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REPORT FROM THE COMMISSION

of 4.8.2017

**assessing the 2022 requirement to avoid highly global warming Hydrofluorocarbons in
some commercial refrigeration systems**

1. Introduction

Regulation (EU) No 517/2014¹ creates an efficient and proportionate mechanism for reducing fluorinated greenhouse gases in order to contribute significantly to the Union's climate targets. It also enhances sustainable growth, stimulates innovation and develops green technologies by improving market opportunities for alternative technologies and gases with a lower global warming potential.² Finally it ensures that the EU can meet its obligations under the recent agreement to phase-down the global consumption and production of hydrofluorocarbons (HFCs) under the Montreal Protocol (the "Kigali Amendment")³, which represents a significant step forward in implementing the Paris Agreement.⁴

The central policy measure to achieve these objectives is the "EU phase-down of HFCs", a reduction in the quantities of HFCs companies may legally import or produce in the EU (i.e. "place on the market for the first time"). This measure is accompanied by a number of requirements to avoid fluorinated gases with a high and medium global warming potential⁵ in sectors where suitable alternatives are available. These requirements should facilitate the availability of HFCs for other sectors where finding alternatives is technically more difficult or costly in the context of declining HFC quantities due to the phase-down measure. These prohibitions are listed in Annex III of Regulation (EU) No 517/2014.

To ensure that the requirement in Annex III for new large-scale refrigeration systems commonly found in larger supermarkets and hypermarkets is feasible by the date specified, the legislation requires the Commission to carry out an assessment thereof by 1 July 2017. Accordingly, Article 21(3) of Regulation (EU) No 517/2014 calls on the Commission to "publish a report assessing the prohibition pursuant to point 13 of Annex III, considering in particular, the availability of cost-effective, technically feasible, energy-efficient and reliable alternatives to multipack centralised refrigeration systems referred to in that provision. In light of that report, the Commission shall submit, if appropriate, a legislative proposal to the European Parliament and to the Council with a view to amending the provision pursuant to point 13 of Annex III."⁶

¹ OJ L 150, 20.05.2014, p.195.

² Communication from the Commission to the European Parliament, the Council, the European Economic and Social committee and the Committee of the Regions: *A policy framework for climate and energy in the period from 2020 to 2030*, COM/2014/015 final: <http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52014DC0015>

³ http://ec.europa.eu/clima/news/articles/news_2016101401_en

⁴ Communication from the Commission to the European Parliament and the Council: *The Road from Paris: assessing the implications of the Paris Agreement and accompanying the proposal for a Council decision on the signing, on behalf of the European Union, of the Paris agreement adopted under the United Nations Framework Convention on Climate Change*, COM(2016) 110 final: <https://ec.europa.eu/transparency/regdoc/rep/1/2016/EN/1-2016-110-EN-F1-1.PDF>

⁵ The global warming potential is a measure of how much heat, relative to CO₂, a gas traps in the atmosphere and thus contributes to global warming. The global warming potential of CO₂ is set to 1.

⁶ Point 13 of Annex III reads as follows: "*Multipack centralised refrigeration systems for commercial use with a rated capacity of 40 kW or more that contain, or whose functioning relies upon, fluorinated greenhouse gases with GWP of 150 or more, except in the primary refrigerant circuit of cascade systems where fluorinated greenhouse gases with a GWP of less than 1500 may be used*" are prohibited from 1 January 2022.

This report responds to this request and is based on technical work by external experts, including extensive consultations with stakeholders and a survey of affected stakeholders,⁷ as well as deliberations within the Consultation Forum⁸ established pursuant to Article 23 of Regulation (EU) No 517/2014.

2. Current state of technology and availability of feasible and reliable alternative solutions in commercial refrigeration

According to Regulation (EU) No 517/2014 a move away from HFCs with a very high global warming potential⁹ shall take place in the commercial refrigeration sector from 2020¹⁰, when the placing on the market restriction for new stationary refrigeration equipment with such refrigerants becomes applicable and their use for the servicing of existing large refrigeration equipment will be stopped.¹¹ The 2022 requirement, the subject of this report, will in addition not permit the use of fluorinated greenhouse gases with a medium high¹² global warming potential for most newly installed centralised systems¹³. Centralised systems refer to systems where the refrigeration capacity for the whole store is produced centrally in one location, often in a separate machine room. The majority of refrigeration systems that are currently installed in larger supermarkets and hypermarkets are so-called "multipack centralised refrigeration systems"¹⁴.

