkish refrigeration and air conditioning

Appendix 2: Summary table of number of systems, refrigerant charge, Leakage and Emissions baseline data

Countries of Interest	Population	Adjusted Estimated Person / Systems	Adjusted Estimated number of Systems	Actual number of Systems	Proportion of Smaller Systems	Charge (kg)	Adjusted Charge (kg)	Estimated Total Charge (t)	Adjusted Total Charge (t)	Actual Refrigerant Charge (t)	Total Leakages (t)	Emission leakages (t CO_{2eq})
UK	66,573,504	14	4,820,000		83%			6,034	9,093		2,873	10,056,491
France	65,233,271	15	4,377,072		71%			5,479	8,257		2,609	9,132,362
Germany	82,293,457	15	5,521,789		58%			6,912	10,417		3,292	11,520,711
Belgium	11,498,519	15	771,536		71%			966	1,455		460	1,609,741
Italy	60,656,000	2.4	24,910,062	24,900,000	80%			31,184	46,991		14,849	51,972,575
Spain	46,064,604	3	15,354,868		80%			19,222	28,966		9,153	32,036,534
Poland	39,000,000	16.3	2,385,029		84%	0.6	1.9	2,986	4,499	4,499	1,422	4,976,085
Croatia	4,176,031	7.3	567,781		80%			711	1,071	1,071	338	1,184,624
Czech Republic	11,000,000	90	122,222		84%			153	231		73	255,006
Slovakia	5,449,816	90.8	60,000	60,000	84%			75	113		36	125,185
Romania	19,580,634	90	217,563		84%			272	410		130	453,925
Turkey	81,916,871	7	11,702,410	10,818,500	80%			14,650	22,076		6,976	24,416,013
		Total Systems	**70,810,333**				Total (t)		**133,580**		**42,211**	**147,739,251**