Other, more decentralised, ways of providing refrigeration are also commonly used today, particularly in smaller supermarkets and convenience stores. These include the use of several distributed condensing units and/or stand-alone units, both of which will not be affected by the 2022 requirement.¹⁵ However, by analogy, the use of HFCs with medium¹⁶ global warming potential in new stand-alone units is also not permitted from 2022 onwards.¹⁷

Many centralised systems currently *in use* today still use HFCs with a very high global warming potential. However, this is changing quickly for newly installed equipment. Regulation (EU) No 517/2014 has created a dynamic situation in this sector where demand for climate-friendly options is growing rapidly.¹⁸ As evidenced by the stakeholder survey⁷,

⁷ Öko-Recherche: "Availability of alternatives to HFCs in commercial refrigeration in the EU":

https://ec.europa.eu/clima/sites/clima/files/20161201_briefing_supermarket_en.pdf.

⁸ https://ec.europa.eu/clima/events/articles/0106_en

⁹ Very high global warming HFCs not allowed anymore from 2020 in this sector have a global warming potential 2500 times higher than CO₂.

¹⁰ See point 12 of Annex III of Regulation (EU) No 517/2014.

¹¹ Pursuant to Article 13(3) of Regulation (EU) No 517/2014.

¹² i.e. all fluorinated greenhouse gases with a global warming potential that is at least 150 times higher than CO₂ will not be permitted anymore; however, fluorinated gases up to a global warming potential of 1500 times higher than CO₂ will still be allowed for special refrigeration systems (examples E and F in Annex II).

¹³ Annex II schematically shows the different centralised system types and refrigerants that would be allowed under the 2022 requirement.

¹⁴ See definition in Annex I.

¹⁵ Condensing units may be affected if they fall under the definition of a multipack centralised systems pursuant to Article 2(37) of Regulation (EU) No 517/2014, e.g. in case they have 2 or more compressor operated in parallel; and provide more than 40kW of cooling capacity.

¹⁶ i.e. all HFCs with a global warming potential that is at least 150 times higher than CO₂ will not be permitted anymore.

¹⁷ See point 11 of Annex III of Regulation (EU) No 517/2014.

¹⁸ Shecco (2016) F-Gas Regulation is shaking up the HVAC&R industry. https://issuu.com/shecco/docs/f-gas_impact_shecco_october2016

CO₂ technology and other non-HFC technologies are starting to be widely used. A number of technically feasible alternatives, which will be allowed for newly installed systems after 2022, are already available on the market and used by retailers in their stores today. These available technology options include (i) centralised systems using CO₂ as refrigerant in a so-called "transcritical cycle"¹⁹, (ii) a number of different types of **indirect centralised systems**, and (iii) **systems made up of stand-alone units** using different low global warming potential refrigerants.

2.1 Centralised systems using "transcritical CO₂"

Centralised systems using transcritical CO₂²⁰ have become a standard technology in many parts of Europe and over 9 000 stores already use this technology.¹⁸ There appears to be a consensus in the industry that transcritical CO₂ is a mature and feasible technology for commercial refrigeration, especially in cool and mild climates. This technology was first installed around 1998 and has since been subject to an impressive growth in the market. Transcritical CO₂ systems have now been built in most European countries and there are clear indications that the use of this technology has been spreading southwards in recent times as systems now operate in Italy, Spain, Portugal and Romania. In terms of the reliability of transcritical CO₂ systems, such systems have been planned, built and kept running for over a decade and today's CO₂ systems have leakage rates in the same order as conventional HFC systems but use a refrigerant with a global warming potential of 1⁵ rather than several thousand for commonly used HFCs today.⁹

2.2 Indirect centralised systems

Indirect centralised systems comprise a number of diverse system designs which employ various refrigerants. This system type includes a number of cascading systems where two or more circuits carrying refrigerants are connected in series so that the absorbed heat is transferred from one circuit to another.²¹ These systems combine the use of CO₂, glycol or heat-transferring fluids inside the store to cool the display cabinets, freezers etc. with refrigerants such as hydrocarbons, ammonia, or HFOs (blends)²² in the outer machine room loop (the "primary refrigerant circuit").^{23,24} Indirect systems using an ammonia/CO₂ cascade are of particular interest for large store formats in warmer climates, yielding good efficiencies under these conditions. Indirect systems have been traditionally used in industrial refrigeration, but various systems have been recently installed across Europe as commercial refrigeration systems.⁷ In Luxembourg and Sweden targeted legislation has particularly favoured their installation. While such systems are not as commonly found as transcritical CO₂ systems, some technical experts believe that efficient indirect systems can be conceived

¹⁹ A special technology where CO₂ undergoes different thermodynamic states (both sub-critical and super-critical).

²⁰ Example G in Annex II.

²¹ It is important to point out that the 2022 requirement does not allow a simple cascade with e.g. HFC R134a (global warming potential of 1430 times higher than that of CO₂) in the primary circuit that also serves the whole medium-temperature cooling requirements while absorbing the heat from a CO₂ circuit for the low temperature. The requirement demands instead that the medium-temperature itself is split into two circuits, where only the primary circuit would be allowed to use HFCs < 1500, such as R134a.

²² Hydrofluoroolefins or unsaturated HFCs; synthetic refrigerant with low GWP; covered by reporting obligations pursuant to Annex II of Regulation (EU) No 517/2014.

²³ Such systems can include the use of chiller technology. A chiller is a machine that removes heat from a liquid via a vapour-compression or absorption refrigeration cycle.

²⁴ Examples C-F in Annex II.

at a cost very much comparable to other solutions and may therefore have their rightful place in the post-2022 era.

2.3 Stand-alone systems

Commercial stand-alone systems comprise of stand-alone units with hermetically sealed refrigeration circuits that provide refrigeration in a certain temperature range and are simply plugged into a power outlet without a further installation need (“plug-ins” or “integrals”). Such single units are similar to domestic refrigerators or freezers but usually of a larger size and with larger cooling capacities. Stand-alone systems are very common around the world in light commercial applications but have proven to be technically feasible in larger stores as well. Increasingly, such systems are also installed in supermarkets and discounters across Europe as an alternative to, or to supplement, centralised multipack refrigeration systems. For stand-alone systems a number of different refrigerants are available that would meet the requirement of having a low global warming potential²⁵, including hydrocarbons such as propane or isobutane, but also ammonia or CO₂.

When stand-alone units are used to provide a large fraction of refrigeration needs in a medium or larger store, it is often undesirable to dissipate heat into the vending area (unless this is advantageous for heating purposes). A so-called variation of the stand-alone systems called “semi-plug-ins” transfers the heat via a heat exchanger to a water-cooled system or glycol loop that allows for the excess heat to be collected. It may then be used for heating the store and providing warm water, or dissipated to the outside e.g. via rooftop heat exchangers. In hot climates it is also possible to use chillers to cool the system which can be mounted on the roof in urban environments. Such systems technically represent a combination of indirect systems and stand-alone systems.

2.4 Other systems

Most other systems than the ones described above do not appear to be good solutions at the moment for large supermarkets and hypermarkets. Centralised systems with direct expansion of a low GWP refrigerant other than CO₂ do not seem to be available for very large stores.²⁶ Distributed systems where multiple condensing units in the vending area individually service more than one display cabinet are common in the US but little used in Europe. These systems would make sense in convenience stores and some small supermarkets, but they cannot compete on cost and energy grounds with the three described systems above in commercial applications requiring a total of more than 40 kW refrigeration capacity. Another feasible variation of a distributed system is multifunctional systems that employ compact condensing units with an air conditioning functionality. Such systems can also be used for cooling capacities of less than 40kW and show potential for an increased use in the future.

3. Cost effectiveness and energy efficiency

Some stakeholders have identified initial investment costs, especially in medium-size stores (40-100kW), and energy efficiency losses when operated under higher ambient temperatures as hurdles to a universal application of the technological options fulfilling the Annex III requirement. Objective comparisons between different technologies are difficult to make as a number of factors, including local conditions and details of system designs, influence the performance of each system. However, the extensive technical feedback received indicates

²⁵ i.e. a global warming potential less than 150 times higher than that of CO₂.

²⁶ Example A in Annex II.

that energy efficient systems for all three alternative systems types described above can be manufactured and operated. For all these technologies, various case studies have underlined the potential of significant energy savings compared to conventional HFC systems used today.⁷ Furthermore, alternative technologies offer additional ways of saving energy. Heat recovery in semi-plug-in systems can increase energy savings significantly by reducing the energy required to heat the store, feed into the ventilation system and provide hot water. Combinations of the technological options can deliver even better performing integrated solutions that also provide heating, ventilation, air conditioning and hot water in the store.

Stakeholders from Spain and Portugal as well as the chemical producers of fluorinated gases pointed to the special circumstances in southern Europe as climatic conditions during summer months have an impact on the energy efficiency performance of transcritical CO₂ systems. While these concerns may have been genuine for first generation, so-called "booster" transcritical CO₂ systems, they do not hold true anymore for the more advanced CO₂ systems available today, which can achieve very good energy efficiencies even in warmer climates, when they are equipped with the newest technology developments.²⁷ This is confirmed by a number of existing transcritical CO₂ installations in Spain, Portugal and Italy which suggest energy efficiency improvements over direct HFC/CO₂ cascades and HFC systems.⁷ The former systems, also called subcritical CO₂ systems, have been used as a suitable alternative with good energy performance. Similarly, a Spanish study²⁸ based on mathematical modelling shows that state-of-the-art CO₂ transcritical systems compete well, even under high ambient conditions, with the newest HFC/CO₂ cascade systems using a novel refrigerant (R513A)²⁹. Furthermore, it should be borne in mind that transcritical CO₂ is not the only technology option available to end-users in the southern Member States, but good energy performance is also possible with indirect or standalone systems. Indirect systems have performed well in hot places elsewhere in the world, and stand-alone solutions based on hydrocarbons and CO₂, for example, in Spain have proven to save more than 20% energy compared to stand-alone systems with HFCs.⁷

In many cases improvements in energy efficiency increase the upfront investment costs of equipment. However, the resulting savings in energy consumption make up for these higher initial costs within a few years or even less.⁷ Furthermore, such increases in upfront costs to enhance efficiency apply to all system types, including those operating with conventional HFC technology. For this reason, transcritical CO₂ and stand-alone systems are generally already considered as cost-competitive to conventional systems in most cases today. In response to the survey, manufacturers of CO₂ transcritical systems acknowledge however that the upfront costs of such systems working efficiently in southern Member States is higher today than elsewhere in the EU, but are confident that developments by 2022 will close the remaining cost-gap. Traditionally transcritical CO₂ systems have been developed in northern and central Member States, in particular in Germany and Denmark, not least as a result of early national policies to avoid HFCs, and it is for this reason that there is still less experience in southern Member States with this technology today. Service personnel will need to

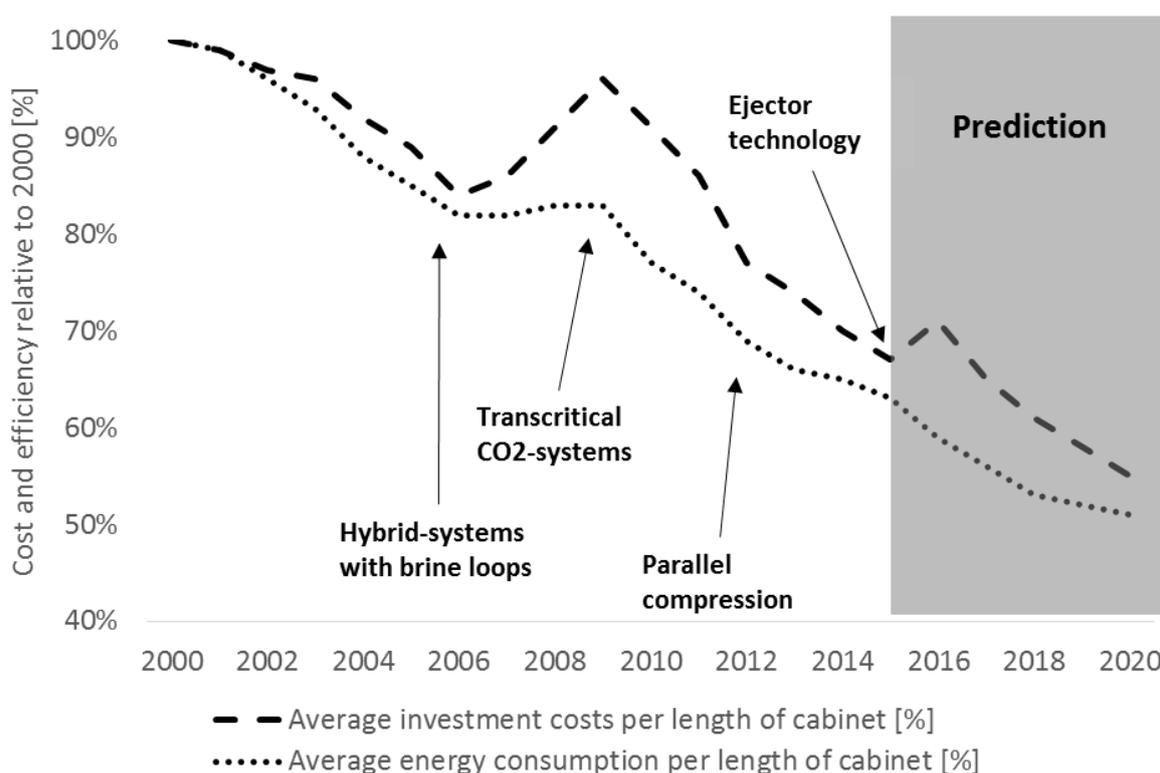
²⁷ i.e. parallel compression, advanced ejector technologies and sub-coolers.

²⁸ University of Castellón (UJI), Tewis Smart Systems, S.I. (2016). "Informe: Estudio de mejoras en ciclos de compresión de doble etapa destinados a refrigeración comercial": http://www.git.uji.es/inicio/docs/Full_Report_Alternative_Refrigeration_Systems_2016.pdf

²⁹ The study results for energy consumptions indicate, for transcritical CO₂ compared to R513A/CO₂ cascades, a range from 12% energy savings to -4% (i.e. energy losses) across 16 different locations in Spain and similar results for Portugal (from 8% energy savings to ca. 2.5% losses).

improve their training for alternative technologies, especially transcritical CO₂ technology, in particular in those countries where professionals have only recently started to work with CO₂ transcritical technology.³⁰ As outlined above under energy efficiency, there are also other technology options that are quite suited to warmer conditions and which can be very cost-effective in southern Member States. Stand-alone systems are an attractive option for those countries where smaller convenience stores dominate urban settings, as is common in Mediterranean countries, and semi-plug-in installations also allow excess heat to be evacuated from the store. The best choice of the most appropriate technology will therefore depend on local conditions as well as cost and energy considerations, with several technology choices available to end-users.

It is expected that prices will go down significantly for all the alternative technology options. At the same time, energy efficiency will further improve, due to volume growth, availability, competition and production efficiency increases. Switzerland, due to its very progressive policies in this sector³¹, is a good example for predicting the developments ahead. Both investment costs and energy consumption for refrigeration costs fell over 30% in a period of five years. This is comparable to the period from today to the date of the 2022 requirement (Figure 1).



³⁰ See also: Report from the Commission *on availability of training for service personnel regarding the safe handling of climate-friendly technologies replacing or reducing the use of fluorinated greenhouse gases*, COM/2016/0748 final: <http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52016DC0748>

³¹ Switzerland has already banned from 2013 the use of fluorinated gases for larger refrigeration systems in the commercial sector. See *Chemikalien-Risikoreduktions-Verordnung, ChemRRV*: <https://www.admin.ch/opc/de/classified-compilation/20021520/201702010000/814.81.pdf>

Figure 1. *Price and efficiency development of refrigeration systems per meter of cabinets installed in Switzerland*³²

4. Conclusions

From a technical assessment it is apparent that there are multiple technological alternatives available today, which are already used in the commercial refrigeration sector across the EU and would not be affected by the 2022 requirement. These include transcritical CO₂ centralised systems, indirect centralised systems and stand-alone systems which all are feasible, reliable and energy-efficient alternatives.

The results further suggest that many of these alternatives are already or will be cost-competitive by 2022, when the new requirement enters into force. It is important to keep in mind that this rule will only apply to newly installed equipment after 1 January 2022, but not to equipment that was installed before that date. The Commission therefore sees no need to amend the provision pursuant to point 13 of Annex III of Regulation (EU) No 517/2014.

³² Source: Frigo-Consulting AG (2016